“EFFECT OF DIFFERENT ORGANIC INPUTS WITH JEEVAMRUT ON YIELD, QUALITY AND SOIL PROPERTIES IN SOYBEAN-WHEAT CROPPING SEQUENCE”

A Thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI – 413 722 DIST. AHMEDNAGAR
MAHARASHTRA, INDIA

By
NITIN SHIVAJIRAO UGALE
(Reg. No. 09/06)

In partial fulfilment of the requirements for the degree of

DOCTOR OF PHILOSOPHY
(AGRICULTURE)

in
AGRONOMY

DEPARTMENT OF AGRONOMY,

POST GRADUATE INSTITUTE,
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722,
DIST. AHMEDNAGAR, MAHARASHTRA, INDIA

2014

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2014

DEDICATION

Dedicated to
My beloved Parents

.... Nitin

CANDIDATE'S DECLARATION

I hereby declare that this thesis or the part there of has not been submitted by me or by other person to any University or Institute for a Degree or Diploma

Place : M.P.K.V., Rahuri

Dated : / /2014

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CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF DIFFERENT ORGANIC INPUTS WITH JEEVAMRUT ON YIELD, QUALITY AND SOIL PROPERTIES IN SOYBEAN - WHEAT CROPPING SEQUENCE**" submitted to the Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, M.S. (India) for the award of the degree of **DOCTOR OF PHILOSOPHY** (AGRICULTURE) in **AGRONOMY**, embodies the results of a *bonafide* research carried out by **Mr. NITIN SHIVAJIRAO UGALE**, under my guidance and supervision and that no part of the thesis has been submitted for any other Degree or Diploma.

The assistance and the help received during the course of this investigation have been acknowledged.

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CERTIFICATE

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Place : M.P.K.V., Rahuri
Dated : / /2014

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Associate Dean

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Place : Rahuri
Date : / / 2014 **(N.S. Ugale)**

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ABBREVIATIONS

Symbol	Reference
^0C	Degree celcious
AGR	Average growth rate
AM	*Ante Meridiem i.e.* before noon
B:C	Benefit cost ratio
CD	Critical difference
DAS	Days after sowing
dm^2	Decimetre square
dSm^{-1}	Deci Siemen per meter
EC	Electrical conductivity
et al.	*et alia* (and other co-workers)
etc.	et cetera (and other similar things)
FYM	Farmyard manure
GDD	Growing degree days
ha	Hectare
i.e.	That is
K	Potassium
Kg	Kilo gram
Kharif	June to September period
l (lit.)	Litre
Max.	Maximum
Min.	Minimum
MJ	Mega Joule
MW	Meteorological week
N	Nitrogen
NAR	Net assimilation rate
NMR	Net monetary returns
NS	Non-significant
NSP	Neem seed powder
P	Phosphorus
SE(m)$\pm$	Standard error (mean)
t	Tonnes
Temp.	Temperature
VC	Vermicompost
Viz.,	Videlict (Namely)

ABSTRACT

EFFECT OF DIFFERENT ORGANIC INPUTS WITH JEEVAMRUT ON YIELD, QUALITY AND SOIL PROPERTIES IN SOYBEAN-WHEAT CROPPING SEQUENCE

By

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A candidate for the degree of

DOCTOR OF PHYLOSOPHY
in

AGRONOMY

2014

Research Guide	**:**	Dr. A.G. Wani
Department	**:**	Agronomy

The present experiment entitled "Effect of different organic inputs with jeevamrut on yield, quality and soil properties in soybean-wheat cropping sequence" was conducted at Integrated Farming Systems Research Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahemadnagar (MS) in Survey No. 132 during 2010-11 and 2011-12.

The experiment was laid out in Randomized Block Design (RBD) with 8 treatments for soybean - wheat cropping system (*viz.* T_1 : 100 % General recommended dose of fertilizer (GRDF), T_2 : 50 % recommonded dose of nitrogen (RDN) through Farmyard manure (FYM) + 50 % RDN through Vermicompost (VC), T_3 : 50 % RDN through VC + 50 % RDN through Neem seed powder (NSP), T_4 : 50 % RDN through FYM + 50 % RDN through NSP, T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times (30 and 45 DAS @ 500 L ha^{-1} $time^{-1}$), T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times (30 and 45 DAS @ 500 L ha^{-1} $time^{-1}$), T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times (30 and 45 DAS @ 500 L ha^{-1} time^{-1}), T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times (30 and 45 DAS @ 500 L ha^{-1} time^{-1}) with 3 replications. The gross plot size was 5.40 m x 3.60 m; net plot size was 4.50 m x 3.00 m for soybean and wheat in cropping system during both the years. 1.50 m distance between replications and 0.75 m distance between each experimental unit was maintained.

The results obtained during experimentation revealed that the growth attributes, yield attributes, yield, quality, gross monetary returns, net monetary returns and benefit : cost ratio in soybean and wheat were found significantly higher with the application of 100 % GRDF followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicmpost + Jeevamrut two times during both the years.

Application of 100 % GRDF followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicmpost + Jeevamrut two times during both the years reported significantly higher values for different growth functions, growing degree days at all the days of observations during both the years.

Soybean-wheat cropping system was found highly remunerative with the application of 100 % GRDF followed by 50 % RDN through farmyard manure + 50 % RDN through vermicmpost + Jeevamrut two times during both the years and registered significantly higher gross and net monetary returns during both the years and in pooled mean. Significantly higher energy output value, energy balance, energy balance per unit input and energy output per input ratio in soybean-wheat cropping system was observed with the application of 100 % GRDF followed by 50 % RDN through farmyard manure + 50 % RDN through vermicmpost + Jeevamrut two times during both the years.

Abstract contd... **N.S. Ugale**

Application of 100 % GRDF applied to soybean-wheat cropping system reported highly positive N, P and K balance during both the years. The physico-chemical and biological properties of soil were improved substantially with the application of 100% GRDF applied to soybean-wheat cropping system during both the years.

Among different cropping sequence evaluation parameters, soybean seed equivalent yield, production efficiency, systems productivity, economic efficiency, returns day^{-1} and numerically higher value for land use efficiency was observed with the application of 100 % GRDF followed by 50 % RDN through farmyard manure + 50 % RDN through vermicmpost + Jeevamrut two times during both the years.

Thus, for the higher productivity and profitability of soybean-wheat cropping sequence was obtained in application of 100 % GRDF, followed by 50 % RDN through farmyard manure + 50 % RDN through vermicmpost + Jeevamrut two times to soybean-wheat cropping system is advisible.

Page 1 to 219

CHAPTER – I

INTRODUCTION

Ever increasing polulation of India would need to produce around 300 million tones of food grains by 2025 A.D. as against the current estimated production of about 209.2 million tonnes (Anonymous, 2010). The enhanced yield in future would have to be harvested from vertical rather than horizontal expansion of net cropped area. Enhanced agricultural production is depleting the finite nutrient resource from the soil and has been shown to potentially degrade the resource base. The present nutrient consumption rate is about 20-25 million tonnes of N, P and K, however, total nutrients consumption will be estimated as 30-35 million tonnes in 2025 A.D. The gap between nutrients removed by crops and addition through fertilizers would remain at about 10 million tonnes of nutrient per annum. The fertilizer production in the country lags behind actual consumption and the import bill for augmenting the locally manufactured fertilizers is staggeringly high. The continuous use of high levels of chemical fertilizers is adversely affecting the sustainability of agricultural production and causing soil pollution.

Further, indiscriminate use of chemical fertilizers and pesticides in intensive production systems has deteriorated the soil fertility, productivity and environment quality, besides, build up of pesticide resistance in insects, toxicity of pesticides to natural predators and parasites affected the natural balance. The growing concern over the environmental problems and increased awareness regarding use of organic crop production has made to search for alternative to intensive chemical based crop production system. Longterm commitments by brands and retailers to use organically grown crops are driving the development of a new global market.

Organic crop production is expected to expand in response to increased demand for organic food. Organic crop production system can bring back the cultivation on sustainable basis without affecting environment. Organic crop production system involves integrated nutrient management practices through organics like, organic manures, oilcakes, green manures, liquid manures, bio-fertilizers etc. and integrated and biological plant protection viz., agronomic practices, crop rotation, bio-pesticides etc., apart from encouraging natural parasites, predators and parasitoids in the ecosystem.

Farmyard manure provides all essential plant nutrients including micronutrients and it also improves soil physical, chemical and biological environment of soil for favourable crop growth and yield. It is also known to accelerate the respiratory process that increase cell permeability and hormonal growth action or by combination of all these processes.

Beneficial effects of earthworms and their cast were known, as early as Darwin's era. But, the potential of vermicompost to supply nutrients and to support beneficial microbes is being recognized recently. Vermicompost is rich source of all nutrients besides, it is valued for humus forming microbes, nitrogen fixers and plant growth promoters (Kale *et al.*, 1994).

Neem has been held high esteem by Indian folk for its manurial, medicinal and insecticidal properties. It contains a large number of chemically diverse and structurally complex azadirachtnoids, which will serve as nutrient supply to crops, as well as repellent/antacedent to insect pests. The neem seed kernel contains 7.1 per cent nitrogen and Azadirachitin content ranged from 0.14 to 2.02 % (W/W, Kernel basis). Unlike chemical pesticides based on single active ingredient, bio-pesticides comprise of an array of chemicals act on both behavioral and physiological processes of insect and reduce the chances of pesticide resistance in insect and offer a harmonious approach to pest management.

The management of soil organic matter and the rational use of organic inputs such as animal manures, crop residues, green manures, sewage, sludge and food industry waste would be major constraint in sustainable agriculture in forthcoming decades. However, since organic manures can not meet the total nutrients need of modern agriculture, integrated use of nutrients from fertilizers and organic sources seems to be a need of the time. The basic concept underlying the integrated nutrient management system (INMS), nevertheless, is the maintenance and possible improvement of soil fertility for sustained crop productivity on long term basis and also to reduce fertilizer input cost. The inclusion of legume in the cropping sequence is one of the important components of the system.

Soybean *(Glycine max* (L.) Merrill) is an important pulse as well as oil seed crop. It is believed to be originated in China in around 2838 B.C. It belongs to family *Leguminaceae* and sub family *Papilionaceae.* Soybean was introduced in sixties as a supplementary oil seed crop to overcome the edible oil shortage in the country. It is an important pulse as well as oilseed crop, used to prepare different byproducts *viz.* soya milk, soya flakes, soybean oil, soya biscuits, soy beverages, fortified bakery products and generate rural employment for improving the economy of the farming community, hence called 'Golden bean'. It contains 38-43 per cent protein, 18-20 per cent oil, 26 per cent carbohydrates, 2 per cent phospholipids and 4 per cent minerals. It also contains 60 per cent polyunsaturated fatty acid and is a good source of vitamin A, B, C, D, E, K and rich in essential amino acids like lucein, methionine, threonine and contains that human body requires. Soybean is a legume crop having considerable potential to fix atmospheric nitrogen.

Soybean has occupied third place in the edible oil scenario of India, next to groundnut, rapeseed and mustard. In India, it has gained enormous importance particularly in view of the present production and availability of edible oil. In addition to unique place in oil seed production, it is also the best and cheapest source of high quality vegetable protein. Soybean is used in formation of low cost nutritionally balanced protein foods and drinks most essential for protein deficient countries. It is one of the most popular protein ingredients in the world in manufacturing of livestock feeds like soybean flakes, soybean pellets for feeding fish, bees, dairy cattle and poultry. Soybean oil is used in the manufacture of a vast number of items like soaps, varnishes, printing ink, fuel oil, lighting oil, candles, disinfectants, insecticides, glasses etc. Soybean is a legume crop and having considerable potential to fix atmospheric nitrogen. After harvest of soybean crop considerable amount of nitrogen fixed by this crop remains in the soil and same can be utilized for succeeding crops.

It is grown on huge areas of Madhya Pradesh, Uttar Pradesh, Rajasthan, Himachal Pradesh, Bihar, Maharashtra, Karnataka and Andhra Pradesh. In India area and production of soybean in 1970-71 was only 0.32 lakh ha and 0.14 lakh tones, respectively, which have been increased to 7.46 million ha and 8.1 million tones in 2005-06, respectively with productivity of 750 kg ha-1 (Anonymous, 2006b). Maharashtra ranks second in terms of production of soybean after Madhya Pradesh in the country. The area and production of soybean in the state of Maharashtra during 1986- 87 was 0.55 lakh ha and 0.20 lakh tones, respectively, which has been increased to 24.0 lakh ha and 26.28 lakh tone, respectively with productivity of 810 kg ha-1 in 2005-06 (Anonymous, 2006a). Although, the soybean is a new crop in the state, the area under this crop is increasing day by day, as it can profitably replace the other legumes like mungbean, black gram, pigeonpea etc. and it can also replace the *kharif* sorghum in Western Maharashtra.

Wheat *(Triticum aestivum)* is an important cereal crop grown in irrigated command areas of the state. Wheat possesses an high nutritive value in the diet of both man and livestock. As a food, it is a major ingredient in the most of breads, rolls, chapaties, crackers, biscuits, cakes etc. Wheat straw is used in manufacturing of straw boards, papers and other pulp products. In the Indian cropping system wheat ranks second next to rice in the food grain production. At present, area under wheat in India is 26.49 million ha with its production 69.40 million tones in 2005-06. In Maharashtra wheat crop occupies an area of 10.31 lakh ha with its production of 14.20 lakh tones in 2005-06. The productivity of wheat in India and Maharashtra is 2718 kg ha-1 and 1257 kg ha-1, respectively (Anonymous, 2006a). The productivity of wheat in Maharashtra is quite low than that of India. Therefore, it is very essential to increase the production and productivity of wheat in the state. The yield of wheat largely depends on cultural practices like tillage, irrigation, plant protection measures and nutritional soil status. The nutrients needed are supplied through organic manures and inorganic fertilizers. The role of FYM in enhancing efficient use of chemical fertilizers is well documented. Often one of the reasons being reported for low yield levels of wheat pointed out to be the inadequate and unbalanced fertilizer application. In agriculture, management practices are usually formulated for individual crop to increase the production potential of crop. But farmers are cultivating different crops in difference seasons based on their adaptability to a particular season, domestic needs and profitability. Therefore, production technology or management practices should be developed keeping in view all the crops grown in a year or more than one year if any sequence or rotation extended beyond one year. Such a package of management practices for all the crops leads efficient use of costly inputs, besides reduction in production cost.

The results of the research indicated that the inclusion of legume in cropping sequence helps to maintain long term soil fertility and higher level of productivity. The physicochemical and biological properties were found to be greatly influenced by inclusion of legume crops in cropping sequences. The inclusion of legume in cropping sequence is one of the important component of system for saving of fertilizers which are now a days costly inputs. The soybean-wheat cropping sequence is predominant in India. Integrated nutrient management plays vital role in improving soil fertility and yield potential of crops through optimization of benefits from all possible sources in an integrated manner *i.e.* use of organic, inorganic fertilizers and biofertilizers, such practice is not only achieved sustained production and productivity but also economical and ecofriendly. Significant contribution has been made by many research workers on integrated nutrient management in respect of soybean and wheat crop alone; however, very meagre work has been done on integrated nutrient management for soybean-wheat cropping sequence.

In view of this, to increase the production potential of soybean-wheat cropping sequence the present experiment entitled "Effect of different organic inputs with *Jeevamrut* on yield, quality and soil properties of soybean-wheat cropping sequence" was conducted during *kharif* and *rabi* season of 2010-11 and 2011-12 at Integraed Farming Systems Research Project, Mahatma Phule Krishi Vidyapeeth, Rahuri with the following objectives.

1. To find out the effect of different organic inputs on growth, yield and quality of soybean-wheat cropping sequence.
2. To study the economics of soybean-wheat cropping sequence as influenced by different organic inputs.
3. To study the nutrient uptake of soybean-wheat cropping sequence.
4. To study the residual available soil nutrients, pH, EC, organic carbon and soil properties under soybean-wheat cropping sequence.

CHAPTER – II

REVIEW OF LITERATURE

The importance of organic manures in agriculture is known since ancient times and found mentioned in ancient Hindu religious scriptures of *Rig Veda*. Organic manure is the life of soil and if neglected, the fertility of soil would not be maintained.

Several thoughts *viz.,* organic food tastes better and is of superior quality; organic food is more nutritious and safe; organic farming is ecofriendly; which improves soil fertility and chemical fertilizers deteriorates it; organic manures are considered good source of plant nutrients etc. are made on organic manures. These thoughts have been proposed by researchers, farmers and teachers in the field of agriculture. However, the research work carried out in the past relevant to the present topic under study is reviewed in this chapter under suitable heads.

2.1. Effect of different organic inputs on growth, yield and quality

2.1.1. Soybean

Nimje and Jagdish (1987) recorded the significant increase in primary branches plant^{-1}, number of root nodules and test weight, seed and stover yield of soybean due to application of FYM @ 15 t ha^{-1} over unmanured crop.

Gopal Krishna and Palaniappan (1992) conducted a field experiment and found that dry matter accumulation in soybean enhanced due to addition of FYM @ 10 to 12.5 t ha^{-1}.

Mishra *et al.* (1994) conducted field study during *kharif* season at Indore (M.P.) and reported that application of 5 t FYM ha^{-1} along with inoculation of *Rhizobium* and use of cycocel in combination to soybean recorded significantly highest value for seed yield (22.86 q ha^{-1}) as compared with control yield (19.80 q ha^{-1}).

Verma *et al.* (1994) conducted a field trial on biofertilizers at Gujarat Agricultural University, Junagadh (Gujarat) and observed that the soybean seed treated with *Rhizobium* culture obtained significantly taller plant with more nodules, pods per plant, seed per pod and seed weight than untreated seeds. Similarly, the *Rhizobium* inoculation increased seed and straw yield than without seed treatment.

A field experiment was conducted at Nagpur on calcareous soil indicated that incorporation of vermicompost produced higher grain yield of soybean as compared to application of 15 t FYM ha^{-1} and control (Anonymous, 1995).

Jain *et al.* (1995) observed that protein and oil content in soybean increased significantly with the application of FYM and sugar pressmud levels over control. FYM 5 t ha^{-1} and sugar pressmud 5 t ha^{-1} combination proved to be the best for increasing the oil content.

Singh *et al.* (1995) worked at ICAR Research Farm, Tadong (Sikkim) and revealed that application of FYM @ 15 t ha^{-1} + full dose of N, P_2O_5, K_2O obtained significantly higher seed and straw yield (15.9 and 45.9 q ha^{-1}) of soybean over the control. Rakesh Kumar and Singh (1996) worked at Birsa Agricultural University, Ranchi (Bihar) and reported that the highest number of pods per plant, pod weight per plant, hundred grain weight, weight of grains per plant and grain yield of soybean were recorded with application of 100 per cent NPK + 15 t ha^{-1} FYM followed by that 100 per cent NPK + lime during *kharif* season.

Bisht and Chandel (1996) conducted a field trial at College of Agriculture, Pantanagar (Uttar Pradesh) and reported that soybean seed of *Cv.* PK-327 was inoculated with *Bradyrhizobium Japonicum* (Control) and applicationof 20 kg N +80 kg P_2O_5 + 40 kg K_2O + 5 kg Zn and 10 t FYM ha^{-1} alone or in combination and revealed that the highest seed yield was recorded with application of 20 kg N + 80 kg P_2O_5 + 40 kg K_2O + 5 kg Zn ha^{-1}.

Honale (1996) conducted a field experiment on clayey soils of Akola and noticed that application of 10 t FYM ha^{-1} resulted in improved plant height and enhanced primary branches in soybean and reported significantly higher oil and protein content in soybean.

Prabhakaran and Ravi (1996) reported that organic amendments increased the seed yield of soybean (995 kg ha^{-1}) as compared to control (835 kg ha^{-1}).

Sharma and Mishra (1997) conducted field experiment at College of Agriculture, Indore (Madhya Pradesh) and reported increase in protein content of soybean due to application of 6 t FYM + 20 kg N ha^{-1} followed by combined use of crop residues and fertilizer (10 kg N + 5 t ha^{-1} soybean crop residues).

Kundu *et al.* (1998) suggested that application of FYM upto 8 t ha^{-1} to soybean was found beneficial in respect of yield of total N_2 fixation. Application of FYM 4, 8 and 10 t ha^{-1} significantly increased seed yield of soybean by 37.2, 59.6 and 64.5 per cent, respectively as compared with no FYM.

Jagdish Prasad *et al.* (1998) conducted field experiment during *kharif* at Nagpur (Maharashtra) and observed that application of FYM @ 15 t ha^{-1} + PSB inoculation recorded higher seed yield of soybean.

Sarawgi *et al* (1998) conducted field trial at IGKW, Raipur (M.P.) and reported that the growth, nodulation, yield attributes and yield were higher with application of 60 kg N ha^{-1} applied in two splits along with 30 kg phosphorus and *rhizobium* inoculation in soybean.

Billore *et al.* (1999) conducted field experiment at National Research Centre for soybean, Indore (Madhya Pradesh) and observed that the application of FYM @ 10 t ha^{-1} alone was sufficient to compensate the requirements of different micronutrients (Zn, B and Mo) rather than individual application of micronutrients or along with FYM. The application of micronutrients with FYM obtained relatively more stable yield performance than treatment without FYM.

Sharma and Namdeo (1999) reported that FYM played indirect role in increasing the number of root nodules per plant. FYM application @ 10 t ha^{-1} produced significantly higher number of root nodules per plant in soybean as compared to control and *Rhizobium* application alone.

Mandal *et al.* (2000) reported that application of 100 per cent recommended NPK and 10 t FYM ha^{-1} was significantly superior to 100 per cent recommended dose of NPK alone or control in respect of dry matter accumulation, crop growth rate, pods per plant, seed and straw yield and agronomic efficiency of fertilizer nutrients in soybean.

Saxena *et al.* (2001) reported that plant height (61.5 cm), number of trifoliates (16.3), number of branches (8.7), plant dry matter (22.4 g) and leaf area index (4.93) at 45 DAS and dry matter at harvest (41.9 g) were significantly affected due to application of inorganic nitrogen (50 kg ha^{-1}) combined with FYM (5 t ha^{-1}) in soybean crop. Further he also reported that application of 1 t ha^{-1} neem seed cake and 5 t ha^{-1} FYM recorded 10.72 and 8.00 q ha^{-1} seed yield of soybean, respectively which was significantly higher over no manure treatment.

Pattanshetti *et al.* (2002) found that application of farmyard manure @ 7.5 t ha^{-1} to soybean was at par with poultry manure @ 2.5 t ha^{-1} and recorded significantly higher number of pods $plant^{-1}$, grain weight $plant^{-1}$, 100 seed weight, seed and haulm yield than vermicompost (2.5 t ha^{-1}) and control.

Sharma *et al.* (2002) reported that application of 10 t ha^{-1} farmyard manure to soybean significantly increased the plant height, number of nodules $plant^{-1}$, nodule weight, seed yield and dry matter accumulation $plant^{-1}$ over control.

Sharma and Vyas (2002) conducted field experiment at Avikanagar (Rajasthan) and reported that incorporation of FYM @ 10 t ha^{-1} considerably increased oil and protein content in soybean.

Thanunathan *et al.* (2002) reported that application of vermicompost @ 12.5 t ha^{-1} significantly increased the growth attributes as plant height, number of functional leaves, leaf area index and 100 seed weight as compared with rest of the manurial treatments and control.

Tumbare (2002) conducted a field experiment at MPKV, Rahuri (Maharashtra)indicated that maximum protein and oil content in soybean was recorded due to application of recommended dose where 25 per cent N was substituted through FYM+*Rhizobium*+PSB as compared to recommended dose through inorganic fertilizer alone.

Tiwari *et al.* (2002) conducted 28 years continuous experiment at JNKW, Jabalpur (Madhya Pradesh) and revealed that the application of recommended dose of fertilizer of N, P_2O_5 and K_2O with FYM @ 15 t ha^{-1} helped in sustaining the yield of soybean over the years.

A long term experiment conducted by Vyas *et al.* (2003) on clay loam soil to study the effect of micronutrients and FYM on yield and nutrient uptake by soybean and found the highest seed yield of soybean (1790 kg ha^{-1}) in Zn + FYM treatment.

Siag and Yadav (2004) conducted field study at ARS, Shriganganagar (Rajasthan) during 1999-2001 and observed significant increase in seed yield of frenchbean by the application of vermicompost upto 2 t ha^{-1} owing to increased branches $plant^{-1}$, nodules $plant^{-1}$ over the control.

Singh and Rai (2004) observed that application of recommended level of N:P:K (32:34.4: 33.6 kg ha^{-1}) with FYM (5 t ha^{-1}) and biofertilizers showed superiority for pod weight per plant (25.27 g), pods per plant (38.45), seeds per pod (2.90), 100 seed weight and seed yield, over the sole application of RDF level in soybean.

Billore and Joshi (2005) observed the highest seed yield of soybean with the application of farmyard manure @ 10 t ha^{-1} alone as compared with other treatments and control.

Sabale (2005) revealed that among the organic inputs used for soybean, application of nitrogen through farmyard manure recorded significantly higher values for number of pods $plant^{-1}$, weight of pods $plant^{-1}$, number of seeds pod^{-1}, weight of seeds $plant^{-1}$, 1000 seed weight and seed yield than control and application of nitrogen through compost and vermicompost.

More *et al.* (2008) reported that application of 5 t ha^{-1} FYM + amrutpani + PSB + *Rhizobium* treatment recorded significantly higher values for growth attributes, yield attributes and yield of soybean compared to application of 5 t ha^{-1} FYM, 5 t ha^{-1} FYM + amrutpani, amrutpani and 5 t ha^{-1} FYM + PSB.

Lambade (2013) reported that application of 5 t ha^{-1} FYM + 1.25 t ha^{-1} vermicompost to soybean + pigeonpea intercropping system registered significantly higher value for the different growth, yield attributes and yield of soybean during both the years of experimentation.

2.1.2. Wheat

Patel and Upadhay (1993) conducted a field trial at Anand (Gujarat) and reported that application of N (150 kg ha^{-1}) and P 75 kg ha^{-1}) increased protein percentage by 13.57 per cent and 12.95 per cent, respectively in wheat grains.

Singh and Singh (1994) conducted a field experiment at IARI, New Delhi and observed that the protein and gluten percentage in wheat grains increased significantly with increased P application.

Kumar *et al.* (1994) conducted a field trial at Chaudhary Charan Singh Haryana Agricultural University, Hissar (Haryana) and reported that application of 150 kg N + 33 kg P ha^{-1} to wheat crop recorded significantly higher grain and straw yield and significant increase in the value of most yield contributing characters (spikes per meter, grains per spike, grain weight per spike and 1000 grain weight) and final grain yield of Marconi wheat.

Singh *et al.* (1996) conducted a field trial at College of Agriculture, Pantanagar (Uttar Pradesh) during the winter season on clay loam soil and reported that increase in dry matter production of wheat at 100 % fertility level (120 kg N + 60 kg P ha^{-1}).

Ghosh *et al.* (1997) conducted a field experiment at Institute of Agriculture, Visva-Bharati, Sriniketan (West Bengal) and reported that application of 80:18:34 kg NPK ha^{-1} to wheat significantly increased plant height, tillers per meter length, leaf area index, grains per ear, number of panicles, number of grains 14 per panicle, weight of grains per panicle and grain yield as compared to 40:9:17 kg NPK ha^{-1}.

Kumar and Kumar (1997) conducted a field trial at Chaudhary Charan Singh Haryana Agricultural University, Hissar (Haryana) and found that there was significant improvement in grain and straw yield during both the years with every additional dose upto 120 kg N + 13.2 kg P ha^{-1}. The increase in N dose from the control to 120 kg and P upto 13.2 kg ha^{-1} increased grain yield by 141.8 and 197.3 per cent during 1994-95 and 1995-96, respectively.

Auti *et al.* (1999) conducted field experiment at M.P.K.V., Rahuri (Maharashtra) during winter season on clay soil and reported that with increase in fertilizer level up to 120:60:60 kg NPK ha^{-1} significantly increased plant height, number of tillers per plant, number of grains per panicle, grain weight per panicle, 1000 grain weight, grain yield, straw yield and protein content in wheat over other treatments.

Kumar *et al.* (2001) conducted a field experiment at Bawal (Haryana) and observed that application of 120:60 kg NP ha^{-1} significantly increased protein content of wheat grain by 13.74 per cent than other treatments.

Gwal *et al.* (1999) conducted a field trial at JNKW, Sehore (Madhya Pradesh) on late sown wheat HD-2236 and reported that increase in fertilizer level 180:90:90 kg NPK ha^{-1} increased plant height and number of tillers per plant significantly.

Jain and Dahama (2006) conducted a field experiment at Bikaner (Rajasthan) and reported that the application of 60 kg P_2O_5 ha^{-1} significantly improved the growth and yield attributes as well as grain (43.95 q ha^{-1}) and straw yield (68.61 q ha^{-1}) of wheat crop and also significantly improved protein content (10.72 per cent) of wheat grains over control.

Tulasa and Mir (2006) conducted a field experiment at Kargil (Jammu and Kashmir) and reported that application of 10 t FYM + 120 kg N ha^{-1} significantly increased plant height, effective tillers per meter length, grains per spike, grain and straw yield over the control.

2.1.3. Cropping sequence

Sharma *et al.* (1990) conducted a field experiment on soybean-wheat cropping sequence and reported that application of half dose of nutrients through chemical fertilizers and 8 t FYM ha^{-1} to soybean crop gave significantly higher yield of both the crops as compared to full dose of nutrient through chemical fertilizer, FYM alone and control.

Khare *et al.* (1998) conducted a field experiment at JNKW, Jabalpur (Madhya Pradesh) and revealed that wheat yield was higher after soybean with biofertilizers than fallow.

Ravankar *et al.* (1998) conducted a field experiment at PDKV, Akola (Maharashtra) and reported that soybean yield was higher at 45 kg N ha^{-1} and wheat grain yield was higher after groundnut and soybean crops.

Singh *et al.* (1999) revealed that application of fertilizer 50 kg N with 8 t FYM ha^{-1} gave significantly higher yield of soybean and it was higher by 35.7 per cent over the control. Wheat yield after soybean increased by 63.4 per cent over control due to application of fertilizer N 180 kg with 16 t FYM ha^{-1}.

Sharma and Vyas (2002) conducted experiment at CSWRI, Akivanagar (Rajasthan) and revealed that application of FYM @ 10 t ha^{-1} with 60 kg P_2O_5 ha^{-1} considerably increased seed yield of soybean while with 90 kg P_2O_5 ha^{-1} increased seed yield of succeeding wheat.

Tiwari *et al.* (2002) conducted field experiment at JNKW, Jabalpur (Madhya Pradesh) and found that the application of recommended dose of NPK with FYM @ 15 t ha^{-1} helped in sustaining the yield of soybean and wheat over the control.

Ravankar *et al.* (2003) conducted field study at PDKV, Akola (Maharashtra) to evaluate the influence of different fertility management practices involving organic and inorganic fertilizers on trends in productivity and fertility status under soybean wheat cropping sequence and revealed that application of fertilizer in combination with organic manures gave significantly higher yield.

Ghosh *et al.* (2004) conducted field experiment at Indian Institute of Soil Science, Bhopal (Madhya Pradesh) to compare the comparative effectiveness of cattle manure, poultry manure, phosphocompost and fertilizer NPK on three cropping systems and revealed that soybean as preceding crop recorded significantly the highest plant height, number of tillers, dry matter and nitrate reductase activity in wheat as compared to other systems.

Joshi and Billore (2004) conducted field experiment at JNKW, Indore (Madhya Pradesh) and reported that the integration of 100 per cent NPK with 10 t ha^{-1} FYM resulted better yield levels by 26 per cent and 90.6 per cent for soybean and wheat respectively, over the control.

Tanwar and Shaktawat (2004) conducted field experiment on integrated phosphorus management in soybean wheat cropping system at Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan) and revealed that incorporation of FYM with and without PSB significantly improved the yield attributes, yield of both the crops of the system over PSB inoculation alone.

Shikha-Jain *et al.* (2004) conducted field experiment on effect of organics and chemical fertilizers on the growth, yield attributes and yield of soybean-wheat cropping sequence at JNKW, Indore (Madhya Pradesh) and revealed that application of 125 per cent RDF through 10 t FYM ha^{-1} to soybean recorded maximum plant height, number of branches, number of compound leaves, yield contributing characters and soybean equivalent yield. While application of 125 per cent RDF recorded maximum growth and yield attributing characters and yield of wheat crop.

Singh and Singh (2005) conducted experiment at IARI, New Delhi and found that application of 60 kg N + 10 t FYM ha^{-1} to soybean crop recorded maximum number of plants per meter length, plant height, ear length, number of spiklets per meter length, number of grains per earhead and 1000 grain weight of succeeding wheat crop with highest soybean equivalent yield than 30 kg and 90 kg N ha^{-1}.

Dadhich and Somani (2007) conducted field experiment at Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan) and revealed that grain yield of soybean and wheat significantly increased with application of increasing levels of phosphorus, FYM and biofertilizers.

Kundu *et al.* (2007) conducted long term soybean-wheat experiment at Hawalbagh, Almora (Uttaranchal) to study the effects of organic and inorganic sources of nutrients on yield and revealed that maximum yields of soybean and residual wheat were obtained in the plots under NPK + FYM treatment than other treatments.

Trakroo and Singh (2007) conducted field experiment at Punjab Agricultural University, Ludhiana (Punjab) and revealed that dry matter accumulation by wheat varied from 135.2 and 133.3 q ha^{-1} preceded by soybean during 2003-04 and 2004-05.

Ved *et al.* (2007) conducted field experiment at Vivekananda Parvatiya Krishi Anusandhan Shala, Almora, (Uttaranchal) and revealed that annual application of RDF with 10 t FYM ha^{-1} on fresh weight basis (NPK + FYM) to soybean sustained yield of soybean-wheat cropping sequence.

Badiyala and Verma (1991) carried out field investigation at Palampur (Himachal Pradesh) to study the effect of FYM and biofertilizers in maize + soybean–wheat cropping sequence and concluded that wheat equivalent yield was increased with increased N rate upto 80 kg ha^{-1} and was the highest with FYM + *Azotobactor chrococcum.*

Kurlekar *et al.* (1994) observed that the highest per annum gross as well as net monetary returns were obtained from sorghum-sunflower-groundnut sequence closely followed by sunflower-chickpea-groundnut and cotton-groundnut sequences.

Newaj and Yadav (1994) conducted a field experiment at Faizabad (Uttar Pradesh) on different cropping sequences *viz.*, rice-wheat-greengram, maize-pigeonpea-commonmillet,pigeonpea-wheat-greengram and maize-potato-Indian mustard-blackgram. They reported that the maize-potato+ Indian mustard -black gram as the most productive system.

Tomar *et al.* (1996) conducted field trial at Tikamgarh (Madhya Pradesh) to evaluate most productive and economic double cropping with pulses and oilseeds against wheat. The production potential in terms of wheat-grain equivalent was higher in legume based cropping system *viz.*, soybean-chickpea and blackgram-chickpea double cropping systems. Growing of chickpea in winter after soybean and blackgram was highly profitable compared with that of wheat.

Reddy and Reddy (1998) conducted an experiment at Rajendranagar (Andhra Pradesh) and reported that use of organic manures would not only improved soil health but also helped to sustain crop productivity of soybean-sorghum cropping sequence.

Binod Kumar and Roysharma (2000) conducted a field investigation to study the effect of preceding crops and nitrogen rates on growth and yield attributes on wheat. The results revealed that growing of Dhaincha (GM) and black gram as preceding crop exerted significant positive effects on growth and yield attributes of succeeding wheat which ultimately resulted in significantly higher grain yield of wheat than fallow–wheat sequence. However, rice, maize, sorghum (fodder), sesamum and even groundnut as a preceding crop was found to decrease the wheat yield to a considerable extent.

Raskar *et al.* (2000) conducted a field experiment at MPKV, Rahuri (Maharashtra) to study the productivity and economics of soybean based cropping sequence under irrigated condition. The results revealed that the total seed equivalent of soybean - chickpea (65.92 q ha^{-1}) was significantly higher than rest of sequences, Next in order was soybean-wheat (50.60 q ha^{-1}) and lowest was in groundnut-wheat (41.61 q ha^{-1}).

Singh (2000) recorded that release of earthworms as vermiculture 60,000 ha^{-1} (6 m^{-2}) in groundnut was found significantly better, giving higher pod yield than all other ingradient combinations except farmyard manure 100 q ha^{-1} + vermiculture 60,000 ha^{-1}. The use of FYM 100 q ha^{-1} + release of earthworm in groundnut significantly increased the yield of succeeding crop vegetable pea over all the treatments except use of FYM 100 qha^{-1} in combination with vermiculture 60,000 ha^{-1}.

Jat and Ahlawat (2004) conducted an experiment during winter and summer seasons of 1999-2000 and 2000-01 at IARI, New Delhi and reported that application of vermicompost @ 3 t ha^{-1} significantly increased the growth (dry matter accumulation $plant^{-1}$ and leaf-area index), yield attributes (pods $plant^{-1}$) and seed yield, straw yield of chick pea over no vermicompost. Dry fodder yield of maize increased significantly by the application of vermicompost to preceding chickpea over no vermicompost application in chickpea-maize cropping sequence.

Khang (2008) reported the production potential of soybean-onion cropping sequence was highest in organic treatment with application of 100 per cent N through FYM, vermicompost, neem seed cake and *Rhizobium*.

2.2. Effect of different organic inputs on fertility status of soil

2.2.1. Soybean

2.2.1.1. Physico-chemical properties of soil

Singh and Sandhu (1980) reported that the different crop rotations could not bring any appreciable change in bulk density, however, only the inclusion of legume crops in rotation had favourable effects on bulk density by creating porous condition in soils.

Bhatia and Shukla (1982) reported that continuous application of FYM for five years improved the physical condition of eroded alluvial soil resulting in the higher crop yield.

Burl Meck *et al.* (1982) studied long term effect of manure application and reported that continuous manure application increased water infiltration rates in silty clay soils.

Magar *et al.* (1983) reported improvement in infiltration by about four folds and two folds due to incorporation of FYM and wheat straw in black soil.

A field experiment was conducted to study the effect of vermicompost on soil properties and showed that the pH of the soil in combination with lime and worms remained near neutral because of earthworm activities (Springett, 1983).

George and Prasad (1989) compared the cereal-cereal and cereal-legume cropping system and reported that inclusion of legume in system tended to improve organic carbon and available N and lessened the depletion of soil P and K.

Mahajan *et al.* (1989) noted that application of farmyard manure reduced electrical conductivity of soil from 9.2 to 1.93 per cent, exchangeable sodium from 23.4 to 4.8 per cent.

Bhawalkar (1991) observed that the use of vermicompost reduced irrigation requirement because of increased water holding capacity, infiltration rate up to 130 mm hr^{-1} by use of vermicompost against the normal value of 10 mm hr^{-1} on conventional farm. He also reported that vermicompost maintained pH near neutral than surrounding soil because of enzymatic activity.

Gaur (1992) noticed from several studies on the impact of organic manures on soil structure and showed improvement in water holding capacity and infiltration rate by promoting greater water retention.

Shinde (1992) reported that organic manures had shown direct, residual and cumulative beneficial effects on soil conditions by improving physico-chemical properties of soil. Application of farmyard manure 15 t ha^{-1} recorded higher values of structural index (32.4), organic carbon content (0.58 per cent), total N (0.056 per cent), available P (18 kg ha^{-1}), available K (258 kg ha^{-1}) and maximum water holding capacity (40.6 per cent) under medium black soils of Pune.

Shinde and Gawade (1992) conducted an incubation laboratory experiment for a period of 60 days to study the effect of FYM application (20 t ha^{-1}) on chemical properties of soil and reported increase in pH, EC, available nitrogen and exchangeable potassium.

The field application of vermicompost significantly increased the hydraulic conductivity of soil due to increased macropores (Urbanek and Dolezal, 1992).

Hapse (1993) noticed that the organic carbon content of the soil increased by 0.27 per cent due to application of vermicompost as compared to application of chemical fertilizers alone.

Lomte *et al.* (1993) observed improvement in bulk density, water stable aggregates, infiltration rate, hydraulic conductivity, pH, EC and organic carbon due to intercropping of pigeonpea or cowpea with sorghum and further reported that application of FYM @ 1000 kg ha^{-1} was better over sole sorghum with only RDF application.

Patil (1993) conducted an incubation study and reported that the application of FYM resulted into significant increase in EC, organic carbon and it was found to be most effective in building up the soil organic matter.

Gaikwad *et al.* (1994) conducted a field experiment on rotational system of *rabi* crops on medium black soil at Solapur (Maharashtra) and indicated that crop rotation increased organic carbon content where as soil pH and EC remained more or less same. Available P and K showed depletion due to cropping when compared to initial status.

Newaj and Yadav (1994) conducted a field experiment at Faizabad (Uttar Pradesh) and reported that bulk density of soil was reduced and the infiltration rate, organic carbon, available nitrogen, phosphorus and potassium content of soil increased from their initial values due to inclusion of legumes in the cropping system.

Patil *et al.* (1995) studied the comparative performance of legume-cereal (groundnut-wheat), cereal-legume (pearlmillet-chickpea) and cereal-cereal (pearlmillet-wheat) crop sequences under different fertility levels and reported significant increase in available soil N, P and K due to cereal-legume or legume-cereal sequence.

Shinde (1997) carried out an experiment at MPKV, Rahuri (Maharashtra) to study the effect of FYM, city compost and vermicompost on soil properties and reported that application of 100 per cent recommended dose through FYM and vermicompost decreased the bulk density and increased the pore space and volume of soil over control.

Malewar *et al.* (1999) worked on oilseed based cropping sequences *viz.,* groundnut-sunflower-sesamum, sesamum-sunflower-groundnut, soybean-sesamum-sesamum, cotton- groundnut and cotton - sunflower at MKV, Parbhani (Maharashtra) and reported that inclusion of legumes in the systems was beneficial for maintenance of soil fertility and productivity and indicated that cotton - groundnut sequence improved porosity, water stable aggregates and organic carbon buildup over other sequences.

Singh *et al.* (2000) reported that application of farmyard manure significantly brought down the bulk density of both surface and sub surface soil in comparison with the control.

A field experiment at Gandhi Krishi Vigyan Kendra, Bangalore was carried out by Srikant *et al.* (2000) to study the direct and residual effects of enriched composts in comparison with FYM, vermicompost and inorganic fertilizers on finger millet and cowpea in alfisol. They reported that incorporation of FYM and vermicompost increased the soil pH. However, the highest pH was recorded in FYM (6.90 and 7.08) followed by vermicompost (6.88 and 7.04) after the harvest of finger millet and cowpea over the initial soil pH (6.20).

Ghosh *et al.* (2001) recorded maximum total water content when groundnut crop was applied with phosphocompost over control.

Awasarmol (2002) indicated that application of FYM @ 5 t ha^{-1}, glyricidia @ 20 t ha^{-1}, wheat straw @ 5 t ha^{-1} proved better moisture conservation, infiltration rate, reduced bulk density over RDF treatments in soybean-sorghum cropping system in vertisol.

Maruthi *et al.* (2002) conducted experiment at Hyderabad and reported that continuous application of FYM for consecutive seven years to rainfed crops like sorghum, soybean increased the organic carbon and N content.

Tiwari *et al.* (2002) observed that the inclusion of FYM in the treatment schedule for soybean-wheat cropping sequence improved the organic carbon status in soil by sustaining the soil health.

Tumbare (2002) conducted an experiment on integrated nutrient management in soybean-onion cropping sequence at MPKV, Rahuri, Maharashtra and indicated that introduction of legumes in crop sequence and substitution of N through FYM and addition of bio-fertilizers improved the soil physical properties such as decrease in bulk density and increase in porosity and water holding capacity of soil.

A long term field experiment conducted at MPKV, Rahuri (Maharashtra) to the study the effect of integrated nutrient management on soybean-onion cropping sequence based on target yield for soil sustainability. The results revealed that, application of FYM @ 5 t ha^{-1} to preceding crop soybean improved the soil physical properties like pore spaces, water holding capacity and volume of expansion (Anonymous, 2003).

Deria *et al.* (2003) reported no significant difference between the soil chemical properties due to application of pure organic and conventionally managed field during two years study in a Mediterranean climate zone.

Tolanur and Badanur (2003) observed that organic carbon of surface soil increased significantly with incorporation of FYM or subabul. Organic carbon content of soil was higher after pigeonpea crop rotation than after pearl millet crop. This may be attributed to lot of litter fall and other organic matters contributed by pigeonpea.

Bonde *et al.* (2004) conducted cotton + soybean intercropping system trial at MKV, Parbhani (Maharashtra) and reported that application of FYM @ 5 t ha^{-1} recorded higher values for nitrogen, phosphorus and potassium availability in soil as compared to control.

The initial pH of 6.6 was increased significantly to 7.6 in the soil which received farmyard manure @ 4 t ha^{-1} (Balaguruvaidh *et al.*, 2005).

Marinari *et al.* (2007) in one of his study reported that soil organic matter was found to be higher in organically managed soil than in conventional soil despite relatively similar totals of organic carbon.

Paslawar *et al.* (2007) conducted an experiment on vertisol of Regional Research Centre, Amravati (Maharashtra) on INM treatments under NATP, RPPS-6 project and reported that physico-chemical properties of soil were improved by different combination of organic, inorganic, biofertilizers and alone organic source used under soybean + pigeonpea intercropping system.

2.2.1.2. Biological properties of soil

Sharma *et al.* (1983) studied effect of continuous application of fertilizer, FYM and lime on microbial population of soil and reported that bacteria, *actinomycetes*, *azotobacter*, cellulose decomposers increased in soil treated with FYM application alone or in combination with fertilizers and lime.

Application of organic amendments has been reported to stimulate the growth of indigenous *Rhizobium leguminosarum* and *R. meliothi* in soil (Germida, 1988).

Suistova and Diuvelikawkh (1992) demonstrated that the application of farmyard manure @ 5.0 t ha^{-1} promoted two fold increase in bacteria, *actinomycetes* and fungi in the soil.

Kale *et al.* (1994) observed that the vermicompost on chemical degradation by the enzymes activity in the gut of earthworms and the enzymes of the associated microbial population has long range influence on soil in improving biological properties of the soil.

Manna *et al.* (1996) reported that application of FYM @ 4 t ha^{-1} significantly increased the microbial biomass in soybean-wheat cropping system.

Among the organic sources, performance of FYM in stimulation of fungal growth was of higher order which was mainly attributed to dead food material available from FYM. Addition of organic matter significantly improved the *Azotobacter*, *Actinomycete*, population in soil (Tompe and More, 1996).

Badole (2000) reported that application of FYM recorded higher fungal population as compared to other organic sources in cotton-groundnut cropping system.

Badole and More (2001) conducted a field trial at MAU, Parbhani (Maharashtra) to study the changes in soil microbial population under cotton-groundnut cropping system during 1997-99 in calcareous clay soil and concluded that the population of *Azotobacter*, fungi, *actinomycetes* and bacteria were maximum with different combinations of organic sources *i.e.* neem seed cake 2 t ha^{-1}, vermicompost 5 t ha^{-1}, pressmud cake 25 t ha^{-1} and glyricidia 10 t ha^{-1} etc in cotton and groundnut. Also in *kharif* cotton microbial population was increased. It was further observed that there was sharp decline in microbial population with *rabi* groundnut crop as compared to cotton during both the years.

Ghosh *et al.* (2001) recorded maximum soil microbial bio mass in groundnut with the application of phospho compost over control.

Manna and Ganguly (2001) reported that application of FYM @ 8 t ha^{-1} to soybean-wheat-fallow cropping system recorded significantly higher soil microbial count than the application of 100 per cent RDF and control.

Jain *et al.* (2003) reported after 25 years of long term experiment that the FYM application was much superior in maintaining the soil biological health over chemical fertilizer.

Parham *et al.* (2003) conducted long term experiment over 10 years and reported that cattle manure application promoted the growth of bacteria but not fungi when compared with the fungi control soils.

A field experiment was conducted by Deshpande and Murumkar (2007) during winter 2005-06 at Zonal Agricultural Research Station, Solapur (Maharashtra) to assess the effect of organics and tillage on microbial population. The results indicated that, at flowering stage mean population of total bacteria, total fungi, beneficial fungi, *azotobacter* and *actinomycetes* was highest in the treatment of conventional tillage with 100 per cent N through organics.

Kadlag *et al.* (2007) reported that, the increased urease activity in soil might be due to vermicompost application which resulted in enhanced microbial activity and biomass.

Manna *et al.* (2007) conducted an experiment to examine the influence of FYM and fertilizer application on microbial activity and the results showed higher microbial activity at peak vegetative crop growth with application of manure.

2.2.1.3. Nutrient uptake and nutrient balance studies

Patel and Chandravanshi (1996) conducted field trial at IGKW, Raipur (M.P.) and revealed that application of 45 kg N, 90 kg P_2O_5 and 6 t FYM ha^{-1} increased the seed and straw yield and concentration of nitrogen, phosphorus and potassium in soybean.

Sarkar and Tripathi (1996) worked at IGKW, Raipur (Madhya Pradesh) and observed that *Rhizobium* inoculation along with 30 kg N + 60 kg P_2O_5 + 5 t FYM ha^{-1} showed significantly higher N, P and K concentration in different plant parts in soybean.

Bisht and Chandel (1996) worked at College of Agriculture, Pantnagar (Uttar Pradesh) and reported that integrated application of 20 kg N + 80 kg P_2O_5 + 40 kg K_2O + 5 kg Zn ha^{-1} recorded higher uptake of nitrogen and potassium by soybean whereas highest uptake of phosphorus was recorded with the application of 80 kg P_2O_5 + 40 kg K_20 + 10 t FYM ha^{-1}.

Rakesh Kumar and Singh (1996) worked at Birsa Agricultural University, Ranchi (Bihar) and observed that combined use of FYM with recommended NPK fertilizer resulted in higher uptake of NPK by soybean.

Sharma and Mishra (1997) worked at College of Agriculture, Indore (M.P.) and observed that tremendous enhancement in yield and uptake of NPK in combined use of FYM and reduced level of fertilizer N (20 kg N + 6 t FYM ha^{-1}) followed by combined use of crop residues and fertilizers (10 kg N + 5 t FYM ha^{-1}).

Solankey *et al* (1998) observed that the application of half of the recommended dose of NPK to soybean crop along with phosphate solubalizing micro-organism as a top dressing and *Rhizobium* significantly increased the uptake of NPK over control.

Aruna and Reddy (1999) worked at Agriculture College, Bapatla (Andhra Pradesh) and revealed that the higher rate of manure application (BGS @ 15 t + 50 kg N ha^{-1}) to soybean crop significantly enhanced the NPK uptake by seed and haulm and seed yield over its lower rate.

Ravankar *et al* (1999) worked at PDKV, Akola (Maharashtra) and observed that application of recommended dose of NP + S + Zn to soybean crop significantly increased the uptake of NPK over control.

Paneerselvam *et al.* (2000) conducted field experiment at Coimabatore (Tamil Nadu) and found that application of bio-digested slurry @ 5 t ha^{-1} + 30:120:40 kg NPK ha^{-1} recorded highest P uptake by soybean.

Bacchav (1994) observed that application of 5 t ha^{-1} of vermicompost to soybean increased the uptake of nitrogen ha^{-1} over control.

Singh *et al.* (1995) from their experiment on *kharif* soybean at Gangtok, Sikkim observed maximum uptake of nutrients with the use of organic manures and concluded that these might be responsible for higher values of growth characters and yield attributes of soybean.

Prabhakaran and Ravi (1996) worked at TNAU, Vamban (Tamil Nadu) and revealed that nodulation was highest in inoculation with *Bradyrhizobium japonicum* strain 67-A76 and was also increased by organic amendments (FYM or sheep manure @ 5 t ha^{-1}) compared to untreated control in soybean.

Sharma and Namdeo (1999) studied the response of soybean to FYM, biofertilizers and fertilizers and observed that FYM @ 10 t ha^{-1} alone significantly increased the N, P and K content of seed and straw over control and PSB application alone.

Rani and Sanoria (2000) conducted field trial at Varanasi (Uttar Pradesh) and reported that inoculation caused highly significant increase in number of nodules on main as well as branched roots over control both at 50 and 72 DAS during both the years. Each of the *Bradyrhizobium* strains+cattle dung manure significantly increased number of nodules and enhanced the NPK and Fe uptake in soybean.

2.2.2. Wheat

2.2.2.1. Physico-chemical properties of soil

Sharma and Vyas (2002) conducted field experiment at Avikanagar (Rajasthan) and reported that incorporation of FYM @ 10 t ha^{-1} to wheat substantially improved the physico-chemical properties of soil as compared with rest of the treatments.

Shikha-Jain *et al.* (2004) conducted field experiment on soybean-wheat cropping sequence at JNKW, Indore (Madhya Pradesh) and revealed that application of 125 per cent RDF through 10 t FYM ha^{-1} reduced the bulk density and improved the organic carbon content in soil.

2.2.2.2. Biological properties of soil

Sharma and Vyas (2002) conducted field experiment at Avikanagar (Rajasthan) and reported that incorporation of FYM @ 10 t ha^{-1} to wheat, considerably increased the microbial status of soil at the end of the soybean-wheat cropping sequence.

2.2.2.3. Nutrient uptake and nutrient balance studies

Jain and Jain (1993) conducted a field trial at Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan) and reported that application of N significantly increased the NPK uptake over the control by wheat crop. The increase in uptake compared with the control was 22.9, 40.1 and 58.2 per cent for N, 13.7, 34.9 and 48.8

per cent for P and 19.2, 36.1 and 52.2 per cent for K due to 40, 80 and 120 kg N ha^{-1}, respectively.

Kumar *et al.* (1995) conducted a field trial at Karnal (Haryana) and observed that application of 180 kg N ha-1 to wheat crop increased N concentration through grain (2.1 per cent) and straw (0.45 per cent) over control.

Kataria and Bassi (1997) conducted a field experiment at Himachal Pradesh Krishi Vishva Vidyalaya, Palampur (Himachal Pradesh) and reported that application of 120 kg N ha^{-1} to wheat crop significantly increased N uptake (107.25 kg N ha^{-1}) over control.

Auti *et al.* (1999) conducted a field trial at M.P.K.V., Rahuri (Maharashtra) and found that the application of 120:60:60 kg NPK ha^{-1} to wheat crop significantly increased the uptake of N (154.69 kg ha^{-1}), P (23.42 kg ha^{-1}) and K (460.21 kg ha^{-1}) and NPK concentration by wheat crop over other treatments.

Pandey *et al.* (2006) conducted a field experiment at Samastipur (Bihar) and revealed that application of 125 per cent recommended dose of fertilizer recorded significantly higher NPK concentration by the wheat crop over other treatments.

2.2.3. Effect on different organic treatments on soil

La Rue and Patterson (1981) reported that the legumes fix 45 to 217 kg N ha^{-1} in their root nodule, which is often in excess of their own growth requirements. The excess fixed N can be utilized by the subsequent crop grown on the same field.

Tondon (1983) stated that in general, the nitrogen contribution could be 10-25 kg N ha^{-1} from grain legumes and 30-40 kg N ha^{-1} from green manuring or forages, prior to irrigated rice crop.

Gakale and Clegg (1987) observed that residual fertility left by soybean was equivalent to 50-60 kg N ha^{-1} over continuous sorghum.

Badanaur *et al.* (1990) found that an application of FYM increased organic carbon, available nitrogen and phosphorus over control.

Sonar and Zende (1991) reported that cereal - cereal crop sequences decreased the N, P and K content of the soils while the sequences with legumes increased the N, P and K content of soils.

Bhawalkar (1992) reported that application of vermicompost showed marked improvement in the soil productivity within year. The vermicompost applied plot had 37 per cent more N, 65 per cent more P_2O_5, 10 per cent more K_2O, 50 per cent less EC and 46 per cent less chlorides than the chemical fertilizer applied plot.

Gunjal and Nikam (1992) reported that increase in total nitrogen in soil was found 6.5 times more in vermiculture treatment over control.

Patil (1993) conducted an incubation study and reported that the application of FYM resulted into significant increase in available N, P and K content of all soil types. The availability of N in soil was appreciably increased by 9.98, 26.27 and 16.21 per cent over control with wheat straw, FYM and sunflower head, respectively indicating that FYM was more beneficial than crop residue in increasing available N content in soil. He reported that DTPA extractable micronutrients *viz.,* Fe, Mn, Zn and Cu content of soil significantly increased upto 30 days of incubation and further found to be decreased in all soil types.

Newaj and Yadav (1994) worked at Faizabad (Uttar Pradesh) with five cropping systems and reported maize-potato+Indian mustard-black gram removed greater amount of N, P and K (345.94, 78.43 and 387.86 kg ha^{-1} $year^{-1}$), respectively from soil compared to the other systems. The balance for N and K was negative in all the systems but higher depletion of N and K (110.94 and 267.94 kg ha^{-1} $year^{-1}$, respectively) was recorded under maize-potato+Indian mustard-black gram systems. The balance for P was positive in all the systems and higher build up of P (101.56 kg ha^{-1} $year^{-1}$) in surface layer was found under maize-potato + Indian mustard-black gram cropping systems.

Sahu (1995) observed the effect of decomposition of organic matter on the activities of micro-organisms and availability of nitrogen, phosphorus and sulphur in soil. He also observed that enhanced microbial mineralization of organic matter universally augmented available nitrogen (NH_4 and NO_3) in soil. Available phosphorus content was significantly increased by the incorporation of organic substrates in soil.

Sheeba and Chellamuthu (1999) conducted a long term experiment at TNAU, Coimbatore (Tamil Nadu) on cereal-legume-oilseed cropping sequence fertilized with organics and inorganics. The study revealed that the higher available N status was ascribed to the mineralization of N from FYM, while that of P to the influence of organic manure which could have enhanced the liable P in soil by complexing the cations like Ca, Mg and Al, responsible for the fixation of P and that of K content to the greater capacity of organic colloids to hold K ions on the exchange sites.

2.2.4. Cropping sequence

Dhama and Sinha (1985) conducted field experiment at IARI, New Delhi and reported that preceding *kharif* soybean and P applied to soybean showed appreciable residual and cumulative effect on nitrogen concentration in unfertilized wheat crop. The residual and cumulative effect of *kharif* crops did not show marked difference in P concentration of wheat.

Ramshe and Patil (1987b) conducted an experiment on importance of legumes in cropping system at Rahuri and reported that there was saving of nitrogen to wheat to the extent of 30, 23 and 6 kg ha^{-1} due to preceding crops of green gram, groundnut and cowpea for fodder, respectively, as compared to that of the preceding pearlmillet.

Jadhav and Koregave, 1988 reported higher uptake of nitrogen and phosphorus due to residual and cumulative effect of legume in the cropping sequence.

Nagre and Chandrasekhar (1988) observed in legume-cereal based cropping sequence that the N contributed to sorghum by cowpea, groundnut, black gram, green gram and soybean was equivalent to 104.0, 73.7, 81.1, 63.2 and 25.64 kg of fertilizer N ha^{-1}, respectively.

Jain and Jain (1993) reported that there was increased NPK uptake by wheat grain in soybean-wheat cropping sequence than maize-wheat and cowpea-wheat cropping sequence.

Reddy (1997) observed that the uptake of NPK under cotton+soybean and sorghum+pigeonpea cropping system was more due to application of press mud cake followed by FYM, glyricidia, wheat straw over control.

Sharma and Parmar (1997) worked at Indore (Madhya Pradesh) to evaluate the influence of biofertilizers and indigenous sources of nutrients on nutrient uptake and productivity of rainfed soybean-chickpea cropping sequence. The results revealed the effectiveness of pyrites, phosphorus solublizing bacteria and FYM in enhancing nutrient uptake with respect of N, P and K by soybean and chickpea crop.

Rao *et al.* (1998) conducted field trial on soybean wheat cropping sequence at Indian Institute of Soil Science, Bhopal (Madhya Pradesh) and reported that P uptake by soybean and wheat and available P in post harvest soil increased significantly with increasing rates of both FYM and fertilizer P. The apparent phosphorus recovery (APR) by the soybean-wheat system from fertilizer 'P' ranged from 24.9 to 25.11 per cent.

Prasad and Kumar (1999) conducted a field trial and reported that soybean-wheat cropping sequence removed maximum quantity of N (198.5 kg ha^{-1}) in soybean-wheat cropping sequence and further removed the highest quantity of P (20.40 kg ha^{-1}) than other crop sequences.

Ghosh *et al.* (2000) conducted field experiment at Vivekananda Parvatiya Krishi Anusandhan Shala, Almora (Uttaranchal) on phosphorus removal and P balance in soybean wheat cropping sequence under long term fertilizer experiment and revealed that the total P removal by grain and straw of soybean and wheat was significantly increased by different fertilizer treatments except NK treatment.

Yadav *et al.* (2000) studied that inclusion of legume in crop sequence showed slightly improvement in the nutrient status of the soil, whereas, inclusion of legume after legume sequence helped in maintaining the soil fertility.

Tiwari *et al.* (2002) observed that the inclusion of FYM in the treatment schedule for soybean-wheat cropping sequence improved the available N, P, K and S status in soil their by sustaining the soil health.

Saha (2003) conducted field experiment at Indian Institute of Soil Science, Bhopal (Madhya Pradesh) to study the effect of manures on retention of moisture by soil profile and uptake by soybean-wheat crops on applied sulphur in vertisol in central India and reported that uptake of nutrients was decreased as FYM application increased but uptake of nutrient was increased upon the application of sulphur.

Tanwar and Shaktawat (2004) conducted field experiment at Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan) and observed that highest P absorption took place by wheat grown after soybean crop, when P was applied @ 90 kg ha-1 to soybean.

Ramesh *et al.* (2006) conducted a field experiment at Bhopal (Madhya Pradesh) and indicated that soil organic carbon, available N, P, K status and biological activity of soil in terms of dehydrogenase enzyme were significantly improved in organic manure treatment compared to chemical fertilizers when studied under soybean-wheat cropping system.

Dadhich and Somani (2007) conducted field experiment at Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan) and revealed that application of increasing levels of P, FYM and biofertilizers significantly enhanced the uptake of Zn, Cu, Mn, Fe by soybean-wheat sequence.

Pillai *et al.* (2007) conducted a field experiment at Rice Research Station, Kayamkulam, Alappuzha (Kerala) to assess impact of INM on four rice based cropping systems. The results indicated that, the crop sequences rice-rice-cowpea and rice-rice-groundnut showed a positive nitrogen balance in the soil, the maximum being after rice-rice-groundnut crop sequence.

Trakoo and Singh (2007) conducted field experiment an effect of preceding *kharif* crops and nitrogen levels on dry matter accumulation and nitrogen use efficiency in wheat at Punjab Agricultural University, Ludhiana (Punjab) and reported that maximum N (146.6 kg ha-1) was removed by wheat when grown after soybean.

Choudhary *et al.* (2008) conducted a field trial at Nagpur (Maharashtra) on vertisol and observed that total uptake of N, P and K significantly influenced due to various organic treatments. FYM @ 5 t ha^{-1} + *Rhizobium* and PSB as soil application recorded highest total nitrogen and phosphorus uptake, where as highest total potassium uptake was recorded in the treatment of vermicompost @ 3 t ha^{-1} + *Rhizobium* and PSB.

2.3. Effect of different organic inputs on energy balance studies

Jadhav (1986) worked at Pune (Maharashtra) and recorded that the energy output was increased with sorghum-wheat cropping sequence than groundnut-wheat cropping. Energy balance was positive in sorghum-wheat cropping. Energy use efficiency was more with sorghum-wheat cropping. The energy balance of groundnut-wheat cropping was negative.

Singh and Pal (1989) found at New Delhi that under semi mechanized operation, summer pigeonpea-wheat cropping system spent 31 per cent more cultural energy (largely through non-renewable sources) on irrigation and threshing and produced 53 per cent and 57 per cent higher biomass and nutritional-equivalent energy, respectively. Intercropping of pigeonpea-dhaincha spent 0.76 g cal ha^{-1} energy from renewable sources and augmented the biomass energy yield by 11 per cent. Energy ratio and energy production ratio were higher when pigeonpea was sown in summer season and intercropped with dhaincha.

Jadhav (1990) worked at Pune (Maharashtra) and reported that sorghum-wheat cropping required more energy than sorghum-groundnut.

Billore *et al.* (1994) reported from Sehore (Madhya Pradesh) that legume based cropping system consumed less energy inputs than cereal based system. The soybean-chick pea sequence was found most energy efficient followed by soybean-sunflower. They stated that wheat cultivation either after soybean or sorghum showed the least energy use efficiency. They also reported the highest energy productivity in soybean-chick pea cropping system, followed by soybean-lentil. The soybean base crop sequences were less energy intensive. While concluding they stated that the legume based cropping systems were the energy efficient, than the cereal based one. The soybean-chick pea sequence was the most energy efficient productive and less energy intensive among all the sequence under study.

Bhatia (1995) reported from New Delhi that the total energy provided in term of calories from all the crop sequences were at par. Soybean-wheat-green gram gave higher energy (28.35 Kx10^6 calories ha^{-1}) followed by soybean – barley - greengram (28.66 K x 10^6 calories ha^{-1}).

An experiment was conducted to evaluate the different cropping sequences *viz.,* soybean-onion, soybean - sorghum and cotton - groundnut at MAU, Parbhani (Maharashtra). The results revealed that among different cropping sequences soybean-onion was the best in the respect of energy followed by cotton-groundnut (Anonymous, 1998).

Vyas *et al.* (1998) studied to evaluate the energy use efficiency of different cropping systems at Sehore (Madhya Pradesh) from 1990-94. It was revealed that soybean based cropping system was found the best which produced more than 40000 MJ net energy ha^{-1} than black gram based and mono cropping systems. Amongst soybean based cropping system, soybean-chickpea (46185.15 MJ ha^{-1}) was found to register highest net energy followed by soybean-saflower (444280 MJ ha^{-1}). Energy use productivity was also found to be more in soybean-chickpea (0.94) cropping system followed by soybean-lentil, soybean-safflower and soybean-linseed cropping.

Mandal *et al.* (2002) revealed that the manures and chemical fertilizers (50.87 per cent), seed bed preparation (18.30 per cent) and sowing management (17.69 per cent) consumed the bulk energy (operational and non-operational) for all crops in soybean-wheat, soybean-mustard and soybean-chick pea in Central India. The specific energy was highest in soybean (9173 MJ t^{-1} grain) followed by mustard (8912 MJ t^{-1} seed), chick pea (7190 MJ t^{-1} seed) and wheat (6646 MJ t^{-1} grain) indicating that soybean was the most energy investment intensive crop.

Pimentel and Patzek (2005) calculated that 7800000 kcal of energy was required to grow 5556 kg of soybean.

Mandal *et al.* (2005) reported that the total energy involved in soybean-wheat cropping sequence was 19817 MJ ha^{-1} which was much greater than soybean - chick pea (11239 MJ ha^{-1}), pigeonpea moncropping (2329 MJ ha^{-1}) and fallow-wheat (13716 MJ ha^{-1}).

The twelve year study by Hoeppner *et al.* (2006) on the impact of organic versus conventional management on energy use, energy output and energy use efficiency reported that energy use was 50 per cent lower with organic than with conventional management. Energy output was 30 per cent lower with organic than with conventional management and energy efficiency (output energy/input energy) was highest in the organic management.

2.4. Effect of different organic inputs on economic evaluation

2.4.1. Soybean

Mishra *et al.* (1994) conducted field study during *kharif* season at Indore (Madhya Pradesh) and reported that application of 5 t FYM ha^{-1} along with inoculation of *Rhizobium* and use of cycocel in combination to soybean recorded significantly highest value of net monetary returns and benefit : cost ratio as compared with the control.

2.4.2. Wheat

Thakur *et al.* (1999) reported that the application of 10 t ha^{-1} organic manure recorded higher value of net returns and net return per rupee invested in wheat than treatment without organic manure.

2.4.3. Cropping sequence

Bharambe *et al.* (1990) worked at Marathwada Agricultural University, Parbhani and observed that sorghum chickpea sequence gave significantly more monetary returns than soybean-wheat, rice-wheat and pigeonpea-wheat. Further, they reported that sorghum-pea system was at par with that of pigeonpea-wheat but significantly superior to soybean-wheat and rice-wheat cropping sequence.

Kurlekar *et al.* (1993) conducted experiment at Marathwada Agricultural University, Parbhani (Maharashtra) to study the comparative performance of legume-cereal and cereal legume with cereal-cereal crop sequences under different fertility levels and reported that gross monetary returns, net monetary returns of legume-cereal (soybean-wheat) sequence with 100 per cent recommended dose of fertilizer were significantly more remunerative than other sequences tried.

Sawarkar *et al.* (1995) showed that groundnut-wheat, groundnut-chickpea and soybean-wheat gave higher net returns of Rs. 14,429, Rs. 13,345 and 13,125 ha^{-1}, respectively. The best crop sequences were found groundnut-wheat, groundnutchickpea followed by soybean-wheat for economic returns.

Tomar *et al.* (1996) conducted field experiment at Zonal Agricultural Research Station, Tikamgarh (Madhya Pradesh) and reported that net returns and benefit cost ratio were higher in soybean-chickpea followed blackgram-chickpea. The increase in net returns from soybean-chickpea over black gram-wheat were Rs. 13,448 ha^{-1} and over soybean-wheat were Rs. 9082 ha^{-1}.

Jain *et al.* (2005) conducted field experiment at JNKW, Jabalpur (Madhya Pradesh) and reported that the net returns of soybean-wheat cropping sequence correspondingly increased with the increasing levels of fertilizer application as 100, 125 and 150 per cent RDF, but the trend of benefit: cost ratio was reversed under varying fertilizer doses. The benefit: cost ratio in soybean-wheat cropping sequence was the maximum (2.54) by growing both crops with 100 per cent RDF.

Ramshe (1985) found that the groundnut-wheat crop sequence gave maximum gross and net returns, but the benefit:cost ratio was maximum in the crop sequence of cowpea for fodder-wheat (Rs 1.00 rupee^{-1} invested) under Rahuri conditions. The second best sequence was groundnut-wheat with benefit:cost ratio of Rs 0.90 per rupee invested.

Ramshe and Patil (1987a) worked at MPKV, Rahuri (Maharashtra) and found that among the cropping sequences, groundnut-wheat crop sequence gave maximum gross and net profit and it was followed by cowpea for fodder-wheat crop sequence. They also found the lowest gross and net income from blackgram-wheat crop sequence. Further, they reported that additional net profit from groundnut-wheat sequence was in the order of Rs. 1924, Rs. 2470, Rs. 2008 and Rs. 1263 ha^{-1} over greengram-wheat, blackgram-wheat, pearlmillet-wheat and cowpea-wheat crop sequences respectively.

Ramshe and Patil (1987b) worked at MPKV, Rahuri, (Maharashtra) and observed maximum benefit : cost ratio in cowpea-wheat crop sequence and that was due to low cost of cultivation of preceding cowpea. They observed the second remunerative crop sequence of groundnut-wheat and lowest benefit: cost ratio from blackgram-wheat crop sequence.

Jadhav and Koregave (1988) worked at Pune (Maharashtra) and found that the pooled monetary returns and net profit were significantly higher with groundnut-wheat cropping than that of sorghum-wheat cropping system. They reported that the pooled monetary returns and net profit were also increased when wheat was preceded by groundnut.

Bharambe *et al.* (1990) worked at Parbhani (Maharashtra) and observed that sorghum - chickpea sequence gave significantly more monetary returns than soybean-wheat, rice-wheat and pigeonpea-wheat. They also reported that sorghum-pea system was at par with that of pigeonpea-wheat but significantly superior to soybean-wheat and rice-wheat cropping sequence.

Yadav and Newaj (1990) observed in their experiment carried out at Faizabad (Uttar Pradesh) that under upland condition maize-potato+mustard-blackgram system produced highest yield and proved to be more remunerative.

Badiyala and Verma (1991) carried out field investigation at Palampur (Himachal Pradesh) to study the effect of FYM and biofertilizers in maize + soybean–wheat cropping sequence and concluded that application of FYM 12 t ha^{-1} alone or in combination with biofertilizers increased the gross and net monetary returns ha^{-1} $year^{-1}$ and was more than that obtained from other supplemental sources of nutrients.

Dubey *et al.* (1991) reported that intercropping of pigeonpea with soybean and black gram was most profitable fetching 32 and 31 per cent more net returns ha^{-1}, respectively than sole pigeonpea.

Tomar *et al.* (1993) conducted a field trial at Tikamgarh (Madhya Pradesh) with different crop sequences *i.e.* blackgram-chickpea, greengram - chickpea, groundnut - chickpea, soybean - chickpea, sesamum - chickpea and reported that the net returns were highest in soybean-chickpea sequence followed by sesamum-chickpea sequence.

Umrani *et al.* (1993) conducted experiment to study the stability and economics of the multiple cropping sequences under assured water supply. Sorghum-wheat-groundnut was reported as the most stable sequence with maximum net returns of Rs. 16364 ha^{-1} (Rs. 6259 + 3616 + 6489 ha^{-1}). Sorghum-chick pea-pearl millet (fodder) was also productive and stable crop sequence with net returns of Rs. 14332 ha^{-1} (Rs. 7007 + 5123 + 2203 ha^{-1}).

Kurlekar *et al.* (1994) observed that the highest $annum^{-1}$ gross as well as net monetary returns were obtained from sorghum-sunflower-groundnut sequence closely followed by sunflower-chick pea-groundnut and cotton-groundnut sequences. The benefit cost ratio and production efficiency was also more under these sequences.

Singh and Lal (1994) conducted field trial at Pantnagar (Uttar Pradesh) reported that soybean-wheat recorded maximum seed equivalent yield followed by rice-lentil sequence. Soybean-wheat sequence proved the best sequence in terms of net returns and benefit: cost ratio.

Patil *et al.* (1995) worked at Niphad (Maharashtra) and observed that the benefit : cost ratio was also higher (1.96) with pigeonpea-wheat cropping sequence, indicating higher profitability. They stated that this might be due to higher production potential and higher prices for pigeonpea than other crops tried in sequences.

Sawarkar *et al.* (1995) showed that groundnut-wheat, groundnut-chickpea and soybean - wheat gave higher net returns of Rs.14,429, Rs.13,345 and 13,125 ha^{-1}, respectively. The best crop sequences were found groundnut - wheat, groundnut - chick pea followed by soybean - wheat for economic returns.

Dwivedi *et al.* (1998) conducted a field experiment at Rewa (Madhya Pradesh) on deep clay loam soil to evaluate the most remunerative double cropping systems under rainfed conditions. The twelve cropping sequences (wheat, chickpea, linseed each followed by blackgram, soybean, sorghum and rice) were tried and the results revealed that the among the rainy season crops, soybean equivalent yield of sorghum and blackgram was significantly higher than sorghum yield. However, among the winter crops the chickpea recorded maximum wheat equivalent yield followed by linseed. The maximum net returns (RS 20,637 ha^{-1}) were obtained with soybean-chickpea sequence followed by soybean-linseed (Rs. 17086 ha^{-1}), blackgram - chickepea (Rs. 14101 ha^{-1}) and soybean - wheat (Rs. 14018 ha^{-1}).

An experiment was conducted to evaluate the different cropping sequences *viz.,* soybean-onion, soybean-sorghum and cotton-groundnut at MKV, Parbhani (Maharashtra). The results revealed that among different cropping sequences soybean-onion was the best in the respect of economics followed by cotton-groundnut (Anonymous, 1998).

A field experiment was conducted by Raskar and Bhoi (2000) at Rahuri to study comparative productivity and economics of soybean based cropping sequences. Among the six sequences *viz.,* soybean followed by wheat, safflower, sunflower, chickpea, mustard and *kharif* groundnut-wheat, the total grain equivalent yield of soybean-chickpea (6.59 t ha^{-1}) and net returns were significantly higher than other cropping sequences.

Halvankar *et al.* (2002) conducted a field experiment at MACS Research Institute, Pune (Maharashtra) and concluded from the pooled result of soybean based cropping system that among the cropping system studied, soybean-chick pea gave the highest net monetary returns followed by soybean-wheat, soybean-mustard and soybean-safflower. They reported that after soybean, planting of chick pea with no fertilizer was more economical under rainfed condition in Western Maharashtra.

Shukla *et al.* (2002) evaluated the efficiency of legume-cereal, cereal-legume and cereal-cereal crop rotations under arid (Hissar and Sirugappa) and semi-arid (Rahuri, Unagarh, Kathalgere and Banswara) conditions in India. The result reported that, cereal-cereal sequence recorded higher net returns only under arid conditions and the legume-cereal and cereal-legume sequences under semi-arid conditions.

Chaudhari *et al.* (2006) in their four rainy seasons of experimentation, recorded that the intercropping of soybean (JS-335) + pigeonpea (BSMR-736) with 3:1 row proportion produced significantly the highest gross monetary returns, net monetary returns and benefit : cost ratio than their sole cropping.

9.5. Growing Degree Days

Ketring and Wheless (1989) observed that the beginning of the groundnut flowering period required 313 and 360 GDD.

Prasad *et al.* (2000) found that the flowering period for groundnut was affected negatively by high temperatures.

Craufurd *et al.* (2002) reported that groundnut grown in the southern Aegean region require 1450 and 1550 GDD above 10 and 13.5°C, respectively.

CHAPTER – III

MATERIAL AND METHODS

The details of various materials used and experimental methods adopted for conducting the present investigation are described in this chapter under suitable heads and subheads.

3.1. Details of the experimental material

3.1.1. Experimental site

The present experiment entitled "Effect of different organic inputs with jeevamrut on yield, quality and soil properties in soybean-wheat cropping sequence" was conducted at Integrated Farming Systems Research Project Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahemadnagar (MS) in Survey No. 132 during 2010-11 and 2011-12.

3.1.2. Soils

The soils in the experimental plot was medium deep black and well drained. The topography of the land was fairly levelled. In order to understand the initial physical nature and fertility status of the soil, a representative composite soil samples from 0-20 cm soil layer were taken from ten randomly selected spots before conduct of the experiment. These soil samples were analysed for physical, chemical and biological properties and presented in Table 1 along with the different analytical methods used.

The data presented in Table 1, indicated that the soils of the experimental plot was clayey in texture. The chemical composition according to criteria laid by Muhr *et al.* (1965) indicated that the soil was low in available nitrogen (181.32 kg ha^{-1}), medium in available phosphorus (15.17 kg ha^{-1}) and high in potassium content (288.85 kg ha^{-1}),

Table 1. Physico-chemical properties of soil and method used

Sr. No.	Particulars	Value	Method used	Reference
I.	**Physical properties**			
a.	Coarse sand (per cent)	12.04	International pipette method	Piper, (1966)
b.	Fine sand (per cent)	18.62		
c.	Silt (per cent)	29.57		
d.	Clay (per cent)	38.83		
e.	Soil texture	Clayey		
f.	Bulk density ($g\ cm^{-3}$)	1.23	Core sampler method	Dastane ,1972
g.	Hydraulic conductivity ($cm\ hr^{-1}$)	1.65	Constant head method	Klute and Dirksen ,(1986)
h.	Maximum water holding capacity (per cent)	30.03	Pressure plate appratus	Piper, (1966)
II.	**Chemical properties**			
a.	pH (1:2.5)	8.03	Potentiometric	Jackson, (1973)
b.	EC (dSm^{-1}) at 25 ^0C	0.26	Conductometer	Jackson, (1973)
c.	Organic carbon (per cent)	0.51	Wet oxidation	Nelson and Sommers, (1982)
d.	Available nitrogen ($kg\ ha^{-1}$)	181.32	Modified alkaline permanganate	Sharawat and Burford, (1982)
e.	Available phosphorus ($kg\ ha^{-1}$)	15.17	Ascorbic acid	Nelson and Sommers,(1982)
f.	Available potassium ($kg\ ha^{-1}$)	288.85	Flame photometric	Knudsen *et al.*, (1982)
III.	**Plant analysis**			
a.	Oxidation of plant sample	-	Binanary Mixture	Parkinson and Allen, (1975)
b.	Nitrogen	-	Micro-Kjeldhal's	Jackson, (1973)
c.	Phosphorus	-	Vandomolybdate phosphoric yellow colour method in nitric acid system	Jackson ,(1973)
c.	Potassium	-	Flame photometric	Jackson, (1973)

IV	**Grain analysis**			
a.	Crude protein content	--	Microkjeldahl (N per cent x Factor)	A.O.A.C. (2005)
b.	Oil content	--	Soxhlet method	Piper (1966)
V.	**Organic inputs used** (Farmyard manure, Vermicompost, Neem seed powder and Jeevamrut)			
a.	Total nitrogen	--	Macro-Kjeldhal's	A.O.A.C. (2005)
b.	Total phosphorus	--	Vando molybdate yellow colour in nitric acid	Jackson (1973)
c.	Total Potassium	--	Flame photometric	A.O.A.C. (2005)
VI.	**Biological properties**			
a.	Bacteria (CFU x 10^{-6} g^{-1} soil)	--	Serial dilution and pour plate technique	Chhonkar *et al.* (2007)
b.	Fungi (CFU x 10^{-4} g^{-1} soil)	--		
c.	Actinomycetes (CFU x 10^{-4} g^{-1} soil)	--		

Total soluble salt content in soil (Electrical conductivity) was normal (0.26 dSm^{-1}), the soil was moderately alkaline in reaction (pH 8.03) and the corresponding numerical values for bulk density, hydraulic conductivity and maximum water holding capacity are 1.21 Mg m^{-3}, 1.63 cm hr^{-1} and 30.07 per cent, respectively.

3.1.3. Climatic conditions

A. General

Geographically Central campus of Mahatma Phule Krishi Vidyapeeth, Rahuri is situated between 19^{O} 48' and 19^{O} 57' North latitude and 74^{O} 52' and 74^{O} 19' East longitude, and its mean height above sea level is 395 to 565 meters. This tract is lying on the eastern side of Western Ghat and falls under rain shadow area. It comes under transition belt having semi-arid climate. It receives most of the rainfall from South-West monsoon, commencing from middle of June.

The mean annual precipitation approximates to about 520 mm received in about 15 to 45 rainy days from the middle of June to middle of October. About 75 per cent of the total rainfall is received from South-West monsoon between June and September, while the rest from North-East monsoon between October and November.

At Rahuri, the mean maximum temperature is 37.9 ^{Oc} with a range between 33 ^{Oc} to 43 ^{Oc} and annual mean minimum temperature is 17.2 ^{Oc} with a range between 7 to 23 ^{Oc}. The temperature fluctuation start from the commencement of monsoon it falls down to about 28.0 ^{Oc} and fluctuates between 26.0 to 29.9 ^{Oc} during the months of July and August. But again, it rises to about 38.8 ^{Oc} in months of September and October until cold season begins. From November to January the mean maximum temperature ranges between 26.5 and 33.3 ^{Oc}. But again it rises from about 33.0 ^{Oc} in the month of February to about 41.0 ^{Oc} in May. The mean minimum temperature is about 13.3 ^{Oc} in the month of October after which, it gradually drops down to about 4.8 ^{Oc} in the coldest months of December and January. Again it rises gradually from about 9.7 ^{Oc} in the month of February to about 33.0 ^{Oc} in the month of March.

The mean relative humidity during morning and evening hours is 59 and 35 per cent, respectively. The mean pan evaporation ranges from 5.3 to 12.1 mm, while, sunshine hours from 7 to 9 hrs day^{-1}.

Agro-climatically the location is in the drought prone area of Maharashtra state, characterized by low and erratic rainfall with less rainy days coupled with long dry spells.

B. Nature and season during the experimental period

In order to get an idea about the climatic conditions prevailed during the period of present investigation, the meteorological data recorded on the important weather parameters during both the cropping seasons at Meteorological Observatory of the Central Campus, MPKV, Rahuri, are presented in Table 2 and depicted in Fig. 1.

During cropping season of soybean-wheat cropping sequence, the corresponding values for weather parameters recorded at Meterological observatory were as, total rainfall received (875.2 and 421.6 mm), rainy days (36 and 25), mean maximum temperature (30.7 and 30.9 ^{0}C), mean minimum temperature (17.2 and 16.9 ^{0}C), relative humidity at morning hours (77.4 and 68.6 per cent), evening hours (51.4 and 42.3 per cent), mean wind velocity (2.4 and 3.6 ms^{-1}) and mean bright sunshine hours per day (6.3 and 6.6 hrs) during 2010-11 and 2011-12, respectively.

Climate during 2010

During the cropping season, the rainfall received was 875.2 mm in 36 rainy days Table 2. The total rainfall received in the month of June was 146.4 mm which was sufficient for land preparation of *kharif* crops. Due to timely onset of monsoon good germination of soybean was observed which resulted in maintaining optimum plant population. In general, season for both the crops was fairly good during 2010.

Climate during 2011

The rainfall received was 421.6 mm in 25 rainy days. The total rainfall received in the month of June 2011 was 79.2 mm which was sufficient for land preparation and sowing of soybean in *kharif* season. The continues rainfall received in the month of July and August 2011 was beneficial for good germination and also maintaining optimum plant population of soybean.

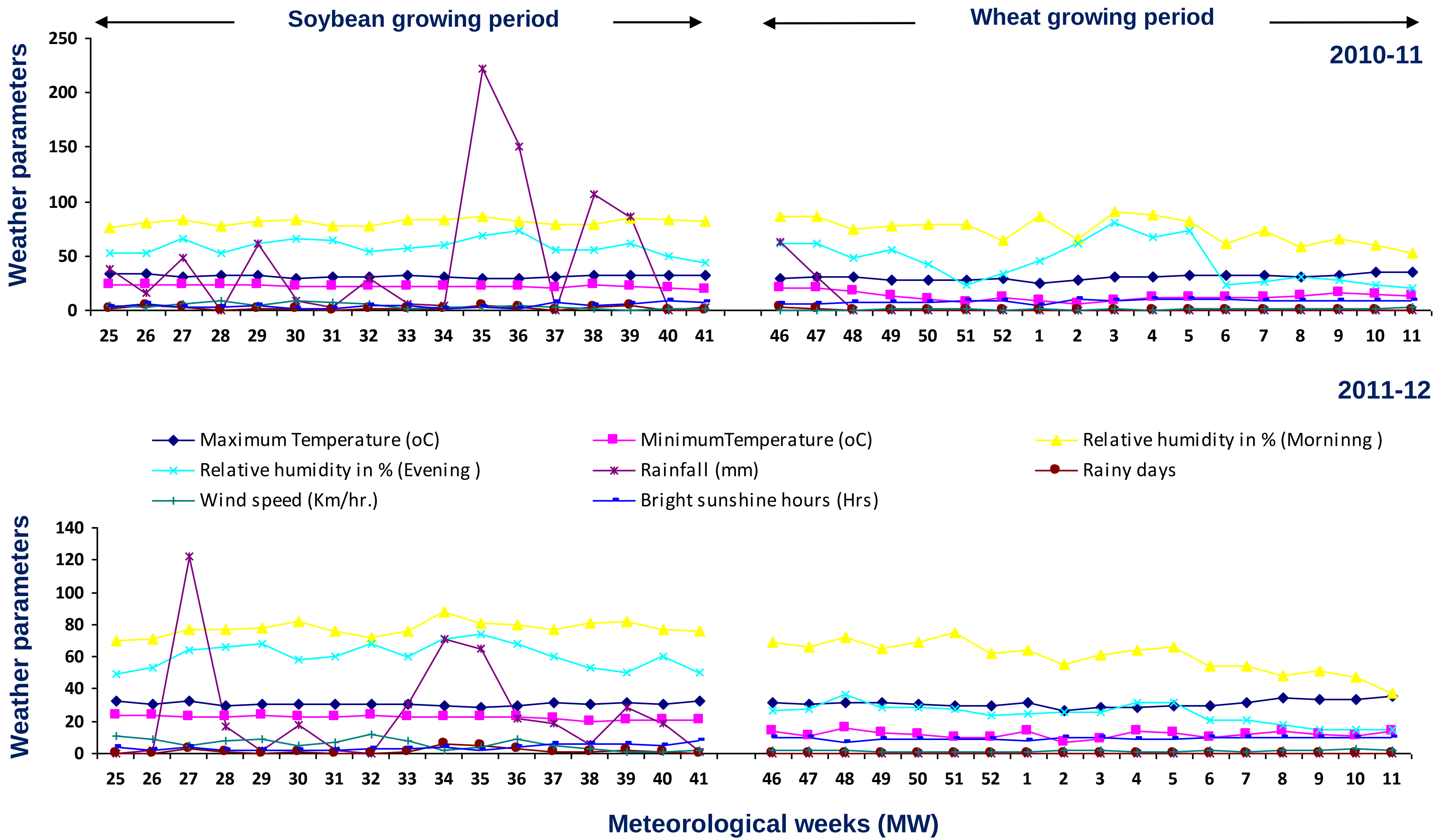


Fig. 1 : Meteorological data during 2010-11 and 2011-12

Table 2 : Meteorological data for the cropping season (2010-11 and 2011-12)

MW	Date	Temperature (°C)				Relative humidity (%)				Rainfall (mm)		Rainy days (Days)		Wind velocity (m/s)		Bright sunshine (hrs/day)	
		Maximum		Minimum		Morning		Evening									
		10-11	11-12	10-11	11-12	10-11	11-12	10-11	11-12	10-11	11-12	10-11	11-12	10-11	11-12	10-11	11-12
Soybean (Base crop)																	
25	18-24 Jun.	32.9	33.0	22.9	24.1	76.0	70.0	53.0	49.0	37.8	0.0	2.0	0.0	3.9	11.1	3.6	4.4
26	25-01 Jul.	34.0	30.6	23.7	23.6	80.0	71.0	53.0	53.0	16.4	1.6	4.0	0.0	3.4	9.2	5.7	1.7
27	02-08 Jul.	30.6	32.4	22.7	22.5	83.0	77.0	66.0	64.0	47.8	122.6	3.0	3.0	5.5	4.6	2.4	3.5
28	09-15 Jul.	31.8	29.2	23.4	22.5	78.0	77.0	52.0	66.0	0.0	16.6	0.0	1.0	8.4	8.0	3.2	1.9
29	16-22 Jul.	31.7	30.7	23.2	23.4	82.0	78.0	62.0	68.0	61.0	2.0	2.0	0.0	4.9	8.7	4.0	1.8
30	23-29 Jul.	29.4	31.0	22.6	22.4	84.0	82.0	66.0	58.0	9.0	17.6	2.0	1.0	8.5	4.6	1.5	2.3
31	30-05 Aug.	30.0	30.5	22.1	22.6	77.0	76.0	64.0	60.0	3.4	1.8	0.0	0.0	8.0	7.0	1.2	2.4
32	06-12 Aug.	30.6	31.0	21.5	23.2	77.0	72.0	54.0	68.0	29.8	0.0	1.0	0.0	5.4	11.4	4.3	2.8
33	13-19 Aug.	31.6	31.0	22.4	22.9	83.0	76.0	57.0	60.0	5.6	30.2	1.0	1.0	0.9	7.7	3.8	3.3
34	20-26 Aug.	30.5	29.9	21.6	22.4	84.0	88.0	60.0	71.0	4.0	70.8	1.0	6.0	2.2	1.8	1.9	3.9
35	27-02 Sept.	29.5	28.2	22.2	22.4	86.0	81.0	69.0	74.0	222.8	64.8	5.0	5.0	3.4	3.7	3.1	1.9
36	03-09 Sept.	28.8	29.6	22.2	22.5	82.0	80.0	73.0	68.0	150.4	21.2	3.0	3.0	3.8	8.7	1.6	3.6
37	10-16 Sept.	31.3	31.3	20.5	22.0	79.0	77.0	56.0	60.0	0.0	19.0	0.0	1.0	2.3	4.6	6.9	5.7
38	17-23 Sept.	31.5	30.2	22.7	20.0	79.0	81.0	56.0	53.0	106.6	5.6	3.0	1.0	1.1	2.9	5.0	5.9
39	24-30 Sept.	31.5	31.3	21.2	20.8	85.0	82.0	62.0	50.0	85.6	28.2	5.0	2.0	0.7	1.2	6.3	6.3
40	01-07 Oct.	31.5	30.4	20.9	21.1	83.0	77.0	49.0	60.0	0.0	18.6	0.0	1.0	1.0	0.6	8.3	5.4
41	08-14 Oct.	32.4	32.2	19.5	20.7	82.0	76.0	44.0	50.0	2.4	1.0	0.0	0.0	0.9	2.0	6.7	7.5
Wheat (Sequence crop)																	
46	12-18 Nov.	29.8	31.8	20.5	13.5	86.0	69.0	61.0	27.0	62.2	0.0	3.0	0.0	0.4	1.5	5.6	9.6
47	19-25 Nov.	30.2	30.7	20.5	11.3	86.0	66.0	61.0	28.0	30.4	0.0	1.0	0.0	0.4	2.3	6.5	9.4
48	26-02 Dec.	30.8	31.3	17.1	15.3	74.0	72.0	48.0	36.0	0.0	0.0	0.0	0.0	0.5	2.0	7.2	7.2
49	03-09 Dec.	27.8	31.7	13.0	13.2	77.0	65.0	55.0	29.0	0.0	0.0	0.0	0.0	1.1	1.3	7.8	9.3
50	10-16 Dec.	27.2	30.1	10.8	11.6	79.0	69.0	43.0	29.0	0.0	0.0	0.0	0.0	0.9	1.2	7.9	8.8
51	17-23 Dec.	27.3	29.8	7.0	10.2	79.0	75.0	23.0	28.0	0.0	0.0	0.0	0.0	1.0	1.2	9.1	9.0
52	24-31 Dec.	29.6	29.1	11.1	9.4	65.0	62.0	33.0	24.0	0.0	0.0	0.0	0.0	0.5	1.1	8.2	9.1
01	01-07 Jan.	24.9	31.8	8.5	13.5	86.0	64.0	45.0	25.0	0.0	0.0	0.0	0.0	1.5	1.2	4.6	8.3
02	08-14 Jan.	28.2	26.4	6.1	7.0	66.0	55.0	62.0	26.0	0.0	0.0	0.0	0.0	0.7	1.6	10.0	10.0
03	15-21 Jan.	30.2	28.7	9.1	8.6	90.0	61.0	80.0	26.0	0.0	0.0	0.0	0.0	0.9	1.5	9.2	9.9
04	22-28 Jan.	31.4	29.0	11.0	13.7	87.0	64.0	67.0	32.0	0.0	0.0	0.0	0.0	0.7	1.4	9.6	8.5
05	29-04 Feb.	31.8	29.1	11.0	12.8	82.0	66.0	73.0	32.0	0.0	0.0	0.0	0.0	1.2	1.3	9.8	8.9
06	05-11 Feb	32.0	29.8	11.1	9.6	61.0	54.0	23.0	21.0	0.0	0.0	0.0	0.0	1.0	1.7	10.0	9.5
07	12-18 Feb.	31.7	31.9	12.3	11.9	73.0	54.0	27.0	21.0	0.0	0.0	0.0	0.0	1.2	1.4	9.4	9.4
08	19-25 Feb.	30.4	34.3	13.0	13.7	59.0	48.0	31.0	18.0	0.0	0.0	0.0	0.0	1.8	1.7	9.3	9.7
09	26-04 Mar.	32.3	33.6	15.8	12.0	66.0	51.0	28.0	15.0	0.0	0.0	0.0	0.0	1.6	2.1	8.1	9.7
10	5-11 Mar.	34.7	33.1	15.0	10.9	60.0	47.0	24.0	15.0	0.0	0.0	0.0	0.0	1.6	2.6	9.0	9.6
11	12-18 Mar.	34.7	35.3	13.1	13.9	52.0	37.0	20.0	15.0	0.0	0.0	0.0	0.0	2.2	2.1	9.5	9.4

3.1.4. Cropping history

The cropping history of the experimental plots for the last three years preceding the present investigation is given in Table 3.

Table 3 : Cropping history of the experimental plot

Sr. No.	Years	Season		
		Kharif	***Rabi***	**Summer**
1.	2007-08	Pearl millet	Onion	Fallow
2.	2008-09	Soybean	Wheat	Fallow
3.	2009-10	Soybean	Maize	Fallow
4.	2010-11	Present Investigation (I year trial)		
5.	2011-12	Present Investigation (II year trial)		

3.1.5. Experimental details

The details of the experiment conducted during 2010-11 and 2011-12 are given below.

A. Treatment details (for both the crops)

Sr. No.	Treatment	Symbol
1.	100 % General recommonded dose of fertilizer (GRDF)	T_1
2.	50 % recommonded dose of nitrogen RDN - FYM + 50 % RDN- VC	T_2
3.	50 % RDN h VC + 50 % RDN -NSP	T_3
4.	50 % RDN FYM + 50 % RDN- NSP	T_4
5.	50 % RDN- FYM + 50 % RDN- VC + Jeevamrut two times (30 and 45 DAS @ 500 L ha^{-1})	T_5
6.	50 % RDN- VC + 50 % RDN - NSP + Jeevamrut two times (30 and 45 DAS @ 500 L ha^{-1})	T_6
7.	50 % RDN - FYM + 50 % RDN- NSP + Jeevamrut two times (30 and 45 DAS @ 500 L ha^{-1})	T_7
8.	1/3rd RDN- FYM + 1/3rd RDN- NSP + 1/3rd RDN - VC + Jeevamrut two times (30 and 45 DAS @ 500 L ha^{-1} $time^{-1}$)	T_8

B. Other details

Start of experiment	:	*Kharif* 2010
Cropping system	:	Soybean – wheat cropping sequence
Design	:	Randomized Block Design (8 treatments)
Replications	:	3 (Three)
Treatments	:	8 (Eight)

Plot size : *Kharif* *Rabi*

	Kharif	*Rabi*
Gross	5.40 m x 3.60 m	5.40 m x 3.60 m
Net	4.50 m x 3.0 m	4.50 m x 3.0 m

Sowing details :

Method of sowing : Dibbling

Date of sowing :

Crops/Trial	**I year**	**II year**
Soybean	27.06.2010	08.07.2011
Wheat	20.11.2010	12.11.2011

Seed rate : Soybean : 75 kg ha^{-1}
Wheat : 100 kg ha^{-1}

Spacing : Soybean : 30 cm x 10 cm
Wheat : 22.5 cm row to row line sowing

Varieties : Soybean : JS-335
Wheat : Trimbak (Cv. NIAW 301)

Organic sources : Farmyard manure, Vermicompost, Neem seed powder, *Jeevamrut*

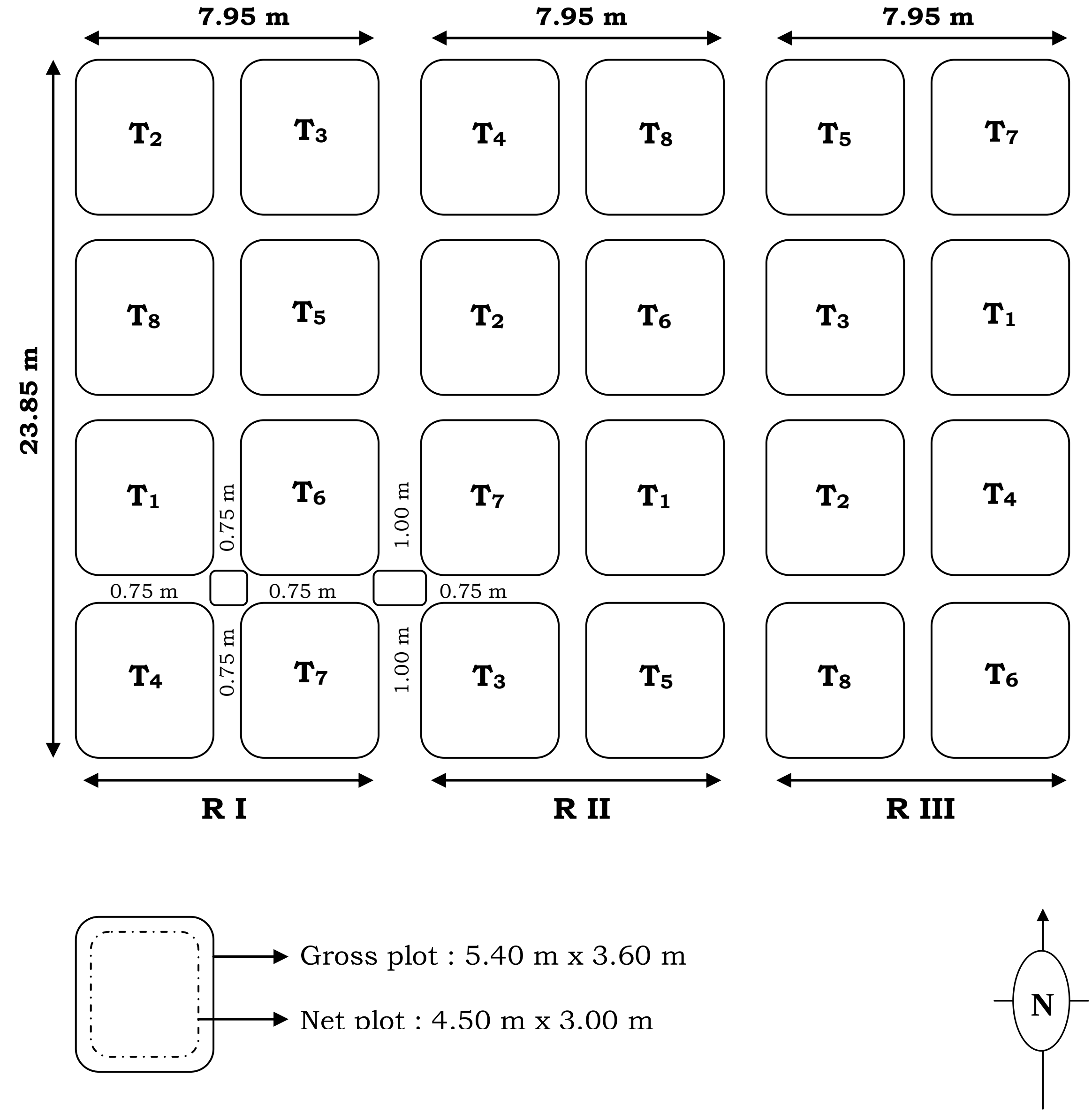
Chemical fertilizers : Urea, Single superphosphate (SSP) and Muriate of potash (MOP)

Date of harvesting :

Crops/Trial	**I year**	**II year**
Soybean	02.10.2010	12.10.2011
Wheat	12.03.2011	08.03.2012

3.2. Crop husbandry details

The schedule of various cultural operations carried out during the course of investigation are given in Table 4.



Cropping system	:	Soybean – wheat cropping sequence
Design	:	Randomized Block Design (8 treatments)
Replications	:	3 (Three)

Fig 2 : Plan of Layout (Soybean-wheat cropping sequence)

Table 4. Schedule of cultural operations carried out in the experimental plots during 2010-11 and 2011-12

Cultural operation	Operation schedule			
	2010-11		2011-12	
	Soybean	Wheat	Soybean	Wheat
Preparatory tillage				
Ploughing (Tractor)	13.05.2010	3.11.2010	07.06.2011	27.11.2011
Harrowing (Cultivator/Rotavator)	18.06.2010	8.11.2010	21.06.2011	02.11.2011
Layout preparation	19.06.2010	13.11.2010	27.06.2011	07.11.2011
Manure application				
FYM, VC and NSP	20.06.2010	14.11.2010	29.06.2011	08.11.2011
Jeevamrut : 30 DAS	28.07.2010	14.12.2010	05.08.2011	10.12.2011
45 DAS	11.08.2010	30.12.2010	20.08.2011	24.12.2011
Seed treatment				
Rhizobium, PSB and *Trichoderma*	27.06.2010	--	08.07.2011	--
Azetobactor, PSB and *Trichoderma*	--	15.11.2010	--	12.11.2011
Sowing/dibbling	27.06.2010	15.11.2010	08.07.2011	12.11.2011
Intercultural operations				
Gap filling	05.07.2010	--	17.07.2011	--
Thinning	13.07.2010	--	26.07.2011	--
Weeding : First	17.07.2010	06.12.2010	02.08.2011	30.11.2011
Second	30.07.2010	21.12.2010	11.09.2011	14.12.2011
Plant protection				
Neemark spraying (Azadiractin)	19.07.2010	07.11.2010	29.07.2011	29.12.2011
Irrigation application				
First (Common)	28.06.2010	15.11.2010	08.07.2011	12.11.2011
Second (Light)	09.07.2010	26.11.2010	14.07.2011	23.11.2011
Third (Jeevamrut)	28.07.2010	09.12.2010	07.08.2011	04.12.2011
Fourth (Jeevamrut)	12.08.2010	24.12.2010	23.08.2011	19.12.2011
Fifth (Protective)	--	11.01.2011	--	04.01.2012
Sixth (--"--)	--	05.02.2011	--	01.02.2012
Harvesting	02.10.2010	12.03.2011	12.10.2011	08.03.2012
Threshing	05.10.2010	18.03.2011	17.10.2011	15.03.2012

3.2.1. Preparatory tillage

Land preparation was done with deep ploughing followed by criss cross harrowing with cultivator. The clods were crushed with rotavator and land was leveled manually by spade to have a loose and friable seed bed. After clean cultivation the beds were laid out for soybean-wheat cropping sequence as shown in Fig 2.

3.2.2. Experimental layout

The experiment was laid out in Randomized Block Design (RBD) with 8 treatments for soybean and wheat (Fig 2) with three replications. The gross plot size for soybean and wheat was 5.40 m x 3.60 m; net plot size was 4.50 m x 3.00 m.

3.2.3. Organic inputs

The farmyard manure, vermicompost and neem seed powder and newly introduced Jeevamrut were used as organic sources in the study. Jeevamrut prepared by using 25 kg fresh cow dung, 12.5 lit fresh indigenous cow urine, 2.5 kg jaggery, 5 kg pulse flour, 500 lit of water and one kg of soil from *rhizoshpere*/ root zone space of same crop or soil under banian tree. Thoroughly mix all above components in a drum having capacity more 500 lit. Stirr the components in the drum with stick for five minutes every morning. The mixture is allowed to fermant for one week before application. This mixture obtained is called *Jeevamrut*. It is sufficient for application on one hectare of area and it is used to apply through irrigation water to the crop at planting and at monthly intervals ha^{-1}. It contains 0.01 : 0.02 : 0.02 NPK (per cent). This mixture makes seeds pest-resistant, germinate faster and increases microbai activities in the soil.

3.2.4. Manure and fertilizer application

Organic manures like farmyard manure, vermicompost and neem seed powder were applied 7 days before sowing as per treatments and *jeevamrut* was applied to soybean-wheat cropping system at 30 and

Table 4 : Amount of nutrients applied to soybean in soybean – wheat cropping sequence during 2010-11

Treatments	Source and treatment wise nutrients added in soil (kg ha^{-1})															Amount of nutrients added (kg ha^{-1})		
	Chemical fertilizer			Farmyard manure			Vermicompost			Neem seed powder			Jeevamrut					
	N	P_2O_5	K_2O	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Nutrient content (%)				**0.56**	**0.44**	**0.96**	**1.38**	**0.71**	**0.92**	**2.34**	**0.76**	**1.21**	**0.02**	**0.01**	**0.20**			
Soybean (*kharif*)																		
T_1 : 100 % GRDF**	50.0	75.0	0.0	28.0	22.0	48.0	--	--	--	--	--	--	--	--	--	78.0	97.0	48.0
T_2 : 50 % RDN through FYM + 50 % RDN through VC	--	--	--	25.0	19.6	42.9	25.0	12.9	16.7	--	--	--	--	--	--	50.0	32.5	59.5
T_3 : 50 % RDN through VC + 50 % RDN through NSP	--	--	--	--	--	--	25.0	12.9	16.7	25.0	8.1	12.9	--	--	--	50.0	21.0	29.6
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	--	--	--	25.0	19.6	42.9	--	--	--	25.0	8.1	12.9	--	--	--	50.0	27.8	55.8
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut	--	--	--	25.0	19.6	42.9	25.0	12.9	16.7	--	--	--	0.2	0.1	2.0	50.2	32.6	61.5
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut	--	--	--	--	--	--	25.0	12.9	16.7	25.0	8.1	12.9	0.2	0.1	2.0	50.2	21.1	31.6
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut	--	--	--	25.0	19.6	42.9	--	--	--	25.0	8.1	12.9	0.2	0.1	2.0	50.2	27.9	57.8
T_8 : $1/3^{rd}$ RDN through FYM + $1/3^{rd}$ RDN through NSP + $1/3^{rd}$ RDN through VC + Jeevamrut	--	--	--	16.7	13.1	28.6	16.7	8.6	21.6	16.7	5.4	26.5	0.2	0.1	2.0	50.2	27.2	86.5

** GRDF for soybean (RDF *i.e.* 50:75:00 kg N : P_2O_5 : K_2O + 5 tonnes of FYM ha^{-1}) and for wheat (RDF *i.e.* 120:60:40 kg N : P_2O_5 : K_2O + 10 tonnes of FYM ha^{-1})

Table 5 : Amount of nutrients applied to wheat in soybean – wheat cropping sequence during 2010-11

Treatments	Source and treatment wise nutrients added in soil (kg ha^{-1})															Amount of nutrients added (kg ha^{-1})		
	Chemical fertilizer			Farmyard manure			Vermicompost			Neem seed powder			Jeevamrut					
	N	P_2O_5	K_2O	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Nutrient content (%)				**0.49**	**0.34**	**0.72**	**1.16**	**0.54**	**0.92**	**2.64**	**0.66**	**1.37**	**0.01**	**0.01**	**0.19**			
Wheat (*Rabi*)																		
T_1 : 100 % GRDF**	120.0	60.0	40.0	49.0	34.0	72.0	--	--	--	--	--	--	--	--	--	169.0	94.0	112.0
T_2 : 50 % RDN through FYM + 50 % RDN through VC	--	--	--	60.0	17.3	36.7	60.0	11.6	19.8	--	--	--	--	--	--	120.0	29.0	56.6
T_3 : 50 % RDN through VC + 50 % RDN through NSP	--	--	--	--	--	--	60.0	11.6	19.8	60.0	6.3	13.0	--	--	--	120.0	17.9	32.8
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	--	--	--	60.0	17.3	36.7	--	--	--	60.0	6.3	13.0	--	--	--	120.0	23.6	49.7
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut	--	--	--	60.0	17.3	36.7	60.0	11.6	19.8	--	--	--	0.1	0.1	1.9	120.1	29.1	58.5
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut	--	--	--	--	--	--	60.0	11.6	19.8	60.0	6.3	13.0	0.1	0.1	1.9	120.1	18.0	34.7
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut	--	--	--	60.0	17.3	36.7	--	--	--	60.0	6.3	13.0	0.1	0.1	1.9	120.1	23.7	51.6
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut	--	--	--	40.0	27.8	58.8	40.0	18.6	68.1	40.0	10.0	83.0	0.1	0.1	1.9	120.1	56.5	237.8

** GRDF for soybean (RDF *i.e.* 50:75:00 kg N : P_2O_5 : K_2O + 5 tonnes of FYM ha^{-1}) and for wheat (RDF *i.e.* 120:60:40 kg N : P_2O_5 : K_2O + 10 tonnes of FYM ha^{-1})

Table 6 : Amount of nutrients applied to soybean in soybean – wheat cropping sequence during 2011-12

Treatments	Source and treatment wise nutrients added in soil (kg ha^{-1})															Amount of nutrients added (kg ha^{-1})		
	Chemical fertilizer			Farmyard manure			Vermicompost			Neem seed powder			Jeevamrut					
	N	P_2O_5	K_2O	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Nutrient content (%)				**0.57**	**0.41**	**0.74**	**1.22**	**0.73**	**0.86**	**2.58**	**0.71**	**1.42**	**0.01**	**0.02**	**0.23**			
Soybean (*kharif*)																		
T_1 : 100 % GRDF**	50.0	75.0	0.0	28.5	20.5	37.0	--	--	--	--	--	--	--	--	--	78.5	95.5	37.0
T_2 : 50 % RDN through FYM + 50 % RDN through VC	--	--	--	25.0	18.0	32.5	25.0	15.0	17.6	--	--	--	--	--	--	50.0	32.9	50.1
T_3 : 50 % RDN through VC + 50 % RDN through NSP	--	--	--	--	--	--	25.0	15.0	17.6	25.0	6.9	13.8	--	--	--	50.0	21.8	31.4
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	--	--	--	25.0	18.0	32.5	--	--	--	25.0	6.9	13.8	--	--	--	50.0	24.9	46.2
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut	--	--	--	25.0	18.0	32.5	25.0	15.0	17.6	--	--	--	0.1	0.2	2.3	50.1	33.1	52.4
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut	--	--	--	--	--	--	25.0	15.0	17.6	25.0	6.9	13.8	0.1	0.2	2.3	50.1	22.0	33.7
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut	--	--	--	25.0	18.0	32.5	--	--	--	25.0	6.9	13.8	0.1	0.2	2.3	50.1	25.1	48.5
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut	--	--	--	16.7	12.0	21.6	16.7	10.0	19.6	16.7	4.6	33.3	0.1	0.2	2.3	50.1	26.7	85.3

** GRDF for soybean (RDF *i.e.* 50:75:00 kg N : P_2O_5 : K_2O + 5 tonnes of FYM ha^{-1}) and for wheat (RDF *i.e.* 120:60:40 kg N : P_2O_5 : K_2O + 10 tonnes of FYM ha^{-1})

Table 7 : Amount of nutrients applied to wheat in soybean – wheat cropping sequence during 2011-12

Treatments	Source and treatment wise nutrients added in soil (kg ha^{-1})															Amount of nutrients added (kg ha^{-1})		
	Chemical fertilizer			Farmyard manure			Vermicompost			Neem seed powder			Jeevamrut					
	N	P_2O_5	K_2O	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Nutrient content (%)				**0.66**	**0.43**	**0.84**	**1.45**	**0.67**	**0.89**	**2.47**	**0.91**	**1.31**	**0.02**	**0.02**	**0.23**			
Wheat (*Rabi*)																		
T_1 : 100 % GRDF**	120.0	60.0	40.0	66.0	43.0	84.0	--	--	--	--	--	--	--	--	--	186.0	103.0	124.0
T_2 : 50 % RDN through FYM + 50 % RDN through VC	--	--	--	60.0	16.3	31.8	60.0	11.6	15.3	--	--	--	--	--	--	120.0	27.8	47.2
T_3 : 50 % RDN through VC + 50 % RDN through NSP	--	--	--	--	--	--	60.0	11.6	15.3	60.0	9.2	13.3	--	--	--	120.0	20.8	28.6
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	--	--	--	60.0	16.3	31.8	--	--	--	60.0	9.2	13.3	--	--	--	120.0	25.5	45.1
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut	--	--	--	60.0	16.3	31.8	60.0	11.6	15.3	--	--	--	0.2	0.2	2.3	120.2	28.0	49.5
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut	--	--	--	--	--	--	60.0	11.6	15.3	60.0	9.2	13.3	0.2	0.2	2.3	120.2	21.0	30.9
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut	--	--	--	60.0	16.3	31.8	--	--	--	60.0	9.2	13.3	0.2	0.2	2.3	120.2	25.7	47.4
T_8 : $1/3^{rd}$ RDN through FYM + $1/3^{rd}$ RDN through NSP + $1/3^{rd}$ RDN through VC + Jeevamrut	--	--	--	40.0	26.1	50.9	40.0	18.5	53.1	40.0	14.7	57.6	0.2	0.2	2.3	120.2	59.5	191.2

** GRDF for soybean (RDF *i.e.* 50:75:00 kg N : P_2O_5 : K_2O + 5 tonnes of FYM ha^{-1}) and for wheat (RDF *i.e.* 120:60:40 kg N : P_2O_5 : K_2O + 10 tonnes of FYM ha^{-1})

45 DAS through irrigation during both the years of experimentation (Table 4).

Full dose of N and P was applied to soybean at the time of sowing while, half dose of N and full dose of P and K was applied to wheat at the time of sowing and remaining half dose of N was applied one month after sowing.

3.2.5. Seed and sowing

3.2.5.1. Seed material

The quality seed of soybean *(Cv.* JS-335) and wheat seed *(Cv. Trimbak*) seed was obtained from the Chief Scientist, Breeder Seed Production Unit, MPKV, Rahuri during both the years.

3.2.5.2. Seed treatment

The seeds of soybean were inoculated with *Rhizobium* sp. and that of wheat with *Azetobactor* alongwith PSB culture @ 250 g/ 10 kg each. Further seeds were treated with *Trichoderma* 3 g kg^{-1}. The seeds were dried in shade and used for sowing.

3.2.5.3 Sowing

The sowing was done with 30 cm x 10 cm spacing for soybean and 22.5 cm row spacing for wheat during both the years.

3.2.6. Gap filling and thinning

The gap filling was done about 10 DAS for soybean and wheat to maintain the uniform plant stand in experimental field, while, thinning was undertaken for soybean at 21 DAS to avoid crop competition and only one healthy, vigorous seedling was kept at each hill in all the crops during both the years.

3.2.7. Intercultivation

Two hand weedings in soybean and wheat at 20 and 35 DAS were carried out in order to keep the plots clean and weed-free to avoid the crop-weed competition during both the years.

3.2.8. Irrigation application

First irrigation was applied immediately after sowing of crops to ensure the better germination of each crop and respective irrigations were applied to soybean-wheat cropping system as per the schedule mentioned in the Table 4 for both the years.

3.2.9. Plant protection

To protect soybean and wheat crops from the incidence of aphids (*Aphis gossypii* G.), jassids (*Empoasca bygutulla* D.); two sprayings of Neemark were taken at 15 days interval.

3.2.10. Harvesting

At physiological maturity stage, initially all border rows from each gross plot were harvested separately and thereafter the remaining plots were harvested as net plot produce. Harvesting of soybean and wheat was done manually by cutting plants at their base with sickle and harvested produce was kept for drying for 3-4 days.

3.2.11. Threshing and winnowing

The sundried soybean and wheat plants were threshed by beating with sticks, winnowed and cleaned. Then seed and straw yield were weighed separately. Thus, plot-wise yields obtained were tabulated analyzed and interpreted in experimental result.

3.2.12. Sampling technique

Five representative plants were selected randomly from each net plot to monitor periodical growth and development stages of soybean crop. The selected plants were fixed with wooden sticks and labeled with tags. The plants in one meter row length were marked with wooden sticks. The same plants labled in soybean and wheat plots were harvested separately for recording bio-metric observations during both the years.

3.3. Details of data collection for soybean

3.3.1. Plant count

The total number of plants emerged in each net plot of soybean were counted 15 DAS during both the years. The resultant data was recorded as mean emergence count in per cent. The final plant count from each net plot was taken just before harvesting of soybean during both the years and data expressed in per cent.

3.3.2. Pre-harvest growth studies

The growth contributing characters were recorded on five observational plants of each net plot and reported on mean basis.

3.3.2.1. Plant height

The plant height was measured from the base of the stem to the terminal leaf bud on the main stem at 28, 56 and 84 DAS and at harvest.

3.3.2.2. Number of branches plant^{-1}

The number of branches plant^{-1} was recorded at 28, 56 and 84 DAS and at harvest.

3.3.2.3. Number of functional compound leaves plant^{-1}

The number of functional compound leaves plant^{-1} was recorded at 28, 56 and 84 DAS and at harvest.

Table 8. Details of periodical observations recorded for soybean as base crop in soybean-wheat cropping system

Sr. No.	Particulars	Freq-uency	Size of sample	Days after sowing
a.	**Pre-harvest studies**			
1	Emergence count and Final plant count	1 each	All plants/ plot	After emergence and at harvest
2	Plant height (cm)	4	5	28, 56, 84 DAS and at harvest
3	Number of branches plant^{-1}	4	5	28, 56, 84 DAS and at harvest
4	Number of functional compound leaves plant^{-1}	3	5	28, 56 & 84 DAS
5	Leaf area (dm^2)	3	5	28, 56 & 84 DAS
6	Total dry matter (g plant^{-1})	4	2	28, 56, 84 DAS and at harvest
7	Number of nodules plant^{-1}	1	2	At flowering stage
8	Weed count	2		At 30 and 45 DAS
b.	Microbial count (Fungi, Bacteria and Actinomycetes)	1	2	At flowering stage
c.	**Post-harvest studies**			
1	Number of pods plant $^{-1}$	1	5	At harvest
2	Dry pod weight plant $^{-1}$	1	5	At harvest
3	Number of seeds plant $^{-1}$	1	5	At harvest
4	Seed weight plant^{-1} (g)	1	5	At harvest
5	Test weight (g)	1	Plot wise	At harvest
6	Seed yield (q ha^{-1})	1	--"--	At harvest
7	Straw yield (q ha^{-1})	1	--"--	At harvest
8	Biological yield (q ha^{-1})	1	--"--	At harvest
d.	**Quality studies**			
1	Oil content (per cent)	1	--"--	At harvest
2	Protein content (per cent)	1	--"--	At harvest
e.	**Nutrient balance studies**			
	Plant and grain analysis for N, P, K content (per cent) and uptake studies (kg ha^{-1})	1	At harvest	Bulk of samples from net plot
f.	**Soil fertility studies**			
	Residual soil analysis after harvest of crop for physical, chemical and biological properties	1	--"--	All plots in two Replications

3.3.2.4. Leaf area plant^{-1}

The plants uprooted periodically for dry matter studies were utilized for measuring leaf area in dm^2 plant^{-1}. The leaflets were categorized as large, medium and small and respective leaflets count along with maximum length and width was taken in cm. Then, the leaf area was calculated with the help of formula as given below :

$$\text{Leaf area } (dm^2) = (L \times W \times \text{factor}) \times n$$

Where,

L = Maximum length of leaflet (cm)

W = Maximum width of leaflet at 1/3rd length from base of leaflet (cm)

Factor = Leaf area constant for soybean *i.e.* 0.7860 (Watson, 1952)

N = Number of leaflets in respective group

3.3.2.5. Dry matter plant^{-1}

Two representative plants from each net plot at the periodical growth stages and at harvest were uprooted randomly. The different plant components *viz.,* leaves, stem and pods were separated carefully and kept in brown paper bags. Thereafter, all these samples were sundried first and oven dried later on at 60 ± 5 ^{0}C till the constant weights were obtained. Finally, the dry weight of these plant components was recorded separately and summed up as total dry matter accumulation in g plant^{-1}.

3.3.2.6. Nodule count plant^{-1}

Two plant samples of soybean from each net plot were uprooted carefully at flowering stage. The roots were washed, made free from adhering soil particles with fine jet of water and then the number of nodules developed in soybean were separated from the root, counted treatment wise.

3.3.2.7. Microbial count

The microbial count was taken by using the method suggested by Chhonar *et al.*, 2007.

3.3.2.8. Weed count

The weed count in m^{-2} area was taken at 30 and 45 DAS. The data so obtained was tabulated, analysed and interpreted.

3.3.3. Post harvest studies

3.3.3.1. Yield attributes studies

The yield contributing characters were recorded on five observational plants of each net plot and data were reported on mean basis.

3.3.3.1.1. Number of pods plant^{-1}

The total number of pods plant^{-1} at the different observational days till harvest of soybean was counted and data were reported on mean basis.

3.3.3.1.2. Dry pod weight plant^{-1}

All the dry pods were separated from the plants, weighed and data were reported on mean basis as pod weight plant^{-1} (g).

3.3.3.1.3. Number of seeds plant^{-1}

The pods plucked from five observational plants were threshed separately. The number of seeds were counted and reported on mean basis.

3.3.3.1.4. Seed weight plant^{-1}

After separating and threshing the total number of pods of five observational plants of each net plot, the seeds were weighed and finally treatment wise mean seed weight plant^{-1} was worked out.

3.3.3.1.5. Test weight

The treatment wise hundred seeds were randomly selected from the produce of each net plot and weight was recorded in g.

3.3.3.2. Yield studies

3.3.3.2.1. Seed yield

The seed yield per plot was recorded after threshing all the pods of each net plot. The final seed yield was obtained by adding seed weight of five observational plants of respective net plots and then seed yield per net plot and treatment wise ha^{-1} was computed by multiplying with hectare factor.

3.3.3.2.2. Straw yield

The straw yield per plot was obtained by adding straw weight of five observational plants of respective net plots. From these data per net plot straw yield and treatment wise ha^{-1} was computed by multiplying with hectare factor.

3.3.3.2.3. Biological yield

Biological yield was calculated by summing up the seed yield and straw yield values and data so obtained was interpreted on hectare basis.

Biological yield (kg ha^{-1}) = Seed yield (kg ha^{-1}) + Straw yield (kg ha^{-1})

3.3.3.2.4. Harvest index

Harvest index (per cent) was calculated by using the following formula given by Donald and Humblin (1976).

$$\text{Harvest index (per cent)} = \frac{\text{Economical yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

Where,

Economical yield = Seed yield of crop (kg ha^{-1})

Biological yield= Economical yield (kg ha^{-1}) + Straw yield in (kg ha^{-1})

3.4. Details of data collection for wheat

3.4.1 Plant count

Five rows from each net plot were selected by random sampling and within each row, one meter length was marked by random selection. All the plants from these lengths were counted on 15 days after sowing and at harvest, respectively.

3.4.2 Plant height

Five randomly selected plants from five randomly selected locations from each net plot were used for measuring the plant height. It was measured on the main shoot from the ground level to the base of the last fully opened leaf till the stage of panicle emergence thereafter plant height was measured from ground level to the base of panicle 28, 56, 84 days after sowing and at harvest.

3.4.3 Number of tillers per meter length

The total number of tillers from each of one meter length from five randomly selected locations from each net plot were counted at 28, 56, 84 days after sowing and at harvest.

Table 9. Periodical observations recorded for wheat as sequence crop in soybean-wheat cropping sequence

Sr. No.	Particulars	Freq-uency	Size of sample	Days after sowing
a.	**Pre-harvest studies**			
1	Emergence count and Final plant count	1 each	All plants from 1 m length	After emergence and at harvest
2	Plant height (cm)	4	5	28, 56, 84 DAS and at harvest
3	Number of tillers m^{-1} length	4	5	28, 56, 84 DAS and at harvest
4	Leaf area (dm^2)	3	5	28, 56 & 84 DAS
5	Total dry matter (g $plant^{-1}$)	4	2	28, 56, 84 DAS and at harvest
6	Weed count	2	m^{-2}	At 30 and 45 DAS
b.	Microbial count (Fungi, Bacteria and Actinomycetes)	1	2	At flowering stage
c.	**Post-harvest studies**			
1	Number of panicles	1	5	At harvest
2	Length of panicle (cm)	1	5	At harvest
3	Number of grains $panicle^{-1}$	1	5	At harvest
4	1000 grain weight (g)	1	All plants	At harvest
5	Grain yield (q ha^{-1})	1	--"--	At harvest
6	Straw yield (q ha^{-1})	1	--"--	At harvest
7	Biological yield (q ha^{-1})	1	--"--	At harvest
d.	**Quality studies**			
1	Protein content (per cent)	1	--"--	At harvest
e.	**Nutrient balance studies**			
	Plant and grain analysis for N, P, K content (per cent) and uptake studies (kg ha^{-1})	1	At harvest	Bulk of samples from net plot
f.	**Soil fertility studies**			
	Residual soil analysis after harvest of crop for physical, chemical and biological properties	1	--"--	All plots in two Replications

3.4.4. Leaf area plant^{-1}

The plants uprooted periodically for dry matter studies were utilized for measuring leaf area in dm^2 plant^{-1}. The leaves were categorized as large, medium and small and respective leaf count along with maximum length and width was taken in cm. Then, the leaf area was calculated with the help of formula as given below :

$$\text{Leaf area } (dm^2) = (L \times W \times \text{factor}) \times n$$

Where,

L = Maximum length of leaf (cm)
W = Maximum width of leaflet at 1/3rd length from base of leaf (cm)
Factor = Leaf area constant for wheat *i.e.* 0.7849
N = Number of leaf in respective group

3.4.5. Dry matter plant^{-1}

Two representative plants from each net plot at the periodical growth stages and at harvest were uprooted randomly. The different plant components *viz.,* leaves, stem and panicle were separated carefully and kept in brown paper bags. Thereafter, all these samples were sundried first and oven dried later on at $60 \pm 5\ ^0C$ till the constant weights were obtained. Finally, the dry weight of these plant components was recorded separately and summed up as total dry matter accumulation in g plant^{-1}.

3.4.6. Microbial count

The microbial count was taken by using the method suggested by Chhonar *et al.*, 2007.

3.4.7. Weed count

The weed count in m^{-2} area was taken at 30 and 45 DAS. The data so obtained was tabulated, analysed and interpreted.

3.5. Post harvest studies

3.5.1. Number of panicles

The total number of panicles from randomly selected one meter length from five different locations of each net plot were counted and mean was computed.

3.5.2. Length of panicle

The length of panicle was measured from the basal spikelet to the tip of the panicle excluding awns from five randomly selected plants. The mean length of panicle was then worked out.

3.5.3. Number of grains per panicle

The panicles which were used for the study of length of panicle were used for this study. The grain number per panicle was counted and the mean was computed.

3.5.4. Grain weight per panicle

The grain weight per panicle from each five randomly selected plants from one meter length was recorded and mean was computed.

3.5.5. Thousand grain weight

The random samples of grains from the total grain produce from each net plot was taken and 1000 seeds were counted and weighed to obtain 1000 grain weight for each treatment.

3.6. Yield studies

3.6.1. Grain yield

The grain yield per net plot was recorded after threshing all the plants of each net plot. The final grain yield from each net plot was obtained by adding grain weight of five observation plants of respective net plot. The treatment wise per ha grain yield was computed by multiplying hectare factor.

3.6.2 Straw yield

The straw yield per net plot was obtained by substracting the grain yield from the biological yield of respective net plot. The straw yield per net plot was converted to per ha vith the multiplication of hectare factor.

3.6.3. Biological yield

Biological yield was calculated by summing up the seed yield and straw yield values and data so obtained was interpreted on hectare basis.

Biological yield (kg ha^{-1}) = Seed yield (kg ha^{-1}) + Straw yield (kg ha^{-1})

3.6.4. Harvest index

Harvest index (per cent) was calculated by using the following formula given by Donald and Humblin (1976).

$$\text{Harvest index (per cent)} = \frac{\text{Economical yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

Where,

Economical yield = Seed yield of crop (kg ha^{-1})

Biological yield= Economical yield (kg ha^{-1}) + Straw yield in (kg ha^{-1})

3.5. Growth analysis

The growth functions precisely, the physiological determinants of the overall plant growth and development at different stages. The crop growth characters (plant height, leaf area and total dry matter $plant^{-1}$) were used to work out various growth functions *viz.,* AGR for height and dry matter, CGR, RGR, NAR, LAI, LAD and BMD.

3.5.1. Absolute growth rate (AGR)

Absolute growth rate is the total gain in height or weight by a plant within a specific time interval and expressed as cm day^{-1} for plant height and gm day^{-1} for TDM accumulation plant^{-1} and is calculated by the formula given by Richards (1969) as :

$$\text{AGR (cm day}^{-1}\text{)} = \frac{H_2 - H_1}{t_2 - t_1} \quad \text{..for plant height (cm)}$$

$$\text{AGR (g day}^{-1}\text{)} = \frac{W_2 - W_1}{t_2 - t_1} \quad \text{..for total dry matter (g plant}^{-1}\text{)}$$

Where,

H_2 and H_1 are the values for plant height (cm) of crop plant and

W_2 and W_1 are the total dry matter weight (g) at time t_2 and t_1, respectively.

3.5.2. Relative growth rate (RGR)

According to Blackman (1919), the increase in dry matter of plant is a process of continuous compound interest wherein the increment in any interval adds to the 'capital' for subsequent growth. He called RGR as the efficiency index. The RGR is expressed in g m^{-2} day^{-1} and worked out as per the formula given by Fisher (1921).

$$\text{RGR (g m}^{-2}\text{ day}^{-1}\text{)} = \frac{\text{Loge } W_2 - \text{Loge } W_1}{t_2 - t_1} \times \text{number of plants m}^{-2}$$

Where,

W_2 and W_1 are total dry matter weight (g) at time t_2 and t_1, respectively.

Log_e = Natural logarithm to the base 'e' = 2.3026.

3.5.3. Crop growth rate (CGR)

Crop growth rate is the accumulation of total dry matter per unit of land area per unit of time (Watson, 1952). The CGR is expressed in g m^{-2} day^{-1} and calculated by the formula as given below :

$$\text{CGR (g m}^{-2}\text{ day}^{-1}\text{)} = \frac{W_2 - W_1}{t_2 - t_1} \times \text{ number of plants m}^{-2}$$

Where,

W_2 and W_1 are the total dry matter weight (g) at time t_2 and t_1, respectively.

3.5.4. Net assimilation rate (NAR)

Gregory (1917) suggested the concept of Net Assimilation Rate (NAR) or Average Assimilation Rate (E) which is defined as the net increase in plant weight per unit of assimilatory surface per unit time. The NAR is expressed in g cm^{-2} day^{-1} and calculated by the formula given by Williams (1946) as given below

$$\text{NAR (g m}^{-2}\text{ day}^{-1}) = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\text{Loge } L_2 - \text{Loge } L_1}{L_2 - L_1}$$

Where,

W_2 and W_1 are the total dry matter weight (g) at time t_2 and t_1, respectively.

L_2 and L_1 are the total leaf area (cm^2) at time t_2 and t_1, respectively.

Loge = Natural logarithm to the base 'e' = 2.3026.

3.5.5. Leaf area index (LAI)

Leaf area index is a measure of leaf area existing on unit ground area was proposed by Watson (1952). The LAI was calculated by the following formula :

$$\text{LAI} = \frac{\text{Leaf area plant}^{-1}\text{ (cm}^2)}{\text{Ground area plant}^{-1}\text{(cm}^2)}$$

3.6. Cropping system evaluation

3.6.1. Seed equivalent yield (SEY)

For comparing sole cropping yield with intercropping and sequence cropping, the seed equivalent yield was calculated by the following formula.

$$\text{Seed equivalent yield} = \frac{\text{Monetary value of sequence crop ha}^{-1}}{}$$

(q ha^{-1}) Selling price of soybean (Rs.)

3.6.2. Economic efficiency/ profitability

Economic efficiency was calculated by the following formula (Gangwar *et al.,* 2006).

$$\text{Economic efficiency (Rs day}^{-1}\text{)} = \frac{\text{Net monetary returns over year}}{\text{365 days}}$$

3.6.3. Returns day^{-1}

The returns day^{-1} was worked out by dividing net monetary returns with cropping period of respective cropping sequence (Palaniappan and Sivaraman, 1994).

$$\text{Returns day}^{-1}\text{ (Rs day}^{-1}\text{)} = \frac{\text{Net monetary returns of cropping sequence}}{\text{Total period of cropping sequence (days)}}$$

3.6.4. Production efficiency

Production efficiency was calculated by the following formula.

$$\text{Production efficiency (Kg ha}^{-1}\text{ day}^{-1}\text{)} = \frac{\text{Soybean equivalent yield of sequence (q ha}^{-1}\text{)}}{\text{Total duration of cropping sequence (days)}}$$

3.7.5. Land use efficiency

The land use efficiency (per cent) was worked out by dividing cropping period of respective cropping sequence with 365 days of a year (Palaniappan and Sivaraman, 1994).

$$\text{Land use efficiency (per cent)} = \frac{\text{Total duration of cropping sequence}}{\text{365 days}}$$

3.6.6. Systems productivity

Productivity of cropping sequence was expressed by Gangwar *et al,* 2006 and is calculated by using the formula as given below :

$$\text{Systems productivity (q ha}^{-1}\text{ day}^{-1}) = \frac{\text{Seed equivalent yield (kg ha}^{-1}\text{) of sequence}}{\text{365 days}}$$

3.7. Energy studies

The treatment wise different energy values in Mj Cal were calculated for soybean-wheat cropping sequence during both the years.

3.7.1. Energy input

The treatment wise energy input was worked out by using the item wise energy values mentioned in Appendix II.

3.7.2. Energy output

The treatment wise energy output from biological yield of crop was worked out by multiplying it with respective energy values given in Appendix II. Total energy output was worked out as per following formula.

Energy output = (Economic yield (kg) x Energy value (MJ kg^{1}) +
(Straw yield of crop x Energy value (MJ kg^{1})

3.7.3. Energy balance

The treatment wise energy balance was worked out by subtracting the treatment wise energy input from the treatment wise energy output calculated as above.

3.7.4. Energy balance per unit input

The treatment wise energy balance per unit input was calculated by using following formula.

Energy balance

$$\text{Energy balance per unit input} = \frac{\qquad}{\text{Energy input}}$$

3.7.5. Energy output : input ratio

The treatment wise energy output : input ratio was calculated by using following formula.

$$\text{Energy output : input ratio} = \frac{\text{Energy output}}{\text{Energy input}}$$

3.8. Economic evaluation studies

For economic evaluation of system, cost of cultivation, gross monetary returns, net monetary returns and benefit:cost ratio were calculated herein.

3.8.1. Cost of cultivation

The cost of cultivation (CC) for soybean and wheat was estimated by using the data given in Appendix I on various aspects *viz.* land preparation, cost of input use and wages of hired labours, irrigation charges, machinery charges with implements and interest on working capital etc.

3.8.2. Gross monetary returns

The selling prices of soybean and wheat were obtained from Co-operative Market Committee, Rahuri and were considered for calculation of gross monetary returns (GMR). The treatment-wise gross monetary returns were worked out by multiplying economic and biological yield (Q ha^{-1}) of crops by market prices (Rs Q^{-1}) of respective years as per the formula given.

$$\text{GMR (Rs ha}^{-1}\text{)} = (\text{Economic yield (q ha}^{-1}\text{)} \times \text{Price (Rs q}^{-1}\text{)}) + (\text{Biological yield (q ha}^{-1}\text{)} \times \text{Price (Rs q}^{-1}\text{)})$$

3.8.3. Net monetary returns

The treatment wise net monetary returns (NMR) were worked out by subtracting treatment wise cost of cultivation from treatment wise gross monetary returns as per formula given below.

$$\text{NMR (Rs ha}^{-1}\text{)} = \text{GMR (Rs ha}^{-1}\text{)} - \text{CC (Rs ha}^{-1}\text{)}.$$

3.8.4. Benefit : cost ratio

The treatment wise B:C ratio was worked out by dividing treatment wise gross monetary returns with the treatment wise cost of cultivation.

$$\text{B : C ratio} = \frac{\text{GMR (Rs ha}^{-1}\text{)}}{\text{CC (Rs ha}^{-1}\text{)}}$$

3.9. Soil fertility studies

3.9.1. Physico-chemical and biological properties of soil

Soil analysis for mechanical fractions at initial stage and the physical, chemical and biological properties of the soil after harvest of crops in the cropping sequence under study during both the years for treatment wise deviation, was carried out using the standard methods mentioned in Table 1. The sample size used was all the plots in two replications only.

3.9.2. Nutrient uptake

Total N, P and K content in plant samples was determined by the standard methods as given in Table 1 and then the total uptake of N, P and K was computed by multiplying per cent N, P and K content in seed and straw of plants with treatment wise yield of respective crop.

$$\text{Uptake by seed (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content in seed (per cent)} \times \text{Seed yield (kg ha}^{-1}\text{)}}{100}$$

Nutrient content in straw x Straw yield

$$\text{Uptake by straw (kg ha}^{-1}) = \frac{(\text{per cent}) \quad (\text{kg ha}^{-1})}{100}$$

3.9.3. Nutrient balance

The balance of available N, P and K in soil was calculated as nutrient balance using following formula.

(Initial available nutrient in soil + nutrient added through different organic inputs) – (Total nutrient uptake by crop + Nutrient balance in soil after harvest of crop)

Net loss or gain (kg ha^{-1})= Actual balance at harvest – Computed balance
Gain (kg ha^{-1})= Actual balance at harvest > Computed balance
Loss (kg ha^{-1})= Actual balance at harvest < Computed balance

3.10. Quality studies

3.10.1. Protein content

The per cent nitrogen content in seed was multiplied with 5.71 and 5.83 protein conversion factors to calculate the protein content in soybean and wheat respectively (Anonymous, 2006b).

3.10.2. Oil content

Randomly selected seed samples for recording test weight were used for estimating oil content in soybean. Oil content was estimated by Soxhlet method (Piper, 1966).

3.11. Growing degree days

Thermal units or growing degree days were calculated according to the equation.

$$GDD = \sum_{i=1}^{n} \left(\frac{T_{max} + T_{min}}{2} - Tb \right)$$

Where,

G.D.D.= Growing degree days

T_{max} = Maximum temperature of the day (^{0}C)

T_{min} = Minimum temperature of the day (^{0}C)

Tb = Base temperature for soybean:10 ^{0}C (Ghadekar, 1988), Wheat:5 ^{0}C

3.12. Statistical analysis and interpretation of the data

The data recorded on various growth and yield contributing characters and yield of crops in sequence cropping as influenced by different treatments were statistically analysed by technique of analysis of variance (Fisher, 1958) and test of significance was carried out as given by Panse and Sukhatme [1967). The ancillary and yield data of individual crop was analysed by considering randomized block design for soybean and wheat crop in cropping sequence. The data were presented in appropriate tables and depicted in graphs and figures.

CHAPTER – IV

EXPERIMENTAL FINDINGS

The results obtained from the experiment entitled "Effect of different organic inputs with *Jeevamrut* on yield, quality and soil properties of soybean – wheat cropping sequence" conducted during 2010-11 and 2011-12 are presented in this chapter under appropriate heads and subheads.

4.1. Performance of soybean in soybean-wheat

4.1.1. Plant count

4.1.1.1. Emergence count

The data presented in Table 10 revealed that the per cent values for emergence count in soybean did not differed significantly due to application of different organic inputs during both the years.

4.1.1.2. Final plant stand

The per cent values for final plant stand registered non-significant results for soybean due to application of different organic inputs during both the years.

4.1.2. Growth attributes

4.1.2.1. Plant height

The plant height of soybean was progressively increased with advancement in age of the crop. The data regarding plant height are presented in Table 11.

Application of 100 % general recommended dose of fertilizer (GRDF) recorded significantly higher value for plant height at all the growth stages of observation as compared with rest of the treatments during both the years. Among the organic treatments applied to *kharif* soybean, at 28 DAS during 2010-11, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two

Table 10. Emergence count and final plant stand of soybean (base crop) as influenced by different organic inputs

Treatment	Emergence count				Final plant stand			
	Actual plant count (ha^{-1})		Per cent value		Actual plant count (ha^{-1})		Per cent value	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
T_1 : 100 % GRDF	330308	329200	99.09	98.76	327066	326110	98.12	97.83
T_2 : 50 % RDN through FYM + 50 % RDN through VC	329271	328166	98.78	98.45	324700	325300	97.41	97.59
T_3 : 50 % RDN through VC + 50 % RDN through NSP	328167	327066	98.45	98.12	325433	323866	97.63	97.16
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	327599	326500	98.28	97.95	323133	320133	96.94	96.04
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	329605	328500	98.88	98.55	326066	325417	97.82	97.63
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	329003	327900	98.70	98.37	324500	324823	97.35	97.45
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	327866	326766	98.36	98.03	325266	322766	97.58	96.83
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	329204	328100	98.76	98.43	324866	325021	97.46	97.51
SEm $\pm$	--	--	0.29	0.27	--	--	0.41	0.63
CD at 5 %	--	--	NS	NS	--	--	NS	NS
General mean	**328878**	**327775**	**98.66**	**98.33**	**325129**	**324180**	**97.54**	**97.25**

times reported significantly higher values for plant height of soybean and recorded at par value with application of 50 % RDN through farmyard manure + 50 %RDN through vermicompost as compared with rest of the organic treatments. However, at 28 DAS during 2011-12, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported at par values

Table 11. Plant height of soybean (base crop) as influenced by different organic inputs

Treatment	Plant height (cm)							
	2010-11				2011-12			
	28 DAS	56 DAS	84 DAS	At harvest	28 DAS	56 DAS	84 DAS	At harvest
T_1 : 100 % GRDF	20.70	44.84	51.74	51.89	20.73	46.69	52.43	52.78
T_2 : 50 % RDN through FYM + 50 % RDN through VC	20.11	41.31	45.20	45.32	18.42	39.62	44.49	44.53
T_3 : 50 % RDN through VC + 50 % RDN through NSP	19.53	40.11	43.89	44.01	18.00	38.72	43.48	43.52
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	19.50	40.05	43.82	43.93	17.87	38.44	43.17	43.21
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	20.11	41.31	45.20	45.32	18.46	39.71	44.59	44.63
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	19.64	40.33	44.14	44.25	18.03	38.79	43.56	43.59
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	19.52	40.09	43.87	43.98	17.88	38.46	43.19	43.23
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	19.53	40.11	43.89	44.01	18.09	38.91	43.70	43.74
SEm ±	0.10	1.03	2.03	2.05	0.76	2.36	2.63	2.74
CD at 5 %	0.28	3.00	6.02	6.09	2.26	6.92	7.80	8.13
General mean	**19.83**	**41.02**	**45.22**	**45.34**	**18.43**	**39.92**	**44.83**	**44.90**

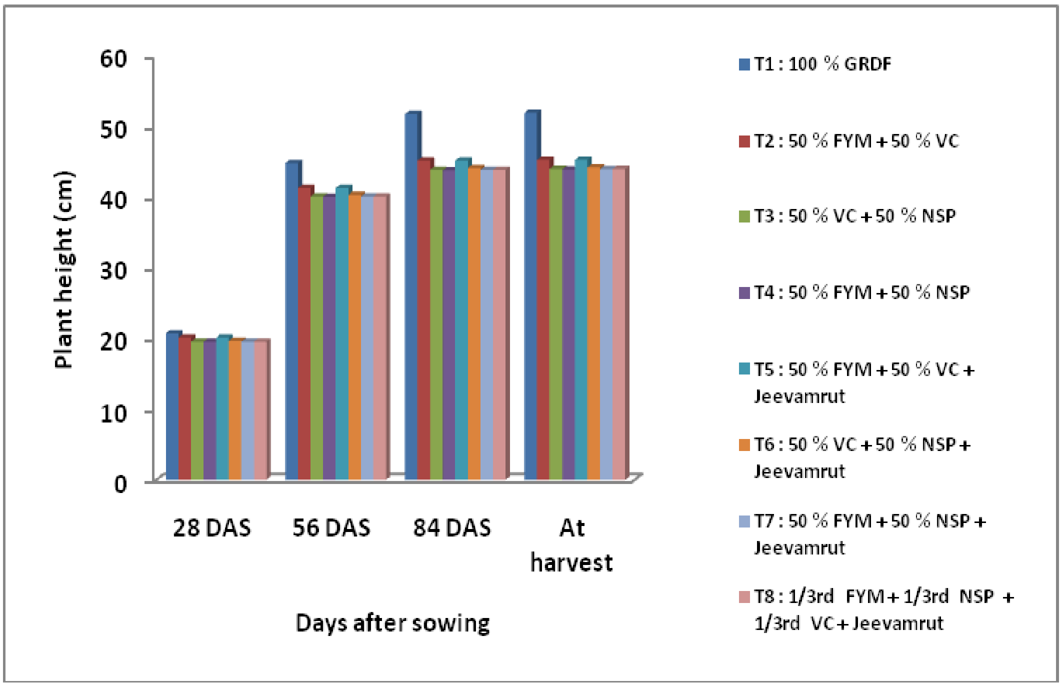


Fig. 3 : Plant height (cm) of soybean in soybean-wheat cropping system as influenced by different treatments during 2010-11

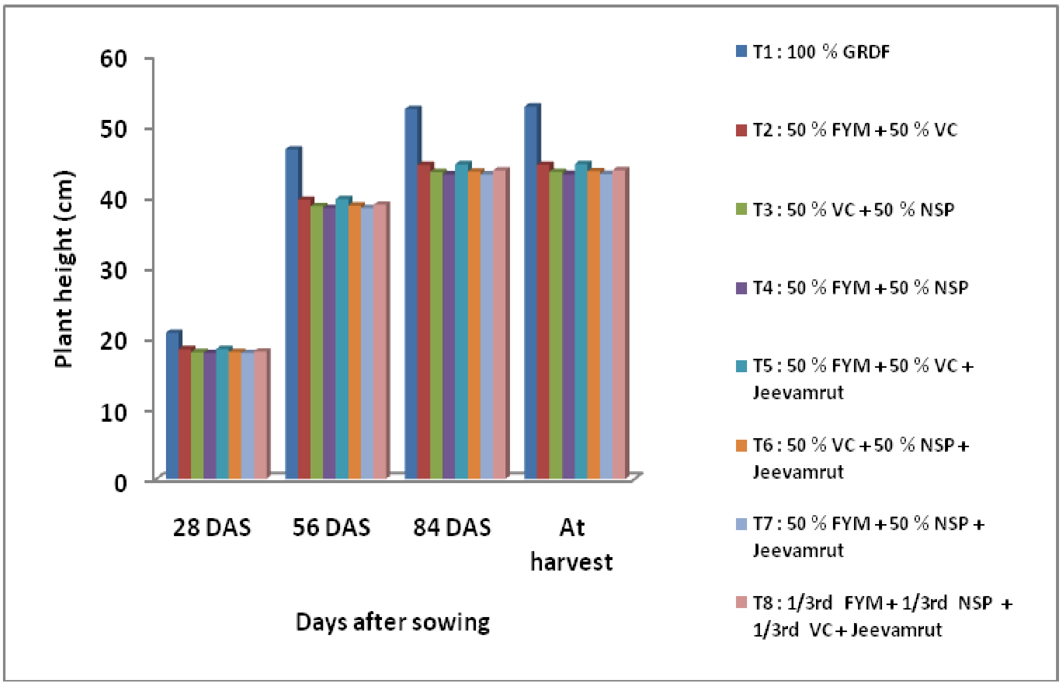


Fig. 4 : Plant height (cm) of soybean in soybean-wheat cropping system as influenced by different treatments during 2011-12

with all the organic treatments applied to *kharif* soybean. Similar trend was noticed at 56, 84 DAS and at harvest during both the years of investigation.

4.1.2.2. Number of branches plant^{-1}

The data on number of branches plant^{-1} of soybean are presented in Table 12.

Application of 100 % GRDF recorded significantly higher number of branches plant^{-1} at all the growth stages of observation as compared with rest of the treatments during both the years. Among the organic treatments applied to *kharif* soybean, at 28 DAS during 2010-11, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher number of branches plant^{-1} and recorded at par values with application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and application of 50 % RDN through vermicompost + 50 % RDN through neem seed powder + Jeevamrut two times as compared with rest of the organic treatments. However, at 28 DAS during 2011-12, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times was at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and reported significantly higher number of branches plant^{-1} as compared with rest of the organic treatments.

At 56, 84 DAS and at harvest application of the organic treatments applied to *kharif* soybean reported significantly higher number of branches plant^{-1} with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times which reported at par values with rest of the all organic treatments applied to *kharif* soybean during both the years of experimentation.

Table 12. Number of branches of soybean (base crop) as influenced by different organic inputs

Treatment	Number of branches ($plant^{-1}$)							
	2010-11				2011-12			
	28 DAS	56 DAS	84 DAS	At harvest	28 DAS	56 DAS	84 DAS	At harvest
T_1 : 100 % GRDF	2.22	5.43	6.65	6.65	2.12	5.37	6.48	6.48
T_2 : 50 % RDN through FYM + 50 % RDN through VC	2.16	5.01	5.81	5.81	2.04	4.88	5.59	5.59
T_3 : 50 % RDN through VC + 50 % RDN through NSP	2.10	4.86	5.64	5.64	1.99	4.77	5.46	5.46
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	2.09	4.85	5.63	5.63	1.98	4.74	5.43	5.42
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	2.16	5.01	5.81	5.81	2.04	4.89	5.60	5.60
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	2.11	4.89	5.67	5.67	2.00	4.78	5.47	5.47
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	2.10	4.86	5.64	5.64	1.98	4.74	5.43	5.43
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	2.10	4.86	5.64	5.64	2.00	4.79	5.49	5.49
SEm ±	0.02	0.13	0.23	0.24	0.01	0.12	0.25	0.25
CD at 5 %	0.05	0.38	0.70	0.70	0.03	0.35	0.73	0.74
General mean	**2.13**	**4.97**	**5.81**	**5.81**	**2.02**	**4.87**	**5.62**	**5.62**

4.1.2.3. Number of functional compound leaves $plant^{-1}$

The data pertaining to number of functional compound leaves $plant^{-1}$ of soybean are presented in Table 13.

Application of 100 % GRDF recorded significantly higher number of functional compound leaves $plant^{-1}$ at all the growth stages of observation as compared with rest of the treatments during both the years. Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher number of functional compound leaves plant^{-1} and recorded at par values for number of functional compound leaves plant^{-1} with application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost at 28 and 56 DAS and at harvest during 2010-11 as compared with rest of the organic treatments.

At 84 DAS, application of 50 % RDN through vermicompost + 50 % RDN through neem seed powder + Jeevamrut two times reported significantly higher number of functional compound leaves plant^{-1}, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments during 2010-11. Similar trend was observed at 28, 56 and 84 DAS during 2011-12 for number of functional compound leaves plant^{-1} as compared with rest of the treatments in soybean.

During 2011-12, at harvest, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported at par values with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost, 50 % RDN through vermicompost + 50 % RDN through neem seed powder, 50 % RDN through vermicompost + 50 % RDN through neem seed powder + Jeevamrut two times and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments.

Table 13. Number of functional compound leaves of soybean (base crop) as influenced by different organic inputs

Treatment	Number of functional compound leaves ($plant^{-1}$)							
	2010-11				2011-12			
	28 DAS	56 DAS	84 DAS	At harvest	28 DAS	56 DAS	84 DAS	At harvest
T_1 : 100 % GRDF	6.05	16.00	8.69	1.74	7.01	18.42	10.18	1.87
T_2 : 50 % RDN through FYM + 50 % RDN through VC	5.43	14.35	7.79	1.56	4.77	12.54	6.93	1.27
T_3 : 50 % RDN through VC + 50 % RDN through NSP	4.92	13.02	7.07	1.41	4.48	11.77	6.50	1.19
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	4.29	11.36	6.16	1.23	3.61	9.48	5.24	0.96
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	5.53	14.61	7.93	1.59	5.07	13.32	7.36	1.35
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	5.01	13.25	7.19	1.44	4.54	11.92	6.59	1.21
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	4.39	11.61	6.30	1.26	3.67	9.64	5.33	0.98
T_8 : $1/3^{rd}$ RDN through FYM + $1/3^{rd}$ RDN through NSP + $1/3^{rd}$ RDN through VC + Jeevamrut two times	5.34	14.11	7.66	1.53	4.70	12.35	6.83	1.25
SEm $\pm$	0.06	0.27	0.19	0.02	0.16	0.36	0.20	0.06
CD at 5 %	0.18	0.79	0.56	0.05	0.47	1.06	0.58	0.17
General mean	**5.12**	**14.26**	**7.35**	**1.47**	**4.73**	**12.96**	**6.87**	**1.26**

4.1.2.4. Leaf area $plant^{-1}$

The perusal of data on leaf area $plant^{-1}$ are presented in Table 14.

Application of 100 % GRDF recorded significantly higher value for leaf area $plant^{-1}$ at all the growth stages of observation as compared with rest of the treatments during both the years. Among the organic

Table 14. Leaf area of soybean (base crop) as influenced by different different organic inputs

Treatment	Leaf area (dm^2 $plant^{-1}$)							
	2010-11				2011-12			
	28 DAS	56 DAS	84 DAS	At harvest	28 DAS	56 DAS	84 DAS	At harvest
T_1 : 100 % GRDF	9.05	48.50	27.06	4.45	10.49	57.76	30.80	5.04
T_2 : 50 % RDN through FYM + 50 % RDN through VC	8.11	43.49	24.27	3.99	7.13	39.30	20.95	3.43
T_3 : 50 % RDN through VC + 50 % RDN through NSP	7.36	39.44	22.01	3.62	6.70	36.88	19.67	3.22
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	6.42	34.42	19.21	3.16	5.39	29.71	15.84	2.59
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	8.26	44.28	24.71	4.06	7.58	41.76	22.27	3.64
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	7.49	40.17	22.41	3.68	6.79	37.38	19.93	3.26
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	6.56	35.19	19.64	3.23	5.49	30.21	16.11	2.64
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	7.98	42.77	23.87	3.92	7.03	38.73	20.65	3.38
SEm $\pm$	0.11	0.75	0.43	0.04	0.17	1.33	0.52	0.09
CD at 5 %	0.33	2.22	1.29	0.13	0.51	3.95	1.54	0.25
General mean	**7.65**	**45.54**	**22.90**	**3.76**	**7.07**	**37.25**	**20.78**	**3.40**

treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher leaf area plant^{-1}, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments at 28, 56 and 84 DAS during 2010-11 and at 56 DAS during 2011-12 as compared with rest of the organic treatments.

At harvest during both the years and at 84 DAS during second year of experimentation, application of 50 % RDN through vermicompost + 50 % RDN through neem seed powder + Jeevamrut two times reported significantly higher value for leaf area plant^{-1}, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost as compared with rest of the organic treatments in soybean.

4.1.2.5. Dry matter plant^{-1}

The data on dry matter plant^{-1} of soybean as influenced significantly by different treatments at all the growth stages of crop growth during both the years are presented in Table 15.

The dry matter plant^{-1} increased with the advancement in the age of the crop and decreased slightly due to senescence of leaves at harvest. The rate of increase was more during 56 to 84 days of growth period. Application of 100 % GRDF recorded significantly higher value for dry matter plant^{-1} at all the growth stages of observation as compared with rest of the treatments during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher dry matter plant^{-1}, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments at 28, 56, 84 DAS and at harvest during both the years of observations.

Table 15. Dry matter of soybean (base crop) as influenced by different organic organic inputs

Treatment	Dry matter (g plant^{-1})							
	2010-11				2011-12			
	28 DAS	56 DAS	84 DAS	At harvest	28 DAS	56 DAS	84 DAS	At harvest
T_1 : 100 % GRDF	8.50	23.89	41.17	42.03	9.40	26.50	44.91	45.74
T_2 : 50 % RDN through FYM + 50 % RDN through VC	7.62	21.42	35.13	36.00	6.39	19.39	31.92	32.14
T_3 : 50 % RDN through VC + 50 % RDN through NSP	6.91	19.43	31.86	32.74	6.00	18.20	29.96	30.17
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	6.03	16.95	27.80	28.70	4.83	14.66	24.13	24.30
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	7.76	21.81	35.76	36.64	6.79	20.61	33.92	34.15
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	7.04	19.78	32.44	33.32	6.08	18.45	30.36	30.57
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	6.17	17.33	28.42	29.32	4.92	14.91	24.54	24.71
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	7.49	21.07	34.54	35.42	6.30	19.11	31.46	31.67
SEm $\pm$	0.09	0.32	0.46	0.43	0.19	0.64	0.99	1.04
CD at 5 %	0.27	0.94	1.38	1.26	0.57	1.86	2.90	3.04
General mean	**7.19**	**20.21**	**33.39**	**34.27**	**6.34**	**18.98**	**31.40**	**31.68**

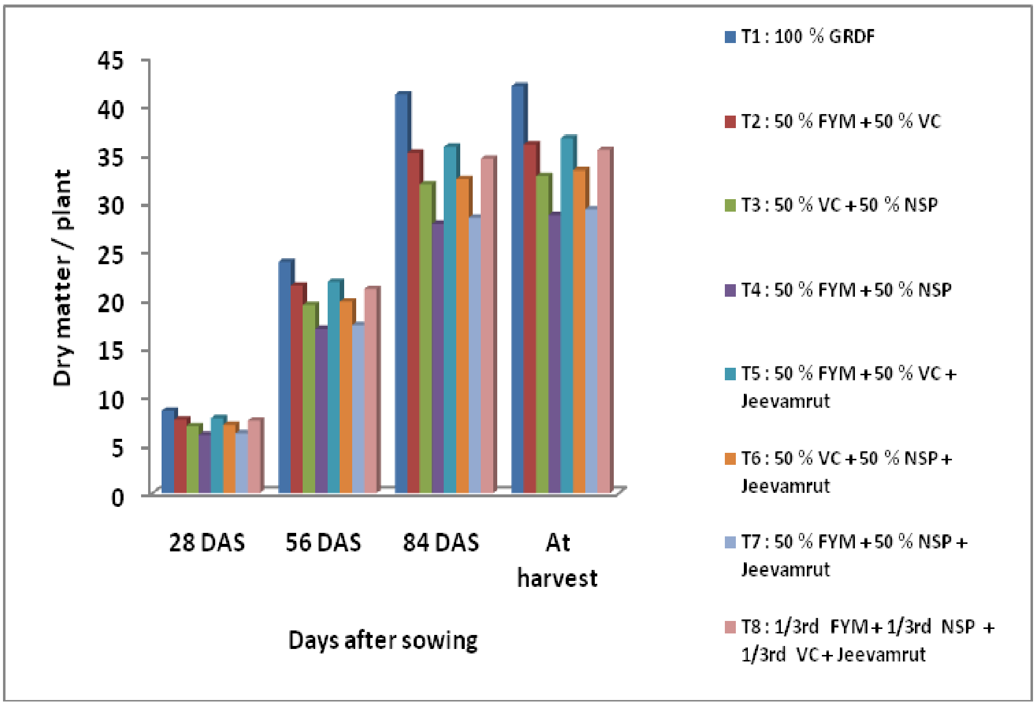


Fig. 5 : Dry matter /plant (g) of soybean in soybean-wheat cropping system as influenced by different treatments during 2010-11

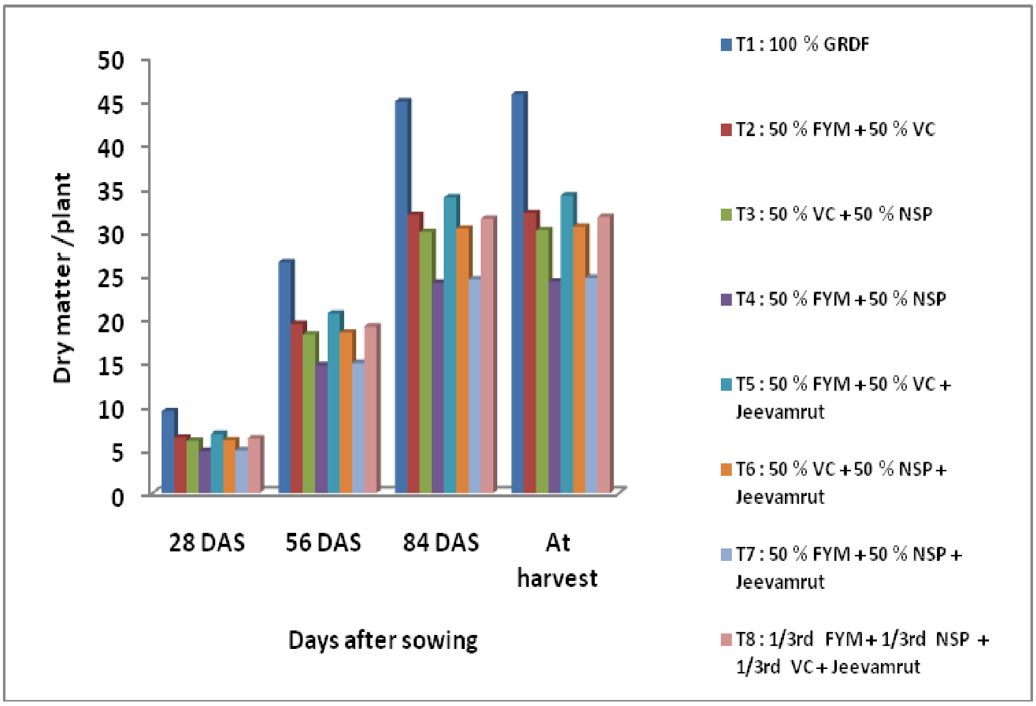


Fig. 6 : Dry matter /plant (g) of soybean in soybean-wheat cropping system as influenced by different treatments during 2011-12

4.1.2.6. Nodule count plant^{-1}

The data on nodule count plant^{-1} at flowering stage in soybean are presented in Table 16.

Application of 100 % GRDF recorded significantly higher value for nodule count plant^{-1} at all the growth stages of observation as compared with rest of the treatments during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher nodule count plant^{-1} at flowering stage during both the years of experimentation in soybean.

4.1.2.7. Days to 50 % flowering

The data on days to 50 % flowering in soybean are presented in Table 16.

Application of 100 % GRDF recorded significantly higher days to 50 % flowering as compared with rest of the treatments during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost during both the years reported significantly higher days to 50 % flowering, however, it was at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times during 2010-11 as compared with rest of the organic treatments under study.

4.1.2.8. Days to maturity

The data on days to maturity in soybean is presented in Table 16.

Application of 100 % GRDF recorded significantly higher number of days to maturity in soyeban as compared with rest of the treatments during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher number of days to maturity as compared with rest of the organic treatments during both the years of experimentation in soybean.

Table 16. Nodule count, days to 50 % flowering and days to maturity of soybean (base crop) as influenced by different organic inputs

Treatment	Nodule count (plant^{-1})		Days to 50 % flowering		Days to maturity	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
T_1 : 100 % GRDF	46.27	51.45	36	36	103	104
T_2 : 50 % RDN through FYM + 50 % RDN through VC	37.56	37.53	35	35	100	99
T_3 : 50 % RDN through VC + 50 % RDN through NSP	34.06	35.22	34	33	97	96
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	29.72	28.37	32	31	94	92
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	40.41	39.88	35	34	101	100
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	37.82	35.70	34	33	98	97
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	30.39	28.85	33	32	95	94
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	37.93	36.98	34	33	99	98
SEm $\pm$	0.53	0.56	0.22	0.20	0.63	0.56
CD at 5 %	1.59	1.64	0.65	0.61	1.89	1.69
General mean	**36.77**	**36.75**	**34**	**33**	**99**	**98**

4.1.2.9. Weed count

The perusal of data presented herein Table 17 indicated that the weed count at 21 and 35 DAS during both the years of experimentation influenced significantly due to application of different organic inputs alone or in combination each other. However, Application of 100 % GRDF recorded significantly higher weed count in soybean at 21 and 35 DAS as compared with rest of the treatments during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher weed count at 21 and 35 DAS as compared with rest of the organic treatments, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during both the years.

4.1.2.10. Dry weed weight

The perusal of data presented herein Table 17 indicated that the dry weed weight reported at 21 and 35 DAS during both the years of experimentation influenced significantly due to application of different organic inputs alone or in combination each other. However, Application of 100 % GRDF recorded significantly higher dry weed weight at 21 and 35 DAS during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher dry weed weight at 21 and 35 DAS as compared with rest of the organic treatments during 2010-11.

During 2011-12, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher dry weed weight at 21 and 35 DAS, however, it was found at par with the application of 50 % RDN through

Table 17. Weed count and dry weed weight in soybean (base crop) as influenced by different organic inputs

Treatment	Weed count (m^{-2})				Dry weed weight ($g\ m^{-2}$)			
	2010-11		2011-12		2010-11		2011-12	
	21 DAS	35 DAS	21 DAS	35 DAS	21 DAS	35 DAS	21 DAS	35 DAS
T_1 : 100 % GRDF	11.25	3.44	14.46	4.99	17.43	4.48	24.35	8.49
T_2 : 50 % RDN through FYM + 50 % RDN through VC	10.09	3.08	12.96	4.47	11.86	3.05	16.57	5.78
T_3 : 50 % RDN through VC + 50 % RDN through NSP	9.15	2.80	11.76	4.06	11.13	2.86	15.55	5.42
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	7.98	2.44	10.26	3.54	8.97	2.31	12.53	4.37
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	10.27	3.14	13.2	4.55	12.6	3.24	17.61	6.14
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	9.32	2.85	11.97	4.13	11.28	2.90	15.76	5.50
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	8.16	2.49	10.49	3.62	9.12	2.34	12.74	4.44
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	9.92	3.03	12.75	4.40	11.69	3.00	16.33	5.70
SEm $\pm$	0.13	0.04	0.16	0.06	0.17	0.04	0.56	0.20
CD at 5 %	0.37	0.11	0.47	0.16	0.52	0.13	1.67	0.58
General mean	**9.52**	**2.91**	**12.23**	**4.22**	**11.76**	**3.02**	**16.43**	**5.73**

farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments in soybean.

4.1.3. Yield attributes

4.1.3.1. Number of pods plant^{-1}

The number of pods plant^{-1} at harvest in soybean was significantly influenced due to different organic treatments during both the years (Table 18).

Application of 100 % GRDF recorded significantly higher number of pods plant^{-1}(50.73) during both the years, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during 2010-11 (48.09) and reported significantly higher number of pods plant^{-1} as compared with rest of the treatments.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher number of pods plant^{-1} during both the years, however, during 2011-12, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments.

4.1.3.2. Dry pod weight plant^{-1}

The data on dry pod weight plant^{-1} in soybean are presented in Table 18.

During both the years of experimentation, application of 100 % GRDF recorded significantly higher value for dry pod weight plant^{-1} during both the years, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during 2010-11 and reported significantly higher number of pods plant^{-1} as compared with rest of the treatments.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher dry pod weight plant^{-1} during both the years, however, during 2011-12, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost, 50 % RDN through vermicompost + 50 % RDN through neem seed powder, 50 % RDN through farmyard manure + 50 % RDN through neem seed powder and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments.

4.1.3.3. Seed weight plant^{-1}

The seed weight plant^{-1} at harvest in soybean was significantly influenced due to different organic treatments during both the years (Table 18).

Application of 100 % GRDF recorded significantly higher value for seed weight plant^{-1} during both the years, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during 2010-11 and reported significantly higher seed weight plant^{-1} as compared with rest of the treatments.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher seed weight plant^{-1} during both the years, however, during 2011-12, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments.

4.1.3.4. Test weight

The test weight at harvest in soybean was significantly influenced due to different organic treatments during both the years (Table 18).

Application of 100 % GRDF recorded significantly higher value for test weight as compared with rest of the treatments during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher test weight, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments during both the years.

Table 18. Yield attributes of soybean (base crop) as influenced by different organic inputs (2010-11 and 2011-12)

Treatment	Number of pods (plant^{-1})		Dry pod weight (g plant^{-1})		Seed weight (g plant^{-1})		Test weight (g)	
	2010-11	**2011-12**	**2010-11**	**2011-12**	**2010-11**	**2011-12**	**2010-11**	**2011-12**
T_1 : 100 % GRDF	50.73	57.29	19.51	22.54	12.83	14.65	15.41	16.99
T_2 : 50 % RDN through FYM + 50 % RDN through VC	43.66	38.81	17.04	14.93	11.10	9.81	12.30	11.79
T_3 : 50 % RDN through VC + 50 % RDN through NSP	41.17	33.57	16.06	12.91	10.46	8.49	11.60	10.20
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	37.23	33.06	14.53	12.72	9.46	8.36	10.49	10.04
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	48.09	42.14	18.76	16.21	12.22	10.65	13.55	12.80
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	41.53	37.37	16.20	14.37	10.56	9.45	11.70	11.35
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	37.60	36.85	14.67	14.17	9.56	9.32	10.60	11.20
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	43.30	41.32	16.89	15.89	11.00	10.45	12.20	12.56
SEm ±	1.67	1.22	0.70	0.72	0.46	0.37	0.46	0.44
CD at 5 %	4.89	3.58	2.09	2.12	1.37	1.09	1.37	1.28
General mean	**42.91**	**40.05**	**16.71**	**15.47**	**10.90**	**10.15**	**12.23**	**12.12**

4.1.4. Yield studies

4.1.4.1. Seed yield

The data regarding seed yield at harvest in soybean was significantly influenced due to different treatments during both the years and in pooled mean are presented in Table 19.

The perusal of data in Table 19 indicated that application of 100 % GRDF recorded significantly higher seed yield during both the years and in pooled mean.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher seed yield, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments during both the years and in pooled mean.

4.1.4.2. Straw yield

The straw yield in soybean was significantly influenced due to different treatments applied in soybean during both the years and in pooled mean. The data pertaining to it are presented in Table 19.

Application of 100 % GRDF recorded significantly higher straw yield in soybean during both the years and in pooled mean.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher straw yield, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost, 50 % RDN through vermicompost + 50 % RDN through neem seed powder and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through

Table 19. Yield of soybean (base crop) as influenced by different organic inputs

Treatment	Seed yield (Kg ha^{-1})			Straw yield (Kg ha^{-1})			Biological yield (Kg ha^{-1})			Harvest index (%)		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Mean
T_1 : 100 % GRDF	2250	2461	2355	2783	2987	2885	5032	5448	5240	44.70	45.17	44.94
T_2 : 50 % RDN through FYM + 50 % RDN through VC	2017	1674	1846	2525	2042	2283	4542	3716	4129	44.42	45.05	44.73
T_3 : 50 % RDN through VC + 50 % RDN through NSP	1829	1571	1700	2347	1977	2162	4177	3548	3863	43.80	44.28	44.04
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	1596	1266	1431	2068	1630	1849	3664	2895	3280	43.56	43.72	43.64
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	2054	1779	1917	2559	2180	2369	4613	3959	4286	44.53	44.93	44.73
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	1863	1593	1728	2339	1967	2153	4202	3559	3881	44.34	44.75	44.54
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	1632	1287	1460	2090	1653	1871	3722	2940	3331	43.85	43.78	43.82
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	1984	1650	1817	2546	2033	2290	4530	3682	4106	43.79	44.80	44.30
SEm ±	30	59	47	72	63	56	74	99	87	--	--	--
CD at 5 %	90	172	139	214	187	165	220	288	254	--	--	--
General mean	**1854**	**1546**	**1700**	**2353**	**1926**	**2140**	**4207**	**3472**	**3839**	**44.12**	**44.56**	**44.34**

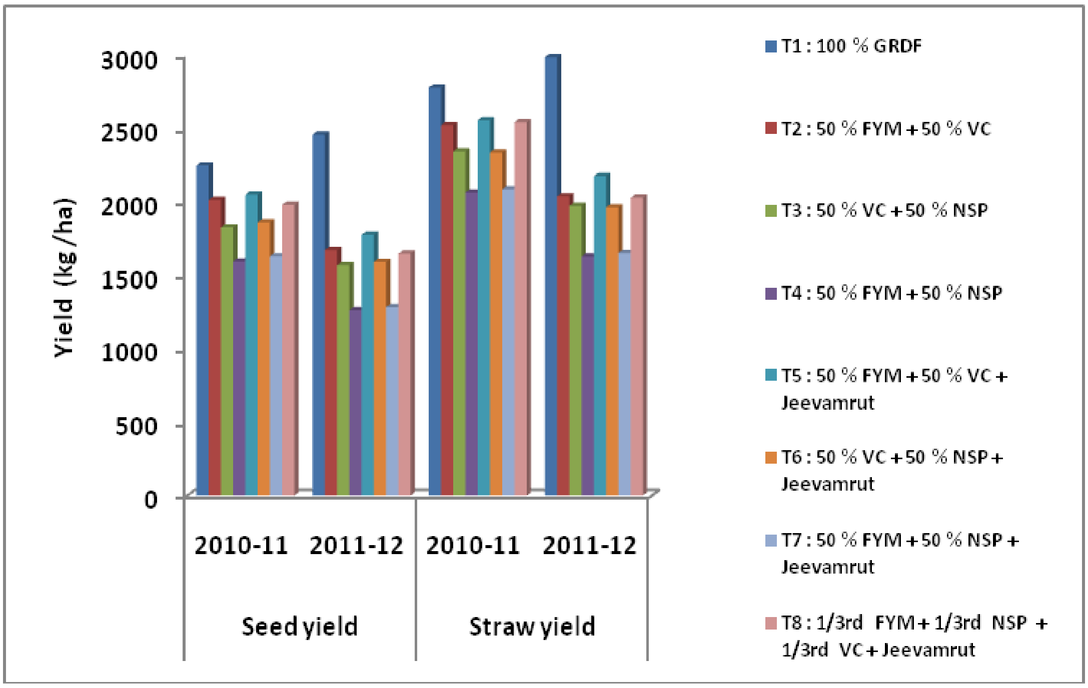


Fig. 7 : Seed and straw yield of soybean in wheat in soybean-wheat cropping system as influenced by different treatments during 2010-11 and 2011-12

vermicompost + jeevamrut two times during 2010-11. However, It was at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments during 2011-12 and in pooled mean.

4.1.4.3. Biological yield

The perusal of data regarding biological yield was significantly influenced due to different treatments during both the years and in pooled mean are presented in Table 19.

Application of 100 % GRDF recorded significantly higher value for biological yield in soybean during both the years and in pooled mean.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher biological yield, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments applied to soybean during both the years and in pooled mean.

4.1.4.4. Harvest index

The data regarding harvest index was not subjected to statistical analysis and the interpretation is done on mean basis.

Application of 100 % GRDF reported numerically maximum value for harvest index during both the years and in two years mean.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported numerically maximum value for harvest index during both the years and in two years mean. Minimum harvest index was observed with the application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder as compared with rest of the treatments.

4.1.5. Quality studies

4.1.5.1. Oil and protein content

The oil and protein content in soybean seed was found to be non significant due to application of different organic treatments during both the years.

Table 20. Quality of soybean (base crop) as influenced by different organic inputs

Treatment	Oil content (%)		Protein content (%)	
	2010-11	2011-12	2010-11	2011-12
T_1 : 100 % GRDF	18.66	19.16	40.45	40.67
T_2 : 50 % RDN through FYM + 50 % RDN through VC	18.49	18.62	40.05	39.52
T_3 : 50 % RDN through VC + 50 % RDN through NSP	18.07	18.08	39.40	38.37
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	17.94	18.05	38.89	38.28
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	18.53	18.62	40.17	39.52
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	18.10	18.18	39.25	38.59
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	17.95	18.07	38.92	38.32
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	18.16	18.07	39.36	38.35
SEm ±	0.26	0.39	0.54	0.82
CD at 5 %	NS	NS	NS	NS
General mean	**18.24**	**18.35**	**39.56**	**38.95**

4.1.6. Growth analysis studies

The growth analysis parameters *viz.*, absolute growth rate (AGR) for plant height (Table 21), absolute growth rate (AGR) for dry matter (Table 22), relative growth rate (RGR) for dry matter(Table 23), crop growth rate (CGR) (Table 24), net assimilation rate (NAR) (Table 25) and leaf area index (LAI) (Table 26) were found to be increased with advancement in age of crop up to 56 DAS, while during both the years and declined thereafter due to senescence of leaves.

Table 21. Absolute growth rate for plant height of soybean (base crop) as influenced by different organic inputs

Treatment	Absolute growth rate for plant height (cm day^{-1})							
	2010-11				2011-12			
	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest
T_1 : 100 % GRDF	0.739	0.862	0.246	0.008	0.740	0.927	0.205	0.018
T_2 : 50 % RDN through FYM + 50 % RDN through VC	0.718	0.757	0.139	0.007	0.658	0.757	0.174	0.002
T_3 : 50 % RDN through VC + 50 % RDN through NSP	0.698	0.735	0.135	0.009	0.643	0.740	0.170	0.003
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	0.696	0.734	0.135	0.011	0.638	0.735	0.169	0.004
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	0.718	0.757	0.139	0.007	0.659	0.759	0.174	0.002
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	0.701	0.739	0.136	0.008	0.644	0.741	0.170	0.003
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	0.697	0.735	0.135	0.010	0.638	0.735	0.169	0.004
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	0.698	0.735	0.135	0.007	0.646	0.744	0.171	0.003
SEm $\pm$	0.011	0.012	0.002	0.001	0.017	0.021	0.004	0.002
CD at 5 %	0.032	0.036	0.006	0.003	0.051	0.063	0.011	0.006
General mean	**0.708**	**0.757**	**0.150**	**0.008**	**0.658**	**0.767**	**0.175**	**0.005**

Table 22. Absolute growth rate for dry matter of soybean (base crop) as influenced by different organic inputs

Treatment	Absolute growth rate for dry matter (g day^{-1})							
	2010-11				2011-12			
	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest
T_1 : 100 % GRDF	0.304	0.550	0.617	0.045	0.336	0.611	0.658	0.042
T_2 : 50 % RDN through FYM + 50 % RDN through VC	0.272	0.493	0.490	0.053	0.228	0.464	0.448	0.014
T_3 : 50 % RDN through VC + 50 % RDN through NSP	0.247	0.447	0.444	0.068	0.214	0.436	0.420	0.018
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	0.215	0.390	0.388	0.090	0.173	0.351	0.338	0.021
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	0.277	0.502	0.498	0.052	0.243	0.494	0.475	0.014
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	0.251	0.455	0.452	0.063	0.217	0.442	0.425	0.016
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	0.220	0.399	0.396	0.082	0.176	0.357	0.344	0.017
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	0.268	0.485	0.481	0.055	0.225	0.458	0.441	0.015
SEm $\pm$	0.001	0.002	0.002	0.001	0.001	0.005	0.003	0.002
CD at 5 %	0.003	0.007	0.007	0.004	0.003	0.014	0.010	0.006
General mean	**0.257**	**0.465**	**0.471**	**0.063**	**0.226**	**0.451**	**0.444**	**0.020**

Application of 100 % GRDF recorded significantly higher value for different growth analysis parameters *viz.*, AGR for plant height, AGR for dry matter, RGR for dry matter, CGR, NAR and LAI as compared with rest of the treatments during both the years of experimentation. However, application of 100 % GRDF was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times for RGR for dry matter, CGR and NAR as compared with rest of the treatments during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher value for different growth analysis parameters *viz.*, AGR for plant height, AGR for dry matter, RGR for dry matter, CGR, NAR and LAI, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the treatments during both the years.

Table 23. Relative growth rate of soybean (base crop) for dry matter as influenced by different organic inputs

Treatment	Relative growth rate (g m^{-2} day^{-1}) for dry matter							
	2010-11				2011-12			
	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest
T_1 : 100 % GRDF	0.699	1.265	1.420	0.104	0.773	1.406	1.513	0.096
T_2 : 50 % RDN through FYM + 50 % RDN through VC	0.626	1.134	1.127	0.122	0.525	1.069	1.030	0.033
T_3 : 50 % RDN through VC + 50 % RDN through NSP	0.568	1.029	1.022	0.156	0.493	1.003	0.967	0.040
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	0.496	0.898	0.892	0.207	0.397	0.808	0.778	0.049
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	0.638	1.155	1.147	0.119	0.558	1.136	1.094	0.033
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	0.579	1.047	1.041	0.145	0.500	1.017	0.979	0.037
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	0.507	0.917	0.912	0.189	0.404	0.821	0.792	0.039
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	0.616	1.116	1.107	0.127	0.518	1.053	1.015	0.035
SEm ±	0.003	0.005	0.006	0.002	0.004	0.006	0.004	0.004
CD at 5 %	0.009	0.015	0.018	0.006	0.011	0.018	0.012	0.011
General mean	**0.591**	**1.070**	**1.083**	**0.146**	**0.521**	**1.039**	**1.021**	**0.045**

Significantly lowest value for different growth analysis parameters *viz.*, AGR for plant height, AGR for dry matter, RGR for dry matter, CGR, NAR and LAI was observed with the application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder as compared with rest of the treatments during both the years of experimentation.

Table 24. Crop growth rate soybean (base crop) for dry matter as influenced by different organic inputs

Treatment	Crop growth rate (g m^{-2} day^{-1})							
	2010-11				2011-12			
	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest
T_1 : 100 % GRDF	9.90	17.92	20.13	1.48	10.98	19.97	21.50	1.36
T_2 : 50 % RDN through FYM + 50 % RDN through VC	8.85	16.03	15.93	1.72	7.41	15.08	14.53	0.46
T_3 : 50 % RDN through VC + 50 % RDN through NSP	7.99	14.48	14.38	2.19	6.97	14.18	13.67	0.57
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	6.89	12.49	12.41	2.88	5.57	11.34	10.93	0.69
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	9.02	16.33	16.21	1.68	7.91	16.09	15.50	0.47
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	8.17	14.78	14.69	2.04	7.05	14.34	13.80	0.52
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	7.11	12.86	12.78	2.65	5.72	11.61	11.19	0.55
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	8.69	15.76	15.64	1.79	7.31	14.86	14.33	0.49
SEm ±	0.01	0.07	0.08	0.02	0.01	0.09	0.07	0.05
CD at 5 %	0.02	0.21	0.24	0.06	0.02	0.27	0.21	0.15
General mean	**8.33**	**15.08**	**15.27**	**2.05**	**7.36**	**14.68**	**14.43**	**0.64**

Table 25. Net assimilation rate of soybean (base crop) for dry matter as influenced by different organic inputs

Treatment	Net assimilation rate (g m^{-2} day^{-1})							
	2010-11				2011-12			
	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest
T_1 : 100 % GRDF	0.699	1.265	1.420	0.104	0.773	1.406	1.513	0.096
T_2 : 50 % RDN through FYM + 50 % RDN through VC	0.626	1.134	1.127	0.122	0.525	1.069	1.030	0.033
T_3 : 50 % RDN through VC + 50 % RDN through NSP	0.568	1.029	1.022	0.156	0.493	1.003	0.967	0.040
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	0.496	0.898	0.892	0.207	0.397	0.808	0.778	0.049
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	0.638	1.155	1.147	0.119	0.558	1.136	1.094	0.033
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	0.579	1.047	1.041	0.145	0.500	1.017	0.979	0.037
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	0.507	0.917	0.912	0.189	0.404	0.821	0.792	0.039
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	0.616	1.116	1.107	0.127	0.518	1.053	1.015	0.035
SEm ±	0.004	0.007	0.005	0.002	0.004	0.007	0.006	0.003
CD at 5 %	0.011	0.021	0.015	0.006	0.012	0.021	0.018	0.009
General mean	**0.591**	**1.070**	**1.083**	**0.146**	**0.521**	**1.039**	**1.021**	**0.045**

Table 26. Leaf area index of soybean (base crop) for dry matter as influenced by different organic inputs

Treatment	Leaf area index							
	2010-11				2011-12			
	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest
T_1 : 100 % GRDF	0.402	2.156	1.203	0.198	0.466	2.567	1.369	0.224
T_2 : 50 % RDN through FYM + 50 % RDN through VC	0.361	1.933	1.079	0.177	0.317	1.747	0.931	0.152
T_3 : 50 % RDN through VC + 50 % RDN through NSP	0.327	1.753	0.978	0.161	0.298	1.639	0.874	0.143
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	0.285	1.530	0.854	0.140	0.240	1.321	0.704	0.115
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	0.367	1.968	1.098	0.180	0.337	1.856	0.990	0.162
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	0.333	1.785	0.996	0.164	0.302	1.661	0.886	0.145
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	0.292	1.564	0.873	0.143	0.244	1.343	0.716	0.117
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	0.355	1.901	1.061	0.174	0.312	1.721	0.918	0.150
SEm $\pm$	0.005	0.024	0.009	0.004	0.007	0.030	0.091	0.003
CD at 5 %	0.015	0.071	0.025	0.012	0.021	0.087	0.270	0.009
General mean	**0.340**	**1.824**	**1.018**	**0.167**	**0.314**	**1.732**	**0.923**	**0.151**

4.1.8. Cumulative growing degree days

The cumulative growing degree days (CGDD) required for attaining the different statges of observations were significantly influenced due to application of organic treatments in soybean during both the years (Table 27).

The perusal of data in Table 27 indicated that application of 100 % GRDF recorded significantly higher value for CGDD at establishment stage, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during 2010-11 and with 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during 2011-12 as compared with rest of the treatments.

The vegetative stage in soybean was attained with significantly higher value of CGDD with the application of 100 % GRDF during both the years, however, among different organic treatments applied in soybean, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher value for CGDD, which was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost during both the years and with 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2010-11 as compared with rest of the organic treatments.

The application of 100 % GRDF reported significantly higher CGDD to attain the flowering stage in soybean during both the years, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during 2010-11. Among different organic treatments applied to soybean, application of 50 % RDN through farmyard manure + 50 %

Table 27. Cumulative growing degree days in soybean (base crop) as influenced by different organic inputs

Treatment	Cumulative growing degree days (CGDD)									
	Establishment stage		Vegetative stage		Flowering		Pod setting and pod filling		Physiological maturity	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
T_1 : 100 % GRDF	178	213	681	846	1072	1371	1556	1978	1718	2154
T_2 : 50 % RDN through FYM + 50 % RDN through VC	178	190	648	824	1040	1329	1507	1915	1654	2119
T_3 : 50 % RDN through VC + 50 % RDN through NSP	161	190	632	802	1008	1266	1458	1852	1605	2063
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	161	190	600	758	976	1224	1389	1769	1540	1956
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	178	213	648	824	1056	1329	1507	1915	1670	2101
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	161	190	632	802	1024	1287	1475	1873	1622	2063
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	161	190	616	780	992	1245	1423	1811	1573	1999
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	161	190	648	802	1024	1308	1491	1894	1638	2085
SEm ±	1.48	2.73	4.86	6.55	7.55	9.43	12.87	16.61	17.63	19.32
CD at 5 %	4.32	7.98	14.23	19.43	22.41	27.98	38.44	49.30	52.33	57.34
General mean	**167**	**196**	**638**	**805**	**1024**	**1295**	**1476**	**1876**	**1627**	**2068**

RDN through vermicompost + Jeevamrut two times reported significantly higher value for CGDD, which was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments.

The application of 100 % GRDF reported significantly higher CGDD required to attain the pod setting and pod filling stage during both the years. Among different organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher value for CGDD, which was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2010-11 and with 50 % RDN through vermicompost + 50 % RDN through neem seed powder + Jeevamrut two times, 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments applied to soybean.

The application of 100 % GRDF reported significantly higher CGDD required to attain the physiological stage during both the years. However, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2010-11 and with 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard

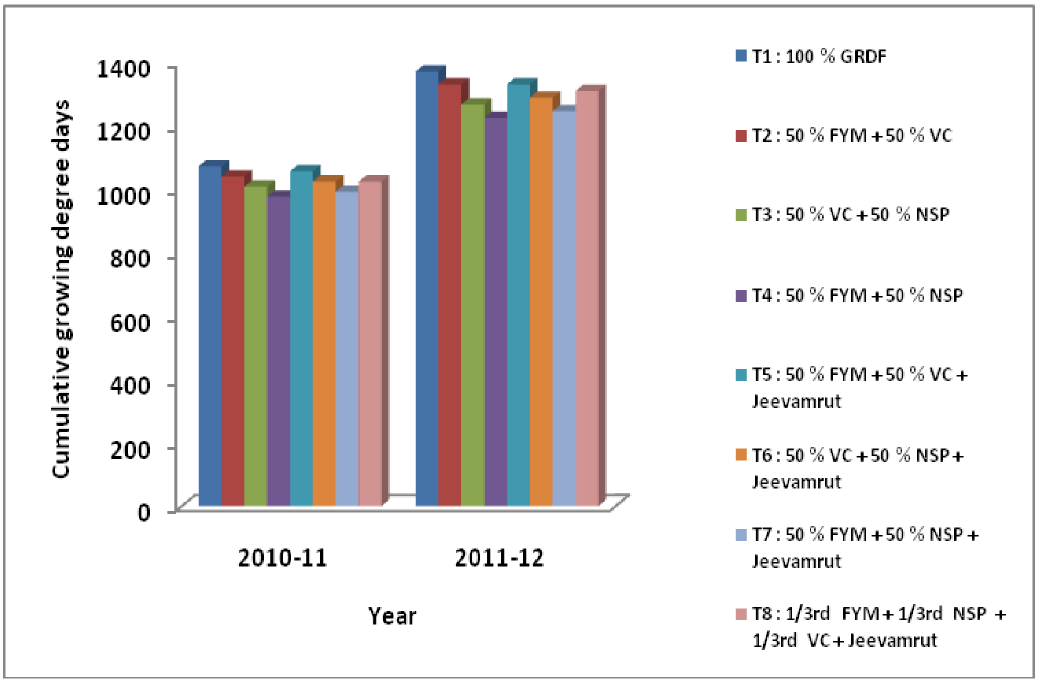


Fig. 8 : Cumulative growing degree days required to attain the flowering stage in wheat in soybean-wheat cropping system as influenced by different treatments

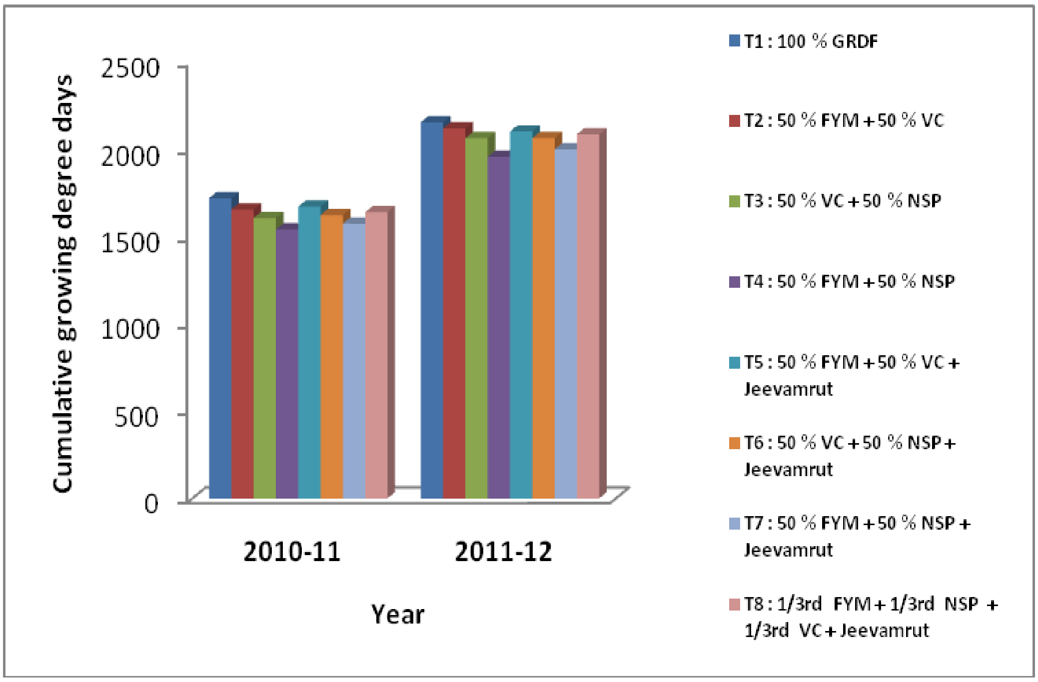


Fig. 9 : Cumulative growing degree days required to attain the physiological maturity stage in wheat in soybean-wheat cropping system as influenced by different treatments

manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2011-12.

Significantly lowest value for CGDD was reported with the application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder as compared with rest of the treatments applied to soybean during both the years of experimentation.

4.2. Performance of wheat in soybean-wheat cropping sequence

4.2.1. Plant count

4.2.1.1. Emergence count

The data presented in Table 28 revealed that the per cent values for emergence count in wheat did not differed significantly due to application of different organic inputs during both the years.

Table 28. Emergence count and final plant stand of wheat (sequence crop) as influenced by different organic inuts

Treatment	Emergence count (m^{-1} row length)		Final plant stand (m^{-1} row length)	
	2010-11	2011-12	2010-11	2011-12
T_1 : 100 % GRDF	40	41	38	39
T_2 : 50 % RDN through FYM + 50 % RDN through VC	39	41	37	38
T_3 : 50 % RDN through VC + 50 % RDN through NSP	39	40	36	36
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	37	39	36	37
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	41	41	37	39
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	40	40	37	37
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	39	39	36	37
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	40	41	36	38
SEm $\pm$	1.41	0.74	0.69	1.02
CD at 5 %	NS	NS	NS	NS
General mean	**39**	**40**	**37**	**38**

4.2.1.2. Final plant stand

The per cent values for final plant stand registered non-significant results for wheat due to application of different organic inputs during both the years.

4.2.2. Growth attributes

4.2.2.1. Plant height

The plant height of wheat was progressively increased with advancement in age of the crop. The data regarding plant height are presented in Table 29.

Application of 100 % GRDF recorded significantly higher value for plant height at all the growth stages of observation as compared with rest of the treatments during both the years. Among the organic treatments applied to *kharif* soybean, at 28 DAS during 2010-11, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for plant height of wheat and recorded at par value with application of 50 % RDN through farmyard manure + 50 %RDN through vermicompost during both the years, however, similar values were also reported with the application of 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times at 28 DAS during 2011-12.

At 56, 84 DAS and at harvest during both the years of investigation, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times recorded significantly higher value for plant height and also was found at par with rest of the organic treatments under study during both the years of experimentation.

Table 29. Plant height of wheat (sequence crop) as influenced by different organic inputs

Treatment	Plant height (cm)							
	2010-11				2011-12			
	28 DAS	56 DAS	84 DAS	At harvest	28 DAS	56 DAS	84 DAS	At harvest
T_1 : 100 % GRDF	29.64	66.27	94.86	95.10	33.06	72.73	100.20	101.15
T_2 : 50 % RDN through FYM + 50 % RDN through VC	28.81	61.06	82.88	83.06	31.85	66.11	86.45	87.23
T_3 : 50 % RDN through VC + 50 % RDN through NSP	27.97	59.29	80.48	80.65	31.13	64.61	84.49	85.25
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	27.92	59.19	80.34	80.51	30.90	64.15	83.88	84.64
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	28.81	61.06	82.88	83.06	31.92	66.25	86.64	87.42
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	28.13	59.62	80.92	81.09	31.18	64.72	84.63	85.39
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	27.96	59.26	80.43	80.60	30.92	64.18	83.93	84.68
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	27.97	59.29	80.48	80.65	31.28	64.93	84.91	85.67
SEm $\pm$	0.12	0.71	1.33	1.36	0.23	1.14	1.86	1.93
CD at 5 %	0.37	2.07	3.94	4.03	0.67	3.33	5.53	5.72
General mean	**28.40**	**60.63**	**82.91**	**83.09**	**31.53**	**65.96**	**86.89**	**87.68**

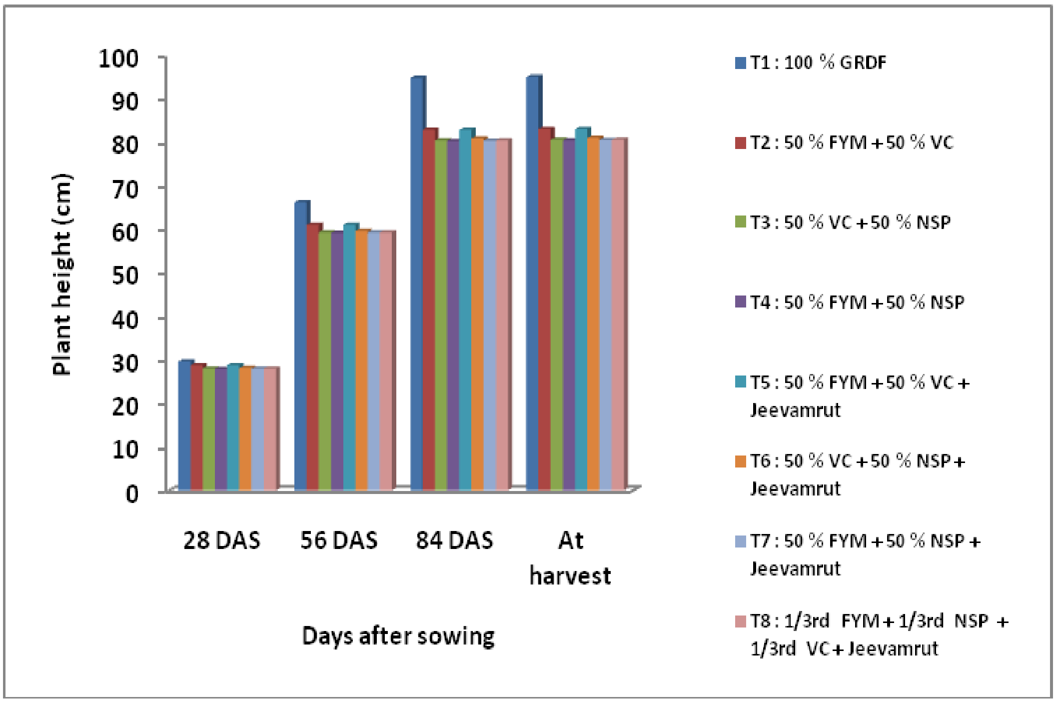


Fig. 10 : Planat height (cm) of wheat in soybean-wheat cropping system as influenced by different treatments during 2010-11

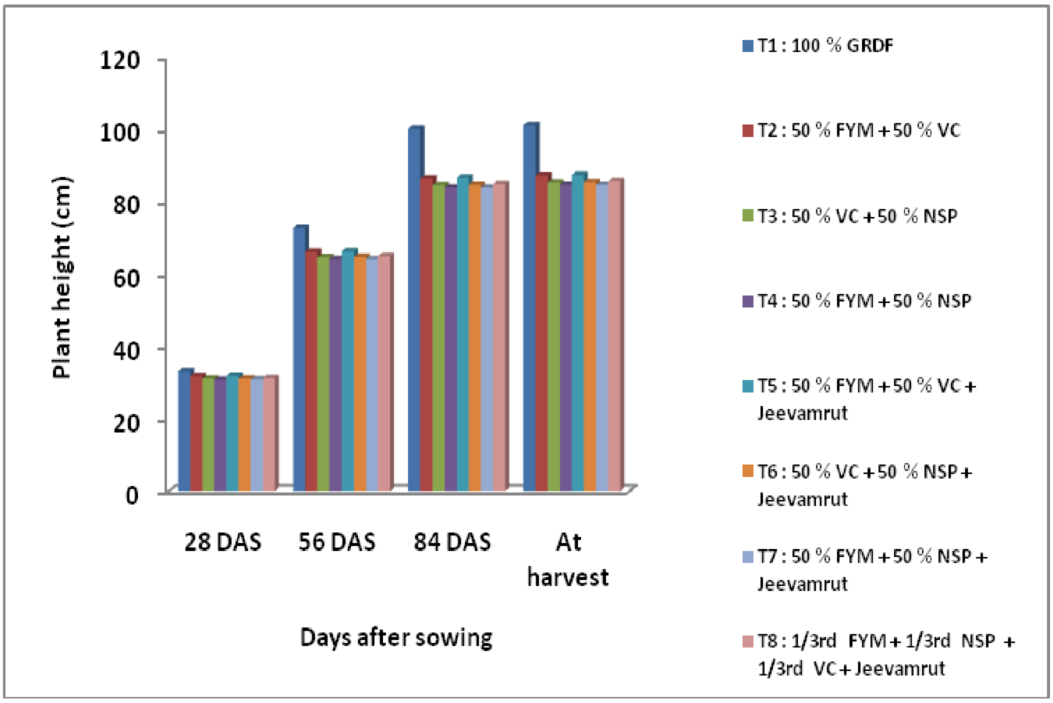


Fig. 11 : Plant height (cm) of wheat in soybean-wheat cropping system as influenced by different treatments during 2011-12

4.1.2.2. Number of tillers m^{-1} row length

The data on number of tillers m^{-1} row length in wheat are presented in Table 30.

Application of 100 % GRDF recorded significantly higher number of tillers m^{-1} row length at all the growth stages of observation as compared with rest of the treatments during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher number of tillers m^{-1} row length and recorded at par values for number of tillers m^{-1} row length with application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times at 28, 56, and 84 DAS and at harvest during 2010-11 as compared with rest of the organic treatments.

However, during 2011-12, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher number of tillers m^{-1} row length, and it was found at par with the application of 50 % RDN through vermicompost/farmyard manure + 50 % RDN through neem seed powder + Jeevamrut two times and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times at at all the days of observations and at harvest as compared with rest of the organic treatments.

Table 30. Number of tillers m^{-1} row length of wheat (sequence crop) as influenced by different organic inputs

Treatment	Number of tillers m^{-1} row length							
	2010-11				2011-12			
	28 DAS	56 DAS	84 DAS	At harvest	28 DAS	56 DAS	84 DAS	At harvest
T_1 : 100 % GRDF	68.50	126.60	117.71	116.33	84.20	146.30	141.25	139.97
T_2 : 50 % RDN through FYM + 50 % RDN through VC	49.61	91.69	85.25	84.25	64.41	111.92	108.05	107.07
T_3 : 50 % RDN through VC + 50 % RDN through NSP	46.78	86.45	80.38	79.43	55.72	96.83	93.48	92.64
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	42.31	78.19	72.70	71.84	54.86	95.34	92.04	91.21
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	54.65	101.00	93.90	92.80	69.93	121.52	117.32	116.26
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	47.19	87.22	81.09	80.14	62.02	107.77	104.05	103.10
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	42.72	78.96	73.41	72.55	61.16	106.28	102.60	101.67
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	49.20	90.92	84.53	83.54	68.58	119.17	115.05	114.01
SEm $\pm$	2.49	4.26	3.97	3.18	4.12	6.40	4.66	4.61
CD at 5 %	7.39	12.47	11.78	9.44	12.23	18.75	13.83	13.67
General mean	**50.12**	**92.63**	**86.12**	**85.11**	**65.11**	**113.14**	**109.23**	**108.24**

4.1.2.3. Number of functional leaves plant^{-1}

The data pertaining to number of functional leaves plant^{-1} of wheat are presented in Table 31.

Application of 100 % GRDF recorded significantly higher value for number of functional leaves plant^{-1} at all the growth stages of observation as compared with rest of the treatments during both the years, except that at 28 and 56 DAS, it was at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times as compared with rest of the treatments.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher number of functional leaves plant^{-1}, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times at all the days during 2010-11 except that at 84 DAS and at harvest it was at par with the application of 50 % RDN through vermicompost + 50 % RDN through neem seed powder + Jeevamrut two times.

During 2011-12, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher number of functional leaves plant^{-1}, however, it was found at par with the application of 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times at all the days, except that at harvest during 2011-12, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost, 50 % RDN through vermicompost + 50 % RDN through neem seed powder + jeevamrut two times and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times.

Table 31. Number of functional leaves plant^{-1} of wheat (sequence crop) as influenced by different organic inputs

Treatment	Number of functional leaves plant^{-1}							
	2010-11				2011-12			
	28 DAS	56 DAS	84 DAS	At harvest	28 DAS	56 DAS	84 DAS	At harvest
T_1 : 100 % GRDF	4.07	9.73	4.80	1.54	4.28	9.87	4.84	2.02
T_2 : 50 % RDN through FYM + 50 % RDN through VC	2.95	7.05	3.47	1.12	3.27	7.55	3.70	1.54
T_3 : 50 % RDN through VC + 50 % RDN through NSP	2.78	6.65	3.28	1.05	2.83	6.53	3.20	1.34
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	2.52	6.01	2.96	0.95	2.79	6.43	3.15	1.31
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	3.25	7.76	3.83	1.23	3.56	8.20	4.02	1.68
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	2.81	6.70	3.30	1.06	3.15	7.27	3.56	1.49
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	2.54	6.07	2.99	0.96	3.11	7.17	3.51	1.47
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	2.93	6.99	3.45	1.11	3.49	8.04	3.94	1.64
SEm ±	0.12	0.28	0.19	0.06	0.09	0.12	0.07	0.07
CD at 5 %	0.36	0.83	0.57	0.18	0.27	0.36	0.22	0.20
General mean	**2.98**	**7.12**	**3.51**	**1.13**	**3.31**	**7.63**	**3.74**	**1.56**

4.1.2.4. Leaf area plant^{-1}

The data on leaf area plant^{-1} of wheat as influenced significantly by different treatments at all the growth stages of crop growth during both the years are presented in Table 32.

The leaf area plant^{-1} increased with the advancement in the age of the crop and decreased slightly due to senescence of leaves at harvest. The rate of increase was more during 28 to 56 days of growth period.

Application of 100 % GRDF recorded significantly higher value for leaf area plant^{-1} at all the growth stages of observation as compared with rest of the treatments during both the years, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times at 28 DAS during 2011-12.

Table 32. Leaf area of wheat (sequence crop) as influenced by different organic inputs

Treatment	Leaf area (dm^2 plant^{-1})							
	2010-11				2011-12			
	28 DAS	56 DAS	84 DAS	At harvest	28 DAS	56 DAS	84 DAS	At harvest
T_1 : 100 % GRDF	4.47	21.51	12.37	2.71	4.96	23.86	12.87	3.67
T_2 : 50 % RDN through FYM + 50 % RDN through VC	3.24	15.58	8.96	1.97	3.79	18.25	9.85	2.81
T_3 : 50 % RDN through VC + 50 % RDN through NSP	3.05	14.69	8.45	1.85	3.28	15.79	8.52	2.43
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	2.76	13.29	7.64	1.68	3.23	15.55	8.39	2.39
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	3.57	17.16	9.87	2.16	4.12	19.82	10.69	3.05
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	3.08	14.82	8.52	1.87	3.65	17.57	9.48	2.71
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	2.79	13.42	7.71	1.69	3.60	17.33	9.35	2.67
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	3.21	15.45	8.88	1.95	4.04	19.43	10.49	2.99
SEm $\pm$	0.15	0.66	0.84	0.14	0.09	0.95	0.40	0.20
CD at 5 %	0.44	1.95	2.49	0.42	0.27	2.81	1.19	0.58
General mean	**3.27**	**15.74**	**9.05**	**1.99**	**3.83**	**18.45**	**9.96**	**2.84**

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher leaf area plant^{-1}, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments at 28, 56, 84 DAS and at harvest during both the years of experimentation, except that it was found at par with the application of 50 % RDN through farmyard manure post + 50 % RDN through neem seed powder + jeevamrut two times at 84 DAS during 2010-11 and at 56 DAS and at harvest during 2011-12.

4.1.2.6. Dry matter plant^{-1}

The data on dry matter plant^{-1} of wheat as influenced significantly by different treatments at all the growth stages of crop growth during both the years are presented in Table 33.

The dry matter plant^{-1} increased with the advancement in the age of the crop and decreased slightly due to senescence of leaves at harvest. The rate of increase was more during 56 to 84 days of growth period. Application of 100 % GRDF recorded significantly higher value for dry matter plant^{-1} at all the growth stages of observation as compared with rest of the treatments during both the years, however it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times at 56, 84 DAS and at harvest during 2010-11.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher dry matter plant^{-1} as comopared with rest of the treatments at all the days of observations during both the years, except that it was found at par with the application of 50 % RDN through vermicompost + 50 % RDN through neem seed powder + Jeevamrut two times, 50 % RDN through vermicompost + 50 % RDN through neem seed powder and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times at 28 DAS during both the years. At 56 DAS during 2011-12 it was also found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost as compared with rest of the organic treatments.

Table 33. Dry matter of wheat (sequence crop) as influenced by different organic inputs

Treatment	Dry matter plant^{-1} (g plant^{-1})							
	2010-11				2011-12			
	28 DAS	56 DAS	84 DAS	At harvest	28 DAS	56 DAS	84 DAS	At harvest
T_1 : 100 % GRDF	1.39	3.80	6.79	7.39	1.69	4.03	7.42	8.11
T_2 : 50 % RDN through FYM + 50 % RDN through VC	1.01	2.75	4.92	5.36	1.30	3.09	5.68	6.20
T_3 : 50 % RDN through VC + 50 % RDN through NSP	0.95	2.59	4.64	5.05	1.12	2.67	4.91	5.37
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	0.86	2.35	4.20	4.57	1.10	2.63	4.84	5.28
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	1.11	3.03	5.42	5.90	1.41	3.35	6.17	6.73
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	0.96	2.62	4.68	5.09	1.25	2.97	5.47	5.97
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	0.87	2.37	4.24	4.61	1.23	2.93	5.39	5.89
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	1.00	2.73	4.88	5.31	1.38	3.29	6.05	6.60
SEm ±	0.06	0.08	0.13	0.17	0.07	0.11	0.16	0.18
CD at 5 %	0.18	0.22	0.39	0.50	0.21	0.32	0.46	0.51
General mean	**1.02**	**2.78**	**4.97**	**5.41**	**1.31**	**3.12**	**5.74**	**6.27**

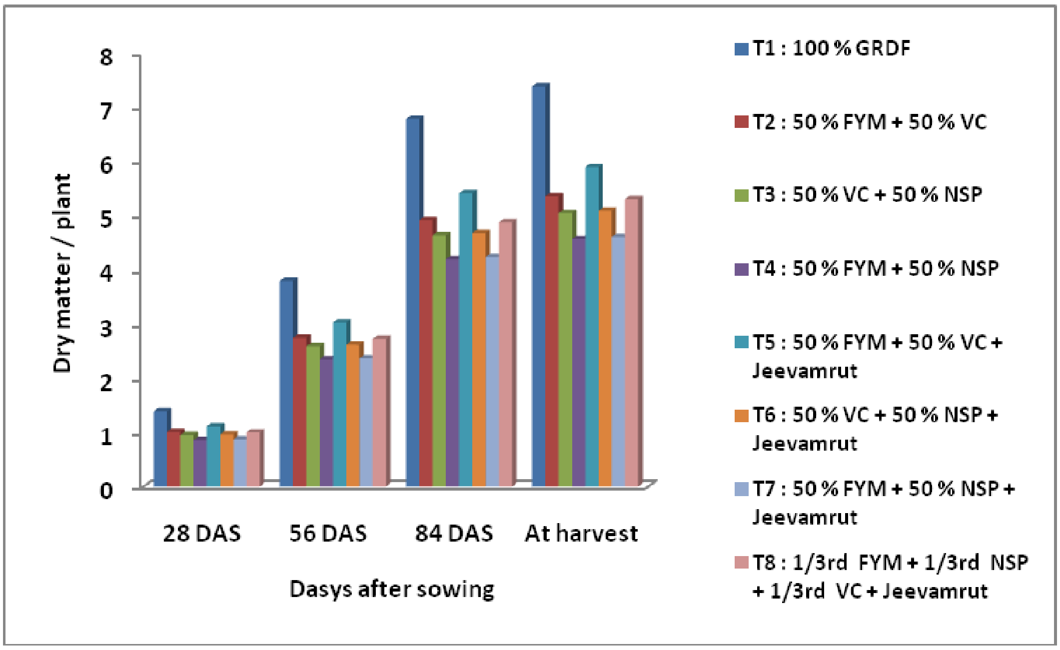


Fig. 12 : Dry matter /plant of wheat in soybean-wheat cropping system as influenced by different treatments during 2010-11

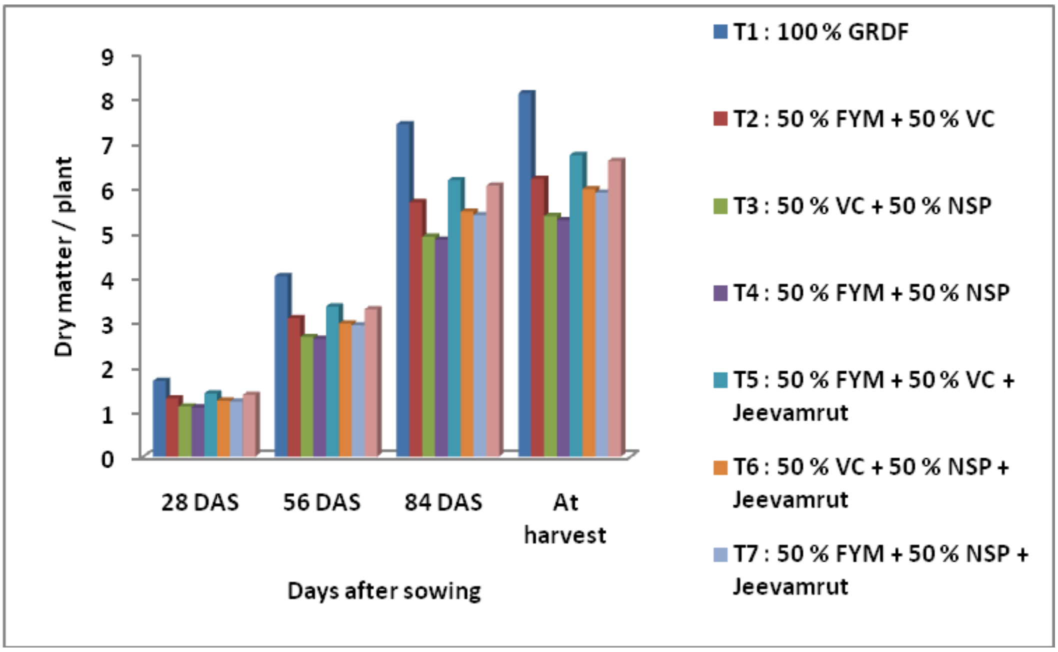


Fig. 13 : Dry matter /plant of wheat in soybean-wheat cropping system as influenced by different treatments during 2011-12

4.2.2.7. Days to 50 % flowering

The data on days to 50 % flowering in wheat are presented in Table 34. Application of 100 % GRDF recorded significantly higher days to 50 % flowering as compared with rest of the treatments during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost during both the years reported significantly higher days to 50 % flowering, however, it was at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times during 2010-11 and with 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2011-12 as compared with rest of the treatments under study.

4.2.2.9. Days to maturity

The data on days to maturity in wheat is presented in Table 34.

Application of 100 % GRDF recorded significantly higher number of days to maturity in wheat as compared with rest of the treatments during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher number of days to maturity, however, it was at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during as compared with rest of the treatments during both the years of experimentation in wheat.

Table 34. Days to 50 % flowering and days to maturity of wheat (sequence crop) as influenced by different organic inputs

Treatment	Days to 50 % flowering		Days to maturity	
	2010-11	2011-12	2010-11	2011-12
T_1 : 100 % GRDF	65	67	115	118
T_2 : 50 % RDN through FYM + 50 % RDN through VC	63	64	111	112
T_3 : 50 % RDN through VC + 50 % RDN through NSP	60	61	107	107
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	58	60	102	105
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	63	65	111	114
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	61	63	108	111
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	59	62	105	109
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	62	64	109	113
SEm $\pm$	0.30	0.42	0.75	0.70
CD at 5 %	0.90	1.26	2.24	2.09
General mean	**62**	**63**	**109**	**112**

4.2.2.10. Weed count

The perusal of data presented herein Table 35 indicated that the weed count at 21 and 35 DAS during both the years influenced significantly due to application of different organic inputs. However, application of 100 % GRDF recorded significantly higher weed count in wheat at 21 and 35 DAS as compared with rest of the treatments during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher weed count at 21 and 35 DAS as compared with rest of the organic treatments, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2010-11.

During 2011-12, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher weed count at 21 and 35 DAS as compared with rest of the organic treatments, however, it was found at par with the application of 50 % RDN through vermicompost + 50 % RDN through neem seed powder + Jeevamrut two times, 50 % RDN through farmyard manure/neem seed powder + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the treatments.

4.2.2.11. Dry weed weight

The perusal of data presented herein Table 35 indicated that the dry weed weight reported at 21 and 35 DAS during both the years of experimentation influenced significantly due to application of different organic inputs alone or in combination each other. However, application of 100 % GRDF recorded significantly higher dry weed weight at 21 and 35 DAS during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher dry weed weight at 21 and 35 DAS as compared with rest of the organic treatments during 2010-11.

During 2011-12, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher dry weed weight at 21 and 35 DAS, however, it was found at par with the application of 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments in wheat.

Table 35. Weed count in wheat (sequence crop) as influenced by different treatments

Treatment	Weed count (m^{-2})				Dry weed weight ($g\ m^{-2}$)			
	2010-11		2011-12		2010-11		2011-12	
	21 DAS	35 DAS	21 DAS	35 DAS	21 DAS	35 DAS	21 DAS	35 DAS
T_1 : 100 % GRDF	12.64	3.86	20.01	6.90	18.42	4.73	25.72	8.97
T_2 : 50 % RDN through FYM + 50 % RDN through VC	10.26	3.14	14.49	5.00	12.55	3.23	18.91	6.59
T_3 : 50 % RDN through VC + 50 % RDN through NSP	9.90	3.03	13.66	4.71	11.09	2.85	16.36	5.71
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	9.33	2.85	12.36	4.26	10.96	2.82	16.11	5.62
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	10.89	3.33	15.96	5.51	13.15	3.38	20.54	7.16
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	9.95	3.04	13.78	4.75	12.00	3.08	18.21	6.35
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	9.39	2.87	12.48	4.31	11.88	3.05	17.96	6.26
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	10.20	3.12	14.37	4.96	12.95	3.33	20.14	7.02
SEm ±	0.25	0.08	0.86	0.30	0.35	0.09	0.40	0.14
CD at 5 %	0.73	0.22	2.56	0.88	1.06	0.27	1.21	0.42
General mean	**10.32**	**3.15**	**14.64**	**5.05**	**12.88**	**3.31**	**19.24**	**6.71**

4.1.3. Yield attributes

4.1.3.1. Number of panicles m^{-1} row length

The number of panicles m^{-1} row length in wheat was significantly influenced due to different organic treatments during both the years (Table 36).

Application of 100 % GRDF recorded significantly higher number of panicles m^{-1} row length in wheat as compared with rest of the treatments during both the years.

Among the different organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher number of panicles m^{-1} row length in wheat during both the years, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments during both the years.

4.1.3.2. Number of grains panicle^{-1}

The data on number of grains panicle^{-1} in wheat are presented in Table 36.

During both the years, application of 100 % GRDF recorded significantly higher value for number of grains panicle^{-1} as compared with rest of the treatments.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher number of grains panicle^{-1} during both the years, however, during 2011-12, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and during 2011-12, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments.

4.2.3.4. 1000 grain weight

The 1000 grain weight at harvest in wheat was significantly influenced due to different organic treatments during both the years (Table 36).

Application of 100 % GRDF recorded significantly higher value for 1000 grain weight as compared with rest of the treatments during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher 1000 grain weight, however, it was at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost during both the year. During 2011-12, it was also at par with the application of 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments.

4.2.3.5. Grain yield plant^{-1}

The grain yield plant^{-1} at harvest in wheat was significantly influenced due to different organic treatments during both the years (Table 36).

Table 36. Yield attributes of wheat (sequence crop) as influenced by different organic inputs

Treatment	Number of panicles (m^{-1} row length)		Number of grains ($panicle^{-1}$)		'1000' grain weight (g)		Grain yield (g $plant^{-1}$)	
	2010-11	**2011-12**	**2010-11**	**2011-12**	**2010-11**	**2011-12**	**2010-11**	**2011-12**
T_1 : 100 % GRDF	126.60	131.90	48.00	50.13	43.76	45.40	23.9	23.5
T_2 : 50 % RDN through FYM + 50 % RDN through VC	91.69	100.90	34.76	38.35	31.70	34.73	17.3	18.0
T_3 : 50 % RDN through VC + 50 % RDN through NSP	86.45	87.29	32.78	33.18	29.88	30.05	16.3	15.6
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	78.19	85.95	29.65	32.67	27.03	29.58	14.8	15.3
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	101.00	109.55	38.29	41.64	34.91	37.71	19.1	19.5
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	87.22	97.16	33.07	36.93	30.15	33.44	16.5	17.3
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	78.96	95.81	29.94	36.42	27.29	32.98	14.9	17.1
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	90.92	107.44	34.47	40.84	31.43	36.98	17.2	19.2
SEm $\pm$	4.16	4.18	1.19	1.45	1.13	1.20	0.06	0.07
CD at 5 %	12.18	12.23	3.54	4.23	3.32	3.51	0.18	0.21
General mean	**92.63**	**102.00**	**35.12**	**38.77**	**32.02**	**35.11**	**17.5**	**18.2**

Application of 100 % GRDF recorded significantly higher value for grain yield plant^{-1}as compared with rest of the treatments during both the years.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher grain yield plant^{-1}, however, it was at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost during both the year. During 2011-12, it was also at par with the application of 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments.

4.1.4. Yield studies

4.1.4.1. Grain yield

The data regarding grain yield at harvest in wheat was significantly influenced due to different treatments during both the years and in pooled mean are presented in Table 37.

The perusal of data in Table 37 indicated that application of 100 % GRDF was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times and recorded significantly higher grain yield as compared with rest of the treatments during both the years and in pooled mean.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher grain yield, however, it was found at par with the application of 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments during both the years and in pooled mean.

4.1.4.2. Straw yield

The straw yield in wheat was significantly influenced due to different treatments applied during both the years and in pooled mean. The data pertaining to it are presented in Table 37.

Application of 100 % GRDF was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during 2010-11 and in pooled mean and with 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2011-12 and recorded significantly higher straw yield as compared with rest of the treatments.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher straw yield as compared with rest of the treatments during both the years and in pooled mean, however, it was found at par with the application of 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2011-12 and in pooled mean.

4.1.4.3. Biological yield

The perusal of data regarding biological yield was significantly influenced due to different treatments during both the years and in pooled mean are presented in Table 37.

Application of 100 % GRDF recorded significantly higher value for biological yield in wheat during both the years and in pooled mean.

Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher biological yield during both the years and in pooled mean, however, it was found at par with the application

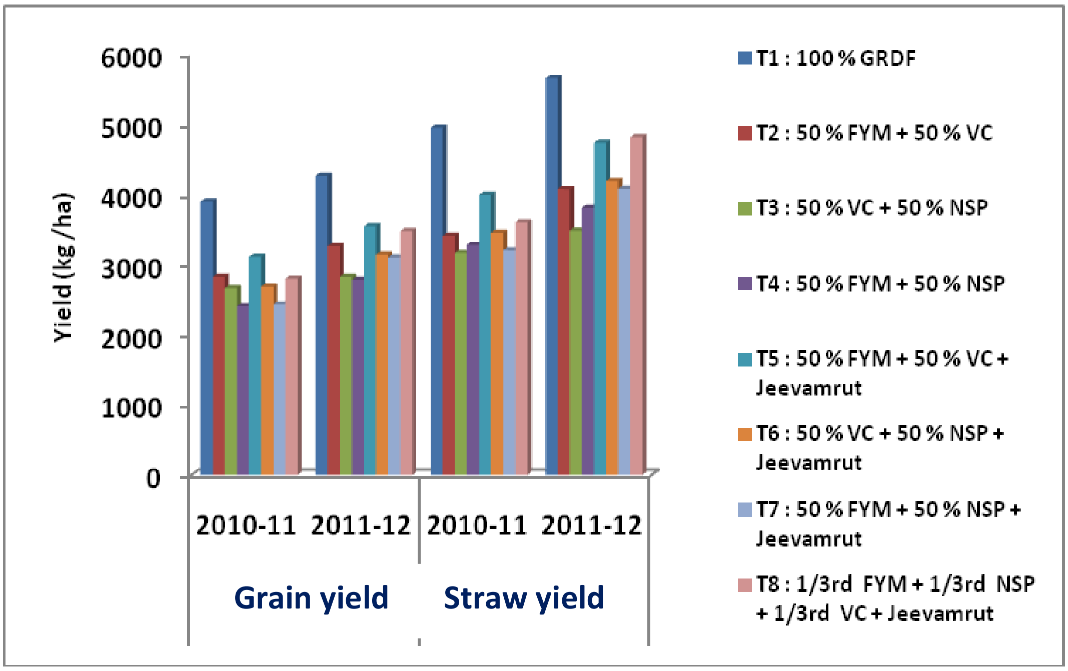


Fig. 14 : Grain and straw yield of wheat in soybean-wheat cropping system as influenced by different treatments

of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2010-11 and in pooled mean and with 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2011-12 as compared with rest of the organic treatments applied to wheat.

4.1.4.4. Harvest index

The data regarding harvest index was not subjected to statistical analysis and the interpretation is done on mean basis.

Application of 50 % RDN through vermicompost + 50 % RDN through neem seed powder reported numerically maximum value for harvest index during both the years and in two years mean. Minimum harvest index was observed with the application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder during 2010-11 and in two years mean and with 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2011-12 as compared with rest of the treatments.

Table 37. Yield of wheat (sequence crop) as influenced by different organic inputs

Treatment	Grain yield (Kg ha^{-1})			Straw yield (Kg ha^{-1})			Biological yield (Kg ha^{-1})			Harvest index (%)		
	10-11	11-12	Pooled	10-11	11-12	Pooled	10-11	11-12	Pooled	10-11	11-12	Mean
T_1 : 100 % GRDF	3901	4270	4086	4951	5664	5308	8852	9934	9393	44.07	42.99	43.53
T_2 : 50 % RDN through FYM + 50 % RDN through VC	2825	3267	3046	3410	4077	3743	6235	7343	6789	45.31	44.49	44.90
T_3 : 50 % RDN through VC + 50 % RDN through NSP	2664	2826	2745	3169	3486	3328	5833	6312	6073	45.67	44.78	45.22
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	2409	2783	2596	3283	3810	3546	5692	6593	6142	42.33	42.21	42.27
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	3112	3547	3330	3995	4736	4365	7107	8283	7695	43.79	42.82	43.31
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	2687	3146	2917	3453	4197	3825	6140	7343	6741	43.77	42.84	43.31
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	2433	3102	2768	3205	4082	3643	5638	7184	6411	43.15	43.18	43.17
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	2802	3478	3140	3607	4820	4213	6408	8298	7353	43.72	41.92	42.82
SEm $\pm$	62	76	70	102	127	115	377	291	324	--	--	--
CD at 5 %	184	223	206	302	378	342	1119	851	949	--	--	--
General mean	**2705**	**3164**	**2934**	**3446**	**4172**	**3809**	**6150**	**7337**	**6743**	**43.98**	**43.15**	**43.56**

4.1.5. Quality studies

4.1.5.1. Protein content

The protein content in wheat seed was found to be non significant due to application of different organic treatments during both the years.

Table 38. Quality of wheat (sequence crop) as influenced by different organic inputs

Treatment	Protein content (%)	
	2010-11	2011-12
T_1 : 100 % GRDF	10.40	11.01
T_2 : 50 % RDN through FYM + 50 % RDN through VC	10.30	10.52
T_3 : 50 % RDN through VC + 50 % RDN through NSP	10.07	10.22
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	9.92	10.18
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	10.33	10.59
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	10.10	10.35
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	9.97	10.25
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	10.12	10.35
SEm $\pm$	0.51	0.85
CD at 5 %	NS	NS
General mean	**10.15**	**10.44**

4.2.6. Growth analysis studies

The growth analysis parameters *viz.*, absolute growth rate (AGR) for plant height (Table 39), absolute growth rate (AGR) for dry matter (Table 40), relative growth rate (RGR) for dry matter(Table 41), crop growth rate (CGR) (Table 42), net assimilation rate (NAR) (Table 43) and leaf area index (LAI) (Table 44) were found to be increased with advancement in age of wheat crop up to 56 DAS, while during both the years and declined thereafter due to senescence of leaves.

Table 39. Absolute growth rate for plant height of wheat (sequence crop) as influenced by different organic inputs

Treatment	Absolute growth rate for plant height (cm day^{-1})							
	2010-11				2011-12			
	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest
T_1 : 100 % GRDF	1.059	1.308	1.021	0.008	1.181	1.417	0.981	0.028
T_2 : 50 % RDN through FYM + 50 % RDN through VC	1.029	1.152	0.779	0.007	1.138	1.224	0.726	0.028
T_3 : 50 % RDN through VC + 50 % RDN through NSP	0.999	1.119	0.757	0.007	1.112	1.196	0.710	0.033
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	0.997	1.117	0.755	0.009	1.104	1.187	0.705	0.036
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	1.029	1.152	0.779	0.006	1.140	1.226	0.728	0.026
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	1.004	1.125	0.761	0.007	1.114	1.198	0.711	0.028
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	0.998	1.118	0.756	0.008	1.104	1.188	0.705	0.030
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	0.999	1.119	0.757	0.007	1.117	1.202	0.713	0.026
SEm $\pm$	0.014	0.016	0.002	0.002	0.020	0.023	0.008	0.003
CD at 5 %	0.042	0.047	0.007	0.005	0.058	0.068	0.023	0.009
General mean	**1.014**	**1.151**	**0.796**	**0.007**	**1.126**	**1.230**	**0.748**	**0.030**

Table 40. Absolute growth rate for dry matter of wheat (sequence crop) as influenced by different organic inputs

Treatments	Absolute growth rate for dry matter (g day^{-1})							
	2010-11				2011-12			
	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest
T_1 : 100 % GRDF	0.050	0.086	0.107	0.020	0.060	0.084	0.121	0.020
T_2 : 50 % RDN through FYM + 50 % RDN through VC	0.036	0.062	0.077	0.016	0.046	0.064	0.093	0.019
T_3 : 50 % RDN through VC + 50 % RDN through NSP	0.034	0.059	0.073	0.018	0.040	0.055	0.080	0.020
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	0.031	0.053	0.066	0.020	0.039	0.054	0.079	0.021
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	0.040	0.069	0.085	0.018	0.050	0.069	0.101	0.019
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	0.034	0.059	0.074	0.017	0.045	0.062	0.089	0.019
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	0.031	0.054	0.067	0.018	0.044	0.061	0.088	0.020
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	0.036	0.062	0.077	0.017	0.049	0.068	0.099	0.019
SEm ±	0.001	0.003	0.003	0.001	0.001	0.005	0.004	0.003
CD at 5 %	0.004	0.010	0.009	0.002	0.003	0.015	0.012	0.009
General mean	**0.036**	**0.063**	**0.078**	**0.018**	**0.047**	**0.065**	**0.094**	**0.020**

Table 41. Relative growth rate of wheat (sequence crop) as influenced by different organic inputs

Treatment	Relative growth rate for dry matter (g m^{-2} day^{-1})							
	2010-11				2011-12			
	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest
T_1 : 100 % GRDF	0.115	0.198	0.246	0.045	0.139	0.192	0.278	0.046
T_2 : 50 % RDN through FYM + 50 % RDN through VC	0.083	0.143	0.178	0.038	0.107	0.147	0.213	0.043
T_3 : 50 % RDN through VC + 50 % RDN through NSP	0.078	0.135	0.168	0.041	0.092	0.127	0.184	0.045
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	0.071	0.122	0.152	0.046	0.091	0.125	0.181	0.049
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	0.091	0.158	0.196	0.040	0.116	0.160	0.231	0.044
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	0.079	0.136	0.170	0.040	0.103	0.142	0.205	0.043
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	0.071	0.123	0.153	0.042	0.101	0.140	0.202	0.046
T_8 : $1/3^{rd}$ RDN through FYM + $1/3^{rd}$ RDN through NSP + $1/3^{rd}$ RDN through VC + Jeevamrut two times	0.082	0.142	0.177	0.040	0.113	0.157	0.227	0.044
SEm $\pm$	0.003	0.007	0.005	0.002	0.005	0.009	0.005	0.004
CD at 5 %	0.009	0.021	0.015	0.006	0.014	0.027	0.016	0.012
General mean	**0.084**	**0.145**	**0.180**	**0.041**	**0.108**	**0.149**	**0.215**	**0.045**

Table 42. Crop growth rate of wheat (sequence crop) as influenced by different organic inputs

Treatment	Crop growth rate (g m^{-2} day^{-1})							
	2010-11				2011-12			
	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest
T_1 : 100 % GRDF	8.96	15.46	19.24	3.53	10.35	14.29	20.69	3.45
T_2 : 50 % RDN through FYM + 50 % RDN through VC	6.33	10.92	13.59	2.86	7.70	10.63	15.39	3.11
T_3 : 50 % RDN through VC + 50 % RDN through NSP	5.97	10.30	12.81	3.15	6.49	8.96	12.97	3.19
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	5.12	8.83	10.99	3.35	6.39	8.82	12.77	3.45
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	7.36	12.69	15.79	3.25	8.37	11.56	16.73	3.16
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	6.17	10.65	13.26	3.11	7.41	10.23	14.81	3.11
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	5.45	9.40	11.70	3.19	7.12	9.84	14.24	3.23
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	6.44	11.11	13.82	3.10	7.98	11.03	15.97	3.12
SEm $\pm$	0.05	0.10	0.07	0.01	0.06	0.09	0.08	0.00
CD at 5 %	0.16	0.30	0.21	0.04	0.18	0.27	0.24	0.01
General mean	**6.47**	**11.17**	**13.90**	**3.19**	**7.72**	**10.67**	**15.45**	**3.23**

Table 43. Net assimilation rate of wheat (sequence crop) as influenced by different organic inputs

Treatment	Net assimilation rate (g m^{-2} day^{-1})							
	2010-11				2011-12			
	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest
T_1 : 100 % GRDF	0.115	0.198	0.246	0.045	0.139	0.192	0.278	0.046
T_2 : 50 % RDN through FYM + 50 % RDN through VC	0.083	0.143	0.178	0.038	0.107	0.147	0.213	0.043
T_3 : 50 % RDN through VC + 50 % RDN through NSP	0.078	0.135	0.168	0.041	0.092	0.127	0.184	0.045
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	0.071	0.122	0.152	0.046	0.091	0.125	0.181	0.049
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	0.091	0.158	0.196	0.040	0.116	0.160	0.231	0.044
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	0.079	0.136	0.170	0.040	0.103	0.142	0.205	0.043
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	0.071	0.123	0.153	0.042	0.101	0.140	0.202	0.046
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	0.082	0.142	0.177	0.040	0.113	0.157	0.227	0.044
SEm ±	0.004	0.008	0.006	0.003	0.004	0.008	0.007	0.002
CD at 5 %	0.012	0.024	0.018	0.009	0.012	0.024	0.020	0.006
General mean	**0.084**	**0.145**	**0.180**	**0.041**	**0.108**	**0.149**	**0.215**	**0.045**

Table 44. Leaf area index of wheat (sequence crop) as influenced by different organic inputs

Treatment	Leaf area index							
	2010-11				2011-12			
	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest	0-28 DAS	29-54 DAS	55-84 DAS	85 to at harvest
T_1 : 100 % GRDF	0.298	1.434	0.825	0.181	0.331	1.590	0.858	0.245
T_2 : 50 % RDN through FYM + 50 % RDN through VC	0.216	1.039	0.597	0.131	0.253	1.217	0.656	0.187
T_3 : 50 % RDN through VC + 50 % RDN through NSP	0.204	0.979	0.563	0.124	0.219	1.053	0.568	0.162
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	0.184	0.886	0.509	0.112	0.215	1.036	0.559	0.160
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	0.238	1.144	0.658	0.144	0.275	1.321	0.713	0.203
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	0.205	0.988	0.568	0.125	0.243	1.172	0.632	0.180
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	0.186	0.894	0.514	0.113	0.240	1.155	0.623	0.178
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times	0.214	1.030	0.592	0.130	0.269	1.296	0.699	0.200
SEm ±	0.005	0.026	0.009	0.004	0.007	0.032	0.009	0.002
CD at 5 %	0.015	0.076	0.027	0.012	0.021	0.094	0.027	0.006
General mean	**0.218**	**1.049**	**0.603**	**0.132**	**0.256**	**1.230**	**0.664**	**0.189**

Application of 100 % GRDF recorded significantly higher value for different growth analysis parameters *viz.*, AGR for plant height, AGR for dry matter, RGR for dry matter, CGR, NAR and LAI as compared with rest of the treatments during both the years of experimentation.

The inconsistent results were observed with the AGR for plant height, AGR for dry matter, RGR for dry matter and NAR due to application of different treatments during both the years. However, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times was found at par with application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the treatments during both the years and reported significantly higher value for different growth analysis parameters *viz.*, AGR for plant height, AGR for dry matter, RGR for dry matter, CGR, NAR and LAI.

Significantly lowest value for different growth analysis parameters was observed with the application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder as compared with rest of the treatments during both the years.

4.2.8. Cumulative growing degree days

The cumulative growing degree days (CGDD) required to attain the different statges of observations were significantly influenced due to application of different organic treatments in wheat during both the years except that application of different treatments could not influence CGDD required to attain establishment stage significantly during 2010-11 (Table 27).

During 2011-12, CGDD required to attain the establishment stage was significantly influenced and reported higher value with the application of 100 % GRDF as compared with rest of the treatments, however, among the organic treatments, application of 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times reproted significantly higher CGDD, however, it was found at par with rest of the treatments except application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder.

The vegetative stage in wheat was attained with significantly higher value of CGDD with the application of 100 % GRDF during both the years, however, among different organic treatments applied in wheat, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher value for CGDD, which was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost during both the years and with 50 % RDN through vermicompost + 50 % RDN through neem seed powder + jeevamrut two times and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2011-12 as compared with rest of the organic treatments.

The application of 100 % GRDF reported significantly higher CGDD to attain the flowering stage in wheat during both the years. Among different organic treatments applied to wheat, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times reported significantly higher value for CGDD, which was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost during 2010-11 and with rest of the organic treatments.

The panicle setting and filling stage in wheat was attained with significantly higher value of CGDD with the application of 100 % GRDF during both the years, however, among different organic treatments applied in wheat, application of 50 % RDN through farmyard manure +

50 % RDN through vermicompost + Jeevamrut two times reported significantly higher value for CGDD, which was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost during both the years and with 50 % RDN through vermicompost + 50 % RDN through neem seed powder + jeevamrut two times and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2011-12 as compared with rest of the organic treatments.

The application of 100 % GRDF reported significantly higher CGDD required to attain the physiological stage during both the years. Among organic treatments applied to wheat, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher CGDD value, however it was found at par with 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2010-11 and with 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2011-12.

Significantly lowest value was reported with the application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder as compared with rest of the treatments applied to wheat during both the years of experimentation.

Table 45. Cumulative growing degree days in wheat (sequence crop) as influenced by different organic inputs (2010-11 and 2011-12)

Treatment	Cumulative growing degree days (CGDD)									
	Establishment stage		Vegetative stage		Flowering		Pod setting and pod filling		Physiological maturity	
	2010-11	**2011-12**	**2010-11**	**2011-12**	**2010-11**	**2011-12**	**2010-11**	**2011-12**	**2010-11**	**2011-12**
T_1 : 100 % GRDF	168	335	398	724	557	911	1114	1318	1681	1509
T_2 : 50 % RDN through FYM + 50 % RDN through VC	168	315	396	674	548	861	1076	1234	1594	1435
T_3 : 50 % RDN through VC + 50 % RDN through NSP	153	320	359	676	488	847	1003	1208	1488	1394
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	153	299	351	637	457	808	957	1171	1422	1354
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	168	315	396	685	536	873	1065	1276	1591	1472
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	153	320	369	678	500	865	1014	1252	1513	1454
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	153	309	360	652	484	823	1014	1183	1522	1368
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	153	330	370	689	503	876	1032	1263	1555	1461
SEm ±	0.04	0.80	5.88	6.14	7.13	8.13	11.65	13.91	18.67	17.40
CD at 5 %	NS	2.34	17.21	18.23	21.17	24.11	34.79	41.26	55.43	51.65
General mean	**158**	**318**	**375**	**677**	**509**	**858**	**1034**	**1238**	**1546**	**1431**

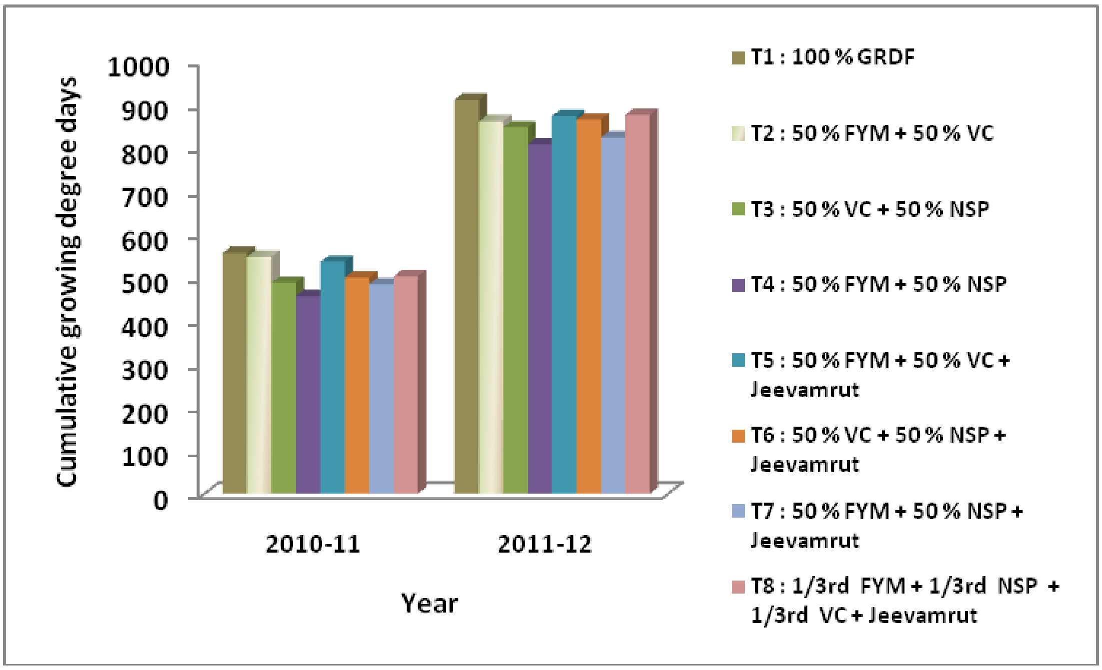


Fig. 15 : Cumulative growing degree days required to attain the flowering stage in wheat in soybean-wheat cropping system as influenced by different treatments

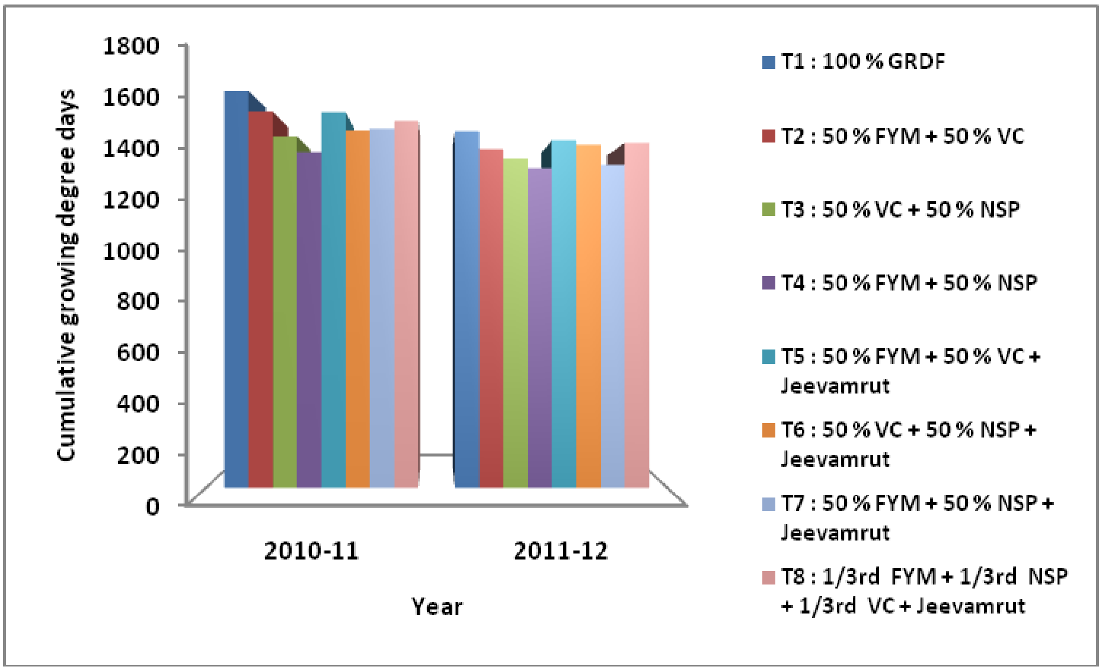


Fig. 16 : Cumulative growing degree days required to attain the physiological maturity stage in wheat in soybean-wheat cropping system as influenced by different treatments

4.5. Performance of soybean-wheat cropping sequence

4.5.1. Economic evaluation

The economic evaluation of soybean - wheat cropping system as influenced by different organic treatments was calculated and the data are presented in Table 48.

4.5.1.1. Cost of cultivation

Among the different treatments applied to soybean–wheat cropping system, application of 100 % GRDF to soybean-wheat cropping sequence reported numerically minimum value for cost of cultivation during both the years and in two years mean, however, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times to soybean- wheat cropping sequence reported numerically maximum value for the cost of cultivation during both the years and in average mean, respectively.

4.5.1.2. Gross monetary returns

The application of 100 % GRDF to soybean-wheat cropping sequence registered significantly higher gross monetary returns during both the years and in pooled (Table 46, 47 and 48). Among the different organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times to soybean-wheat cropping sequence reported significantly higher value for gross monetary returns during both the years and in pooled mean, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times as compared with rest of the treatments.

4.5.1.3. Net monetary returns

Data regarding net monetary returns revealed that application of 100 % GRDF to soybean-wheat cropping system reported significantly higher net monetary returns followed by application of 50 % RDN

Table 46. Economics of soybean in soybean-wheat cropping sequence as influenced by different organic inputs

Treatment	Cost of cultivation (Rs ha^{-1})			Gross monetary returns (Rs ha^{-1})			Net monetary returns (Rs ha^{-1})			Benefit : Cost Ratio		
	2010-11	**2011-12**	**Mean**	**2010-11**	**2011-12**	**Pooled**	**2010-11**	**2011-12**	**Pooled**	**2010-11**	**2011-12**	**Mean**
T_1 : 100 % GRDF	20445	21905	21175	55938	66069	61003	35492	44164	39828	2.74	3.02	2.88
T_2 : 50 % RDN through FYM + 50 % RDN through VC	22626	25412	24019	50186	44958	47572	27560	19546	23553	2.22	1.77	1.99
T_3 : 50 % RDN through VC + 50 % RDN through NSP	22435	24510	23472	45550	42237	43894	23115	17728	20421	2.03	1.72	1.88
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	21465	22601	22033	39760	34052	36906	18295	11451	14873	1.85	1.51	1.68
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	23026	25912	24469	51087	47780	49434	28061	21868	24964	2.22	1.84	2.03
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	22835	25010	23922	46351	42784	44567	23516	17774	20645	2.03	1.71	1.87
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	21865	23101	22483	40637	34622	37629	18772	11521	15147	1.86	1.50	1.68
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	22575	24674	23625	49395	44319	46857	26819	19645	23232	2.19	1.80	1.99
SEm $\pm$	--	--	--	489	973	707	506	626	561	--	--	--
CD at 5 %	--	--	--	1451	2849	2070	1502	1856	1664	2.14	1.86	2.00
General mean	**22404**	**24460**	**23432**	**46138**	**41536**	**43837**	**23734**	**17076**	**20405**	**2.14**	**1.86**	**2.00**

Table 47. Economics of wheat in soybean - wheat cropping sequence as influenced by different organic inputs

Treatment	Cost of cultivation (Rs ha^{-1})			Gross monetary returns (Rs ha^{-1})			Net monetary returns (Rs ha^{-1})			Benefit : Cost Ratio		
	2010-11	2011-12	Mean	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Mean
T_1 : 100 % GRDF	27342	29828	28585	56100	63621	59860	28757	33793	31275	2.05	2.13	2.09
T_2 : 50 % RDN through FYM + 50 % RDN through VC	41347	39226	40286	40577	48590	44583	-770	9364	4297	0.98	1.24	1.11
T_3 : 50 % RDN through VC + 50 % RDN through NSP	38193	39248	38721	38244	42028	40136	52	2779	1416	1.00	1.07	1.04
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	34920	35675	35298	34715	41493	38104	-206	5818	2806	0.99	1.16	1.08
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	41747	39726	40736	44766	52852	48809	3020	13126	8073	1.07	1.33	1.20
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	38593	39748	39171	38660	46872	42766	68	7124	3596	1.00	1.18	1.09
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	35320	36175	35748	35022	46205	40614	-298	10030	4866	0.99	1.28	1.13
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	38553	38550	38552	40305	51884	46094	1752	13334	7543	1.05	1.35	1.20
SEm $\pm$	--	--	--	1898	2073	1964	430	854	631	--	--	--
CD at 5 %	--	--	--	5633	6069	5751	1276	2533	1872	--	--	--
General mean	**38382**	**38336**	**38359**	**38898**	**47132**	**43015**	**517**	**8797**	**4657**	**1.14**	**1.34**	**1.24**

Table 48. Economics of soybean - wheat cropping sequence as influenced by different organic inputs

Treatment	Cost of cultivation (Rs ha^{-1})			Gross monetary returns (Rs ha^{-1})			Net monetary returns (Rs ha^{-1})			Benefit : Cost Ratio		
	2010-11	**2011-12**	**Mean**	**2010-11**	**2011-12**	**Pooled**	**2010-11**	**2011-12**	**Pooled**	**2010-11**	**2011-12**	**Mean**
T_1 : 100 % GRDF	47788	51732	49760	112038	129690	120864	64250	77958	71104	2.34	2.51	2.43
T_2 : 50 % RDN through FYM + 50 % RDN through VC	63973	64639	64306	90763	93548	92155	26790	28910	27850	1.42	1.45	1.43
T_3 : 50 % RDN through VC + 50 % RDN through NSP	60628	63758	62193	83795	84265	84030	23167	20507	21837	1.38	1.32	1.35
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	56385	58275	57330	74474	75545	75010	18089	17269	17679	1.32	1.30	1.31
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	64773	65639	65206	95853	100632	98243	31081	34994	33037	1.48	1.53	1.51
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	61428	64758	63093	85011	89656	87334	23583	24898	24241	1.38	1.38	1.38
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	57185	59275	58230	75659	80827	78243	18474	21552	20013	1.32	1.36	1.34
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	61129	63224	62176	89700	96203	92951	28571	32979	30775	1.47	1.52	1.49
SEm $\pm$	--	--	--	1745	2445	2176	1135	1269	1211	--	--	--
CD at 5 %	--	--	--	5179	7158	6371	3364	3764	3593	--	--	--
General mean	**60786**	**62795**	**61791**	**85036**	**88668**	**86852**	**24251**	**25873**	**25062**	**1.40**	**1.41**	**1.40**

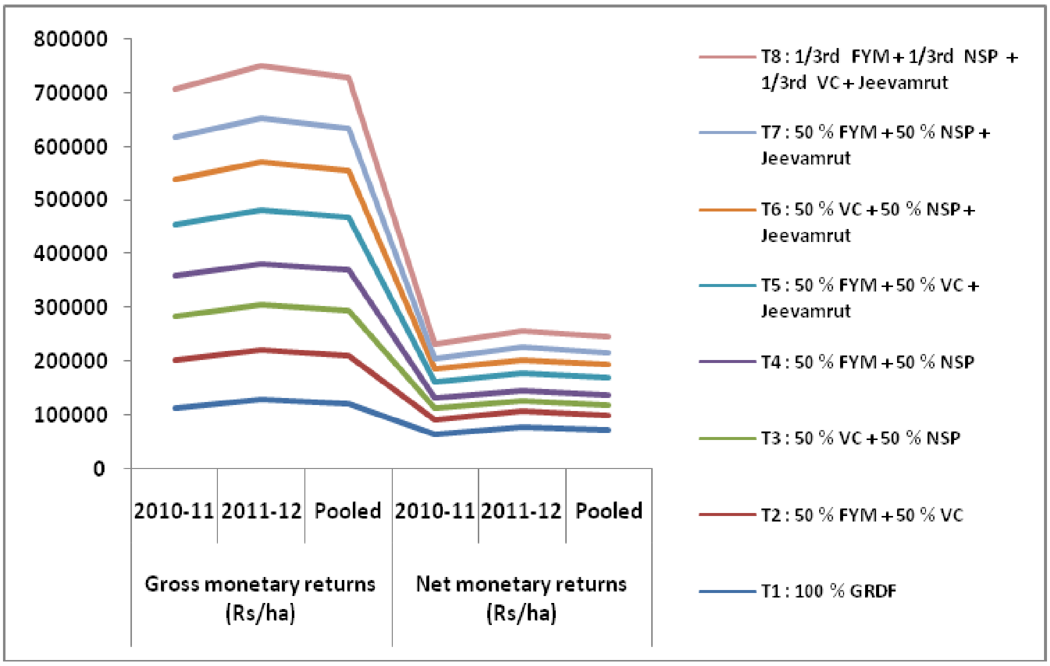


Fig. 17 : Gross and net monetary returns (Rs. /ha) of soybean-wheat cropping system as influenced by different treatments

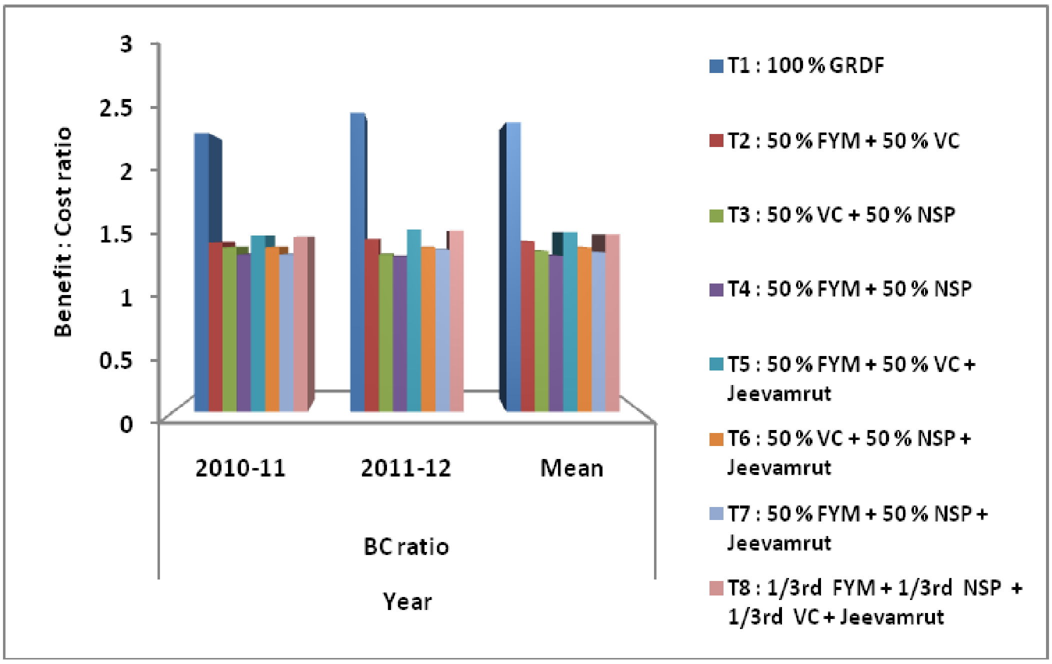


Fig. 18 : Benefit : Cost ratio of soybean-wheat cropping system as influenced by different treatments

through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times during both the years and in pooled mean, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times as compared with rest of the treatments.

4.5.1.4. Benefit : Cost ratio

Data presented in Table 46, 47 and 48 on benefit : cost ratio were not subjected to statistical analysis and the interpretation is done on mean basis during both the years and in average mean.

Application of 100 % GRDF to soybean-wheat cropping system reported numerically maximum value for benefit cost ratio followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times during both the years and in pooled mean as compared with rest of the treatments.

4.5.2. Energy balance studies

Data pertaining to energy parameters as influenced by different organic input treatments in soybean-wheat cropping system are presented in Table 51.

4.5.2.1. Energy input

The data pertaining to energy input was not subjected to statistical analysis and the inferences were drawn on mean basis.

The energy input values were found numerically maximum with the application of 100 % GRDF to soybean-wheat cropping sequence during both the year and in average mean as presented in Table 49, 50 and 51.

Table 49. Energy balance of soybean in soybean-wheat cropping sequence as influenced by different organic inputs

Treatment	Energy input (MJ ha^{-1})			Energy output (MJ ha^{-1})			Energy balance (MJ ha^{-1})			Energy balance per unit input (MJ ha^{-1})			Energy output per input ratio		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1 : 100 % GRDF	20369	20369	20369	67853	73509	70681	47484	53140	50312	2.33	2.61	2.47	3.33	3.61	3.47
T_2 : 50 % RDN through FYM + 50 % RDN through VC	16889	16937	16913	61214	50139	55676	44325	33202	38763	2.62	1.96	2.29	3.62	2.96	3.29
T_3 : 50 % RDN through VC + 50 % RDN through NSP	15871	15912	15891	56235	47812	52023	40364	31900	36132	2.54	2.00	2.27	3.54	3.00	3.27
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	16666	16613	16640	49316	38976	44146	32650	22363	27507	1.96	1.35	1.65	2.96	2.35	2.65
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	17189	17237	17213	62176	53404	57790	44987	36167	40577	2.62	2.10	2.36	3.62	3.10	3.36
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	16171	16212	16191	56623	47994	52309	40452	31782	36117	2.50	1.96	2.23	3.50	2.96	3.23
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	16966	16913	16940	50121	39579	44850	33154	22666	27910	1.95	1.34	1.65	2.95	2.34	2.65
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	16775	16787	16781	60993	49661	55327	44218	32873	38546	2.64	1.96	2.30	3.64	2.96	3.30
SEm $\pm$	--	--	--	774	1207	987	505	1013	719	0.04	0.03	0.05	0.04	0.05	0.03
CD at 5 %	--	--	--	2297	3535	2891	1497	3003	2135	0.12	0.09	0.13	0.12	0.16	0.10
General mean	**17112**	**17123**	**17117**	**58066**	**50134**	**54100**	**40954**	**33012**	**36983**	**2.40**	**1.91**	**2.15**	**3.40**	**2.91**	**3.15**

Table 50. Energy balance studies of wheat in soybean - wheat cropping sequence as influenced by different organic inputs

Treatment	Energy input (MJ ha^{-1})			Energy output (MJ ha^{-1})			Energy balance (MJ ha^{-1})			Energy balance per unit input (MJ ha^{-1})			Energy output per input ratio		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1 : 100 % GRDF	31366	31366	31366	119236	133575	126406	87870	102210	95040	2.80	3.26	3.03	3.80	4.26	4.03
T_2 : 50 % RDN through FYM + 50 % RDN through VC	25427	24170	24799	84155	98977	91566	58728	74807	66767	2.31	3.09	2.70	3.31	4.09	3.70
T_3 : 50 % RDN through VC + 50 % RDN through NSP	22435	22172	22303	78772	85122	81947	56337	62950	59643	2.51	2.84	2.68	3.51	3.84	3.68
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	24557	23658	24107	76451	88533	82492	51894	64875	58385	2.11	2.74	2.43	3.11	3.74	3.43
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	25727	24470	25099	95678	111341	103510	69951	86871	78411	2.72	3.55	3.13	3.72	4.55	4.13
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	22735	22472	22603	82663	98703	90683	59928	76232	68080	2.64	3.39	3.01	3.64	4.39	4.01
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	24857	23958	24407	75825	96625	86225	50968	72667	61818	2.05	3.03	2.54	3.05	4.03	3.54
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	24440	23633	24036	86265	111380	98822	61826	87746	74786	2.53	3.71	3.12	3.53	4.71	4.12
SEm ±	--	--	--	3894	4110	3995	3008	1969	2385	0.07	0.12	0.09	0.08	0.13	0.10
CD at 5 %	--	--	--	11558	12034	11696	8919	5838	7079	0.22	0.37	0.25	0.23	0.37	0.29
General mean	**25300**	**24609**	**24955**	**87540**	**101839**	**94690**	**62240**	**77230**	**69735**	**2.45**	**3.13**	**2.79**	**3.45**	**4.13**	**3.79**

Table 51. Energy balance studies of soybean - wheat cropping sequence as influenced by different organic inputs

Treatment	Energy input (MJ ha^{-1})			Energy output (MJ ha^{-1})			Energy balance (MJ ha^{-1})			Energy balance per unit input (MJ ha^{-1})			Energy output per input ratio		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1 : 100 % GRDF	51735	51735	51735	187089	207085	197087	135354	155350	145352	2.62	3.00	2.81	3.62	4.00	3.81
T_2 : 50 % RDN through FYM + 50 % RDN through VC	42316	41107	41712	145369	149115	147242	103053	108008	105531	2.44	2.63	2.53	3.44	3.63	3.53
T_3 : 50 % RDN through VC + 50 % RDN through NSP	38306	38084	38195	135006	132933	133970	96701	94850	95775	2.52	2.49	2.51	3.52	3.49	3.51
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	41223	40271	40747	125767	127509	126638	84544	87239	85891	2.05	2.17	2.11	3.05	3.17	3.11
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	42916	41707	42312	157854	164746	161300	114938	123039	118988	2.68	2.95	2.81	3.68	3.95	3.81
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	38906	38684	38795	139286	146697	142992	100380	108014	104197	2.58	2.79	2.69	3.58	3.79	3.69
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	41823	40871	41347	125946	136204	131075	84123	95333	89728	2.01	2.33	2.17	3.01	3.33	3.17
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	41215	40421	40818	147259	161041	154150	106043	120620	113332	2.57	2.98	2.78	3.57	3.98	3.78
SEm $\pm$	--	--	--	3583	4146	3821	3176	5366	4991	0.05	0.07	0.06	0.07	0.10	0.09
CD at 5 %	--	--	--	10635	12139	11187	9416	15911	14814	0.14	0.22	0.18	0.21	0.29	0.28
General mean	**42305**	**41610**	**41957**	**145447**	**153166**	**149307**	**103142**	**111556**	**107349**	**2.43**	**2.67**	**2.55**	**3.43**	**3.67**	**3.55**

4.5.2.2. Energy output

Application of 100 % GRDF to soybean-wheat cropping sequence during both the year and in average mean reported significantly higher value for energy output.

4.5.2.3. Energy balance

Data in Table 49,50 and 51 revealed that the application of 100 % GRDF to soybean-wheat cropping sequence reported significantly higher value for energy balance during both the years and in pooled, however, it was followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times to soybean-wheat cropping sequence as compared with rest of the treatments.

4.5.2.4. Energy balance per unit input

Data in Table 49, 50 snf 51 revealed that the application of 100 % GRDF followed by 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times to soybean-wheat cropping sequence reported significantly higher value for energy balance per unit input during both the years and in pooled mean.

4.5.2.5. Energy output per input ratio

The application of 100 % GRDF to soybean-wheat cropping sequence reported significantly higher value for energy output per input ratio followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times during both the years and in pooled mean.

4.5.3. Soil fertility studies

4.5.3.1. Physical properties

The data in respect of different physical properties of soil *viz.,* bulk density, hydraulic conductivity and water holding capacity as influenced by different treatments after completion of each cycle of the cropping system are presented in Table 52.

The bulk density was decreased slightly when the organic inputs were applied to soybean-wheat cropping sequence during both the years. Application of 100 % GRDF and 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times reduced the bulk density of soil during both the years of experimentation and in two years mean.

Hydraulic conductivity and maximum water holding capacity of soil increased substantially due to application of different organic inputs to soybean-wheat cropping sequence. Application of 100 % GRDF and 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times in cropping sequence reported numerically maximum value for hydraulic conductivity and water holding capacity as compared with rest of the treatments during both the years.

4.5.3.2. Chemical properties of soil

The data on chemical properties of soil *viz*. pH, electrical conductivity and organic carbon as influenced by different treatments in soybean-wheat cropping system during both the years are presented in Table 52.

The pH of the soil was improved due to application of various organic inputs in soybean-wheat cropping sequence during both the years. Numerically, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times during both the years reported minimum pH value as compared with the initial pH value.

Table 52 : Physico-chemical properties of soil as influenced by different organic inputs in soybean - wheat cropping sequence

Treatment	Physical properties of soil						Chemical properties of soil					
	Bulk density (g cm-3)		Hydraulic conductivity (cm hr^{-1})		Water holding capacity (per cent)		pH		Electrical conductivity (dSm^{-1})		Organic carbon (per cent)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
T_1 : 100 % GRDF	1.208	1.189	1.65	1.61	30.50	31.65	8.01	7.97	0.270	0.276	0.527	0.537
T_2 : 50 % RDN through FYM + 50 % RDN through VC	1.210	1.191	1.63	1.59	30.01	31.14	8.02	7.99	0.270	0.276	0.518	0.529
T_3 : 50 % RDN through VC + 50 % RDN through NSP	1.211	1.193	1.63	1.59	30.07	31.20	8.03	8.00	0.270	0.277	0.519	0.530
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	1.213	1.193	1.62	1.58	29.82	30.95	8.04	8.00	0.271	0.277	0.515	0.526
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	1.208	1.188	1.65	1.61	30.38	31.52	8.01	7.97	0.270	0.276	0.524	0.535
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	1.211	1.191	1.63	1.59	30.13	31.27	8.03	7.98	0.270	0.276	0.520	0.531
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	1.210	1.192	1.62	1.58	29.95	31.07	8.02	7.99	0.270	0.276	0.516	0.528
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	1.207	1.186	1.64	1.60	30.26	31.39	8.00	7.95	0.269	0.275	0.521	0.533
General mean	**1.210**	**1.190**	**1.63**	**1.59**	**30.14**	**31.27**	**8.02**	**7.98**	**0.270**	**0.276**	**0.520**	**0.531**

Electrical conductivity was not influenced due to different treatments. However, application of bulky organic manures (100 % GRDF and 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times) to soybean-wheat cropping system reduced the electrical conductivity during both the years. Application of 100 % GRDF and 50 % RDN through farmyard manure + 50 % RDN through vermicompost + jeevamrut two times improved the organic carbon content in the soil and reported numerically higher value as compared with rest of the treatments and control during both the years.

4.5.3.3. Nutrient balance studies

At the end of the cropping sequence the nutrient balance sheet during both the year of experiments was worked out with the consideration of inherent soil fertility in respect of soil available N, P and K before commencement of the experiment, nutrients added through different organic inputs into the soil in different seasons and left ever nutrients in the soil at the end of the first and second year of experimentation.

The data pertaining to nutrient balance in respect of N, P and K at the end of soybean-wheat cropping system for 2010-11 and 2011-12 and the two years mean are presented in Table 55, 58 and 59, respectively. The data related to the nutrient balance are not subjected to statistical analysis and the inferences are drawn on mean basis.

The available nutrients before sowing of experiment were 181.30, 15.17, 288.90 NPK kg ha^{-1} for all the treatments during 2010-11 and in two years mean, however, during 2011-12, the mean values for N, P and K were maximum with application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder and minimum with application of 100 % GRDF to soybean-wheat cropping sequence during both the years and two years mean, respectively.

The data indicated that application of 100 % GRDF to soybean-wheat cropping sequence reported maximum value for nutrients applied to crops in sequence during both the years and in two years mean.

The nutrient uptake studies revealed that application of 100 % GRDF to soybean-wheat cropping sequence reported maximum value for nutrient uptake and minimum nutrient uptake was observed with the application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder by soybean-wheat cropping system.

Available nutrients at the end of the sequence were found maximum with the application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder during both the years of experimentation and in two years mean. However, during both the years of experimentation, the available N, P and K in the soil at the end of the sequence was found minimum with the application of 50 % RDN through vermicompost + 50 % RDN through neem seed powder + Jeevamrut two times at the end of soybean-wheat cropping system.

It is evident from the perusal of data presented Table 55, 58 and 59 that the nutrient balance with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported numerically highly negative N balance and application 100 % GRDF to soybean-wheat cropping system reported positive P and K balance at the end of the cropping sequence as compared with rest of the organic treatments.

Table 53 : Nutrient balance studies of soybean in soybean-wheat cropping sequence as influenced by different organic inputs during 2010-11

Treatment	Initial soil available nutrients (kg ha^{-1})			Nutrients applied (kg ha^{-1})			Nutrients uptake by crops (kg ha^{-1})			Soil available nutrients after harvest (kg ha^{-1})			Net soil nutrient balance (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
T_1 : 100 % GRDF	181.30	15.17	288.90	78.00	97.00	48.00	173.02	17.37	63.36	72.79	17.29	152.43	13.50	77.52	121.11
T_2 : 50 % RDN through FYM + 50 % RDN through VC	181.30	15.17	288.90	50.00	32.51	59.52	153.78	15.48	56.73	76.52	17.65	159.66	0.99	14.55	132.04
T_3 : 50 % RDN through VC + 50 % RDN through NSP	181.30	15.17	288.90	50.00	20.98	29.59	137.46	13.92	51.51	79.73	17.84	166.02	14.11	4.39	100.96
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	181.30	15.17	288.90	50.00	27.76	55.78	118.47	12.02	44.67	97.90	19.00	193.79	14.94	11.91	106.22
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	181.30	15.17	288.90	50.20	32.61	61.52	156.95	15.78	57.73	71.52	17.41	150.25	3.03	14.59	142.44
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	181.30	15.17	288.90	50.20	21.08	31.59	139.21	14.02	51.45	89.02	18.36	174.01	3.27	3.87	95.03
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	181.30	15.17	288.90	50.20	27.86	57.78	121.11	12.26	45.33	95.37	18.71	188.23	15.02	12.07	113.12
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	181.30	15.17	288.90	50.20	27.18	50.30	148.93	15.08	55.83	85.33	18.15	170.45	-2.76	9.12	112.92
General mean	**181.30**	**15.17**	**288.90**	**54.09**	**37.11**	**49.11**	**142.86**	**14.41**	**52.97**	**83.52**	**18.05**	**169.36**	**9.26**	**19.84**	**115.85**

Table 54 : Nutrient balance studies of wheat in soybean-wheat cropping sequence as influenced by different organic inputs during 2010-11

Treatment	Initial soil available nutrients (kg ha^{-1})			Nutrients applied (kg ha^{-1})			Nutrients uptake by crops (kg ha^{-1})			Soil available nutrients after harvest (kg ha^{-1})			Net soil nutrient balance (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
T_1 : 100 % GRDF	72.79	17.29	152.43	169.00	94.00	112.00	86.86	20.62	85.54	107.88	18.52	119.35	47.04	72.15	59.54
T_2 : 50 % RDN through FYM + 50 % RDN through VC	76.52	17.65	159.66	120.00	28.98	56.56	61.69	14.48	58.83	112.91	18.92	127.09	21.92	13.23	30.30
T_3 : 50 % RDN through VC + 50 % RDN through NSP	79.73	17.84	166.02	120.00	17.89	32.80	56.70	13.27	53.57	117.24	19.14	133.90	25.79	3.32	11.34
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	97.90	19.00	193.79	120.00	23.60	49.71	51.90	12.52	53.47	141.72	20.44	163.65	24.28	9.63	26.39
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	71.52	17.41	150.25	120.10	29.08	58.46	68.97	16.41	68.40	106.17	18.65	117.02	16.48	11.43	23.29
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	89.02	18.36	174.01	120.10	17.99	34.70	58.21	13.85	57.77	129.76	19.73	142.46	21.15	2.77	8.48
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	95.37	18.71	188.23	120.10	23.70	51.61	52.29	12.51	52.73	138.31	20.12	157.70	24.86	9.77	29.42
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	85.33	18.15	170.45	120.10	56.48	113.16	60.89	14.50	60.50	124.78	19.49	138.65	19.76	40.64	84.46
General mean	**83.26**	**18.03**	**169.20**	**127.04**	**33.61**	**56.55**	**62.37**	**14.81**	**61.47**	**122.35**	**19.38**	**137.48**	**25.93**	**17.47**	**26.97**

Table 55 : Nutrient balance studies in soybean-wheat cropping sequence as influenced by different organic inputs during 2010-11

Treatment	Initial soil available nutrients (kg ha^{-1})			Nutrients applied (kg ha^{-1})			Nutrients uptake by crops (kg ha^{-1})			Soil available nutrients after harvest (kg ha^{-1})			Net soil nutrient balance (kg ha^{-1})		
	N	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**
T_1 : 100 % GRDF	181.30	15.17	288.90	247.00	191.00	160.00	259.9	38.0	148.9	107.9	18.5	119.4	60.5	149.7	180.7
T_2 : 50 % RDN through FYM + 50 % RDN through VC	181.30	15.17	288.90	170.00	61.49	116.09	215.5	30.0	115.6	112.9	18.9	127.1	22.9	27.8	162.3
T_3 : 50 % RDN through VC + 50 % RDN through NSP	181.30	15.17	288.90	170.00	38.87	62.40	194.2	27.2	105.1	117.2	19.1	133.9	39.9	7.7	112.3
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	181.30	15.17	288.90	170.00	51.36	105.49	170.4	24.5	98.1	141.7	20.4	163.6	39.2	21.5	132.6
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	181.30	15.17	288.90	170.30	61.69	119.99	225.9	32.2	126.1	106.2	18.7	117.0	19.5	26.0	165.7
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	181.30	15.17	288.90	170.30	39.07	66.30	197.4	27.9	109.2	129.8	19.7	142.5	24.4	6.6	103.5
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	181.30	15.17	288.90	170.30	51.56	109.39	173.4	24.8	98.1	138.3	20.1	157.7	39.9	21.8	142.5
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	181.30	15.17	288.90	170.30	83.66	163.46	209.8	29.6	116.3	124.8	19.5	138.7	17.0	49.8	197.4
General mean	**181.30**	**15.17**	**288.90**	**181.13**	**70.72**	**105.66**	**205.2**	**29.2**	**114.4**	**122.35**	**19.38**	**137.48**	**35.2**	**37.3**	**142.8**

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Table 56 : Nutrient balance studies of soybean in soybean-wheat cropping sequence as influenced by different organic inputs during 2011-12

Treatment	Initial soil available nutrients (kg ha^{-1})			Nutrients applied (kg ha^{-1})			Nutrients uptake by crops (kg ha^{-1})			Soil available nutrients after harvest (kg ha^{-1})			Net soil nutrient balance (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
T_1 : 100 % GRDF	107.88	18.52	119.35	78.50	95.50	37.00	188.67	18.51	70.25	75.73	17.23	124.82	-78.02	78.27	-38.72
T_2 : 50 % RDN through FYM + 50 % RDN through VC	112.91	18.92	127.09	50.00	32.94	50.08	124.78	12.26	46.61	79.98	17.62	131.85	-41.85	21.99	-1.29
T_3 : 50 % RDN through VC + 50 % RDN through NSP	117.24	19.14	133.90	50.00	21.84	31.38	113.96	11.28	43.43	83.63	17.83	138.04	-30.35	11.87	-16.18
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	141.72	20.44	163.65	50.00	24.86	46.22	91.75	9.14	35.49	104.29	19.07	165.07	-4.33	17.10	9.30
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	106.17	18.65	117.02	50.10	33.14	52.38	132.64	13.05	49.69	104.29	19.07	165.07	-80.66	19.68	-45.36
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	129.76	19.73	142.46	50.10	22.04	33.68	116.01	11.43	43.67	74.29	17.36	122.70	-10.44	12.97	9.77
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	138.31	20.12	157.70	50.10	25.06	48.52	93.38	9.29	36.06	94.20	18.38	145.82	0.83	17.50	24.34
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	124.78	19.49	138.65	50.10	26.75	44.86	119.43	11.76	44.89	101.42	18.76	159.66	-45.96	15.72	-21.05
General mean	**122.00**	**19.36**	**137.31**	**54.11**	**36.48**	**42.75**	**123.03**	**12.14**	**46.45**	**89.73**	**18.16**	**144.13**	**-34.97**	**25.63**	**-8.31**

Table 57 : Nutrient balance studies of wheat in soybean-wheat cropping sequence as influenced by different organic inputs during 2011-12

Treatment	Initial soil available nutrients (kg ha^{-1})			Nutrients applied (kg ha^{-1})			Nutrients uptake by crops (kg ha^{-1})			Soil available nutrients after harvest (kg ha^{-1})			Net soil nutrient balance (kg ha^{-1})		
	N	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**
T_1 : 100 % GRDF	75.73	17.23	124.82	186.00	103.00	124.00	102.16	25.03	104.06	109.94	18.57	104.37	49.63	76.63	40.39
T_2 : 50 % RDN through FYM + 50 % RDN through VC	79.98	17.62	131.85	120.00	27.84	47.16	73.74	17.85	72.26	114.79	19.03	112.86	11.45	8.57	-6.10
T_3 : 50 % RDN through VC + 50 % RDN through NSP	83.63	17.83	138.04	120.00	20.76	28.60	61.86	14.94	60.17	118.95	19.28	120.32	22.82	4.36	-13.85
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	104.29	19.07	165.07	120.00	25.50	45.08	61.99	15.28	64.43	142.51	20.76	152.92	19.80	8.52	-7.20
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	104.29	19.07	165.07	120.20	28.04	49.46	81.74	20.05	83.62	142.51	20.76	152.92	0.24	6.29	-22.01
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	74.29	17.36	122.70	120.20	20.96	30.90	70.85	17.38	72.44	108.30	18.73	101.82	15.34	2.22	-20.65
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	94.20	18.38	145.82	120.20	25.70	47.38	68.99	16.88	69.93	131.00	19.94	129.70	14.41	7.26	-6.43
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	101.42	18.76	159.66	120.20	59.48	98.98	78.97	19.51	82.69	139.23	20.39	146.40	3.42	38.33	29.55
General mean	**88.06**	**18.08**	**141.91**	**129.51**	**35.97**	**53.23**	**74.48**	**18.20**	**75.27**	**125.90**	**19.68**	**127.66**	**19.10**	**16.27**	**-5.12**

Table 58. Nutrient balance studies of wheat in soybean-wheat cropping sequence as influenced by different organic inputs during 2011-12

Treatments	Initial soil available nutrients (kg ha^{-1})			Nutrients applied (kg ha^{-1})			Nutrients uptake by crops (kg ha^{-1})			Soil available nutrients after harvest (kg ha^{-1})			Net soil nutrient balance (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
T_1 : 100 % GRDF	107.88	18.52	119.35	264.50	198.50	161.00	290.8	43.5	174.3	109.94	18.57	104.37	-28.4	154.9	1.7
T_2 : 50 % RDN through FYM + 50 % RDN through VC	112.91	18.92	127.09	170.00	60.78	97.24	198.5	30.1	118.9	114.79	19.03	112.86	-30.4	30.6	-7.4
T_3 : 50 % RDN through VC + 50 % RDN through NSP	117.24	19.14	133.90	170.00	42.60	59.99	175.8	26.2	103.6	118.95	19.28	120.32	-7.5	16.2	-30.0
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	141.72	20.44	163.65	170.00	50.36	91.29	153.7	24.4	99.9	142.51	20.76	152.92	15.5	25.6	2.1
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	106.17	18.65	117.02	170.30	61.18	101.84	214.4	33.1	133.3	142.51	20.76	152.92	-80.4	26.0	-67.4
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	129.76	19.73	142.46	170.30	43.00	64.59	186.9	28.8	116.1	108.30	18.73	101.82	4.9	15.2	-10.9
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	138.31	20.12	157.70	170.30	50.76	95.89	162.4	26.2	106.0	131.00	19.94	129.70	15.2	24.8	17.9
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	124.78	19.49	138.65	170.30	86.23	143.83	198.4	31.3	127.6	139.23	20.39	146.40	-42.5	54.1	8.5
General mean	**122.00**	**19.36**	**137.31**	**183.63**	**72.46**	**95.98**	**197.5**	**30.3**	**121.7**	**111.9**	**17.5**	**113.5**	**-15.9**	**41.9**	**-13.4**

Table 59 : Nutrient balance studies in soybean-wheat cropping sequence as influenced by different organic inputs during 2010-12

Treatment	Initial soil available nutrients (kg ha^{-1})			Nutrients applied (kg ha^{-1})			Nutrients uptake by crops (kg ha^{-1})			Soil available nutrients after harvest (kg ha^{-1})			Net soil nutrient balance (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
T_1 : 100 % GRDF	181.30	15.17	288.90	450.50	301.50	285.00	393.0	68.6	278.4	109.9	18.6	104.4	128.9	229.5	191.2
T_2 : 50 % RDN through FYM + 50 % RDN through VC	181.30	15.17	288.90	290.00	88.62	144.41	272.3	48.0	191.1	114.8	19.0	112.9	84.2	36.8	129.3
T_3 : 50 % RDN through VC + 50 % RDN through NSP	181.30	15.17	288.90	290.00	63.36	88.59	237.7	41.2	163.8	119.0	19.3	120.3	114.7	18.1	93.4
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	181.30	15.17	288.90	290.00	75.86	136.37	215.7	39.7	164.3	142.5	20.8	152.9	113.1	30.6	108.0
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	181.30	15.17	288.90	290.50	89.22	151.31	296.1	53.1	216.9	142.5	20.8	152.9	33.2	30.5	70.4
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	181.30	15.17	288.90	290.50	63.96	95.49	257.7	46.2	188.6	108.3	18.7	101.8	105.8	14.2	94.0
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	181.30	15.17	288.90	290.50	76.46	143.27	231.4	43.0	175.9	131.0	19.9	129.7	109.4	28.6	126.6
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	181.30	15.17	288.90	290.50	145.71	242.81	277.4	50.8	210.3	139.2	20.4	146.4	55.2	89.7	175.0
General mean	**181.30**	**15.17**	**288.90**	**313.14**	**108.43**	**149.20**	**272.0**	**48.5**	**197.0**	**111.9**	**17.5**	**113.5**	**98.5**	**55.5**	**116.1**

Table 60. Microbial population in soybean-wheat cropping sequence as influenced by different organic inputs during 2010-11 and 2011-12

Treatment	2010-11						2011-12					
	Bacteria (CFU x 10^{-6} g^{-1} soil)		**Fungi** (CFU x 10^{-4} g^{-1} soil)		**Actinomycetes** (CFU x 10^{-4} g^{-1} soil)		**Bacteria** (CFU x 10^{-6} g^{-1} soil)		**Fungi** (CFU x 10^{-4} g^{-1} soil)		**Actinomycetes** (CFU x 10^{-4} g^{-1} soil)	
	Flowering	**Harvest**	**Flowering**	**Harvest**	**Flowering**	**Harvest**	**Flowering**	**Harvest**	**Flowering**	**Harvest**	**Flowering**	**Harvest**
T_1 : 100 % GRDF	46	41	28	24	40	34	48	39	29	25	43	38
T_2 : 50 % RDN through FYM + 50 % RDN through VC	44	39	25	22	35	31	47	38	27	21	41	37
T_3 : 50 % RDN through VC + 50 % RDN through NSP	43	41	29	26	32	27	46	40	33	26	37	33
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	43	40	26	24	32	28	47	41	29	24	38	34
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	38	35	29	28	34	29	41	37	32	27	40	35
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	37	33	27	25	32	27	40	34	29	25	37	33
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	32	30	25	23	32	27	36	31	28	23	37	33
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	37	35	25	23	34	29	40	37	27	23	39	36
General mean	**40**	**36**	**27**	**24**	**33**	**29**	**43**	**38**	**29**	**24**	**39**	**35**

4.5.3.4. Microbial count studies

The perusal of data in respect of soil microbial count at the end of soybean-wheat cropping system as influenced by different organic inputs are presented in Table 60. The data regarding microbial count of fungi, bacterial and actinomycetes at flowering stage and at harvest as influenced by different treatments was not subjected to statistical analysis and the inferences are drawn on mean basis.

During 2010-11, the numerical count of bacteria was found numerically higher with the application of 100 % GRDF at flowering stage and at harvest as compared with rest of the treatments. Similar results regarding bacteria count was noticed at flowering stage during 2011-12. However, at harvest, the bacterial count was found numerically higher with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during 2011-12.

Application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times to soybean-wheat cropping sequence reported numerically higher fungi count at flowering stage and at harvest as compared with rest of the treatments during both the years of experimentation.

The numerical count of actinomycetes was found maximum with the application of 100 % GRDF at flowering stage and at harvest as compared to rest of the treatments during both the years.

Application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times to soybean-wheat cropping sequence reported numerically minimum bacterial, fungal and actinomycetes count at flowering stage and at harvest as compared with rest of the treatments during both the years of experimentation.

4.5.4. Cropping system evaluation

Data pertaining to the cropping system evaluation aspects *viz.,* soybean seed equivalent yield, economic efficiency, returns day^{-1}, land

Table 61 : Soybean - wheat cropping system evaluation (2010-11, 2011-12 and pooled)

Treatment	Soybean seed equivalent yield (kg ha^{-1})			Economic efficiency (Rs ha^{-1} year^{-1})			Returns day^{-1} (Rs. day^{-1})		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1 : 100 % GRDF	8937	10118	9528	176	214	195	295	351	323
T_2 : 50 % RDN through FYM + 50 % RDN through VC	6861	7532	7196	73	79	76	127	136	132
T_3 : 50 % RDN through VC + 50 % RDN through NSP	6396	6639	6518	63	56	60	114	101	107
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	5727	6256	5991	50	47	48	93	87	90
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	7389	8139	7764	85	96	91	147	163	155
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	6470	7233	6852	65	68	66	115	119	117
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	5803	6850	6326	51	59	55	93	106	99
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	6787	7887	7337	78	90	84	138	156	147
SEm ±	189	215	202	5	7	6	4	9	8
CD at 5 %	562	629	591	16	21	18	12	25	23
General mean	**6490**	**7219**	**6855**	**66**	**71**	**69**	**118**	**124**	**121**

Table 61 : continued...

Treatments	Production efficiency (kg ha^{-1} day^{-1})			Land use efficiency (Per cent)			Systems productivity (kg ha^{-1})		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1 : 100 % GRDF	41.06	45.56	43.31	59.64	60.84	60.24	24.49	27.72	26.10
T_2 : 50 % RDN through FYM + 50 % RDN through VC	32.65	35.45	34.05	57.57	58.21	57.89	18.80	20.63	19.72
T_3 : 50 % RDN through VC + 50 % RDN through NSP	31.53	32.55	32.04	55.59	55.89	55.74	17.52	18.19	17.86
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	29.45	31.60	30.53	53.27	54.23	53.75	15.69	17.14	16.41
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times	34.96	37.85	36.41	57.90	58.91	58.41	20.24	22.30	21.27
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times	31.56	34.61	33.09	56.16	57.26	56.71	17.73	19.82	18.77
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times	29.21	33.58	31.40	54.43	55.88	55.15	15.90	18.77	17.33
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN hrough VC + Jeevamrut two times	32.77	37.20	34.99	56.74	58.08	57.41	18.59	21.61	20.10
SEm ±	0.84	1.07	0.92	--	--	--	0.68	0.82	0.77
CD at 5 %	2.49	3.17	2.73	--	--	--	2.01	2.43	2.29
General mean	**31.73**	**34.69**	**33.21**	**55.95**	**56.92**	**56.44**	**17.78**	**19.78**	**18.78**

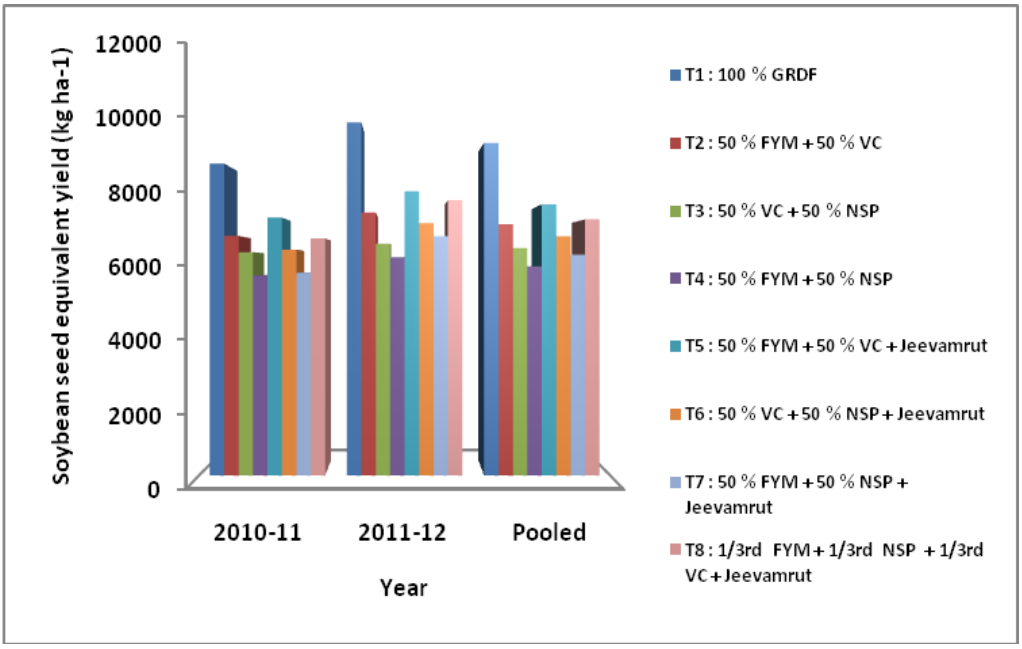

Fig. 19 : Soybean seed equivalent yield of soybean-wheat cropping system as influenced by different treatments

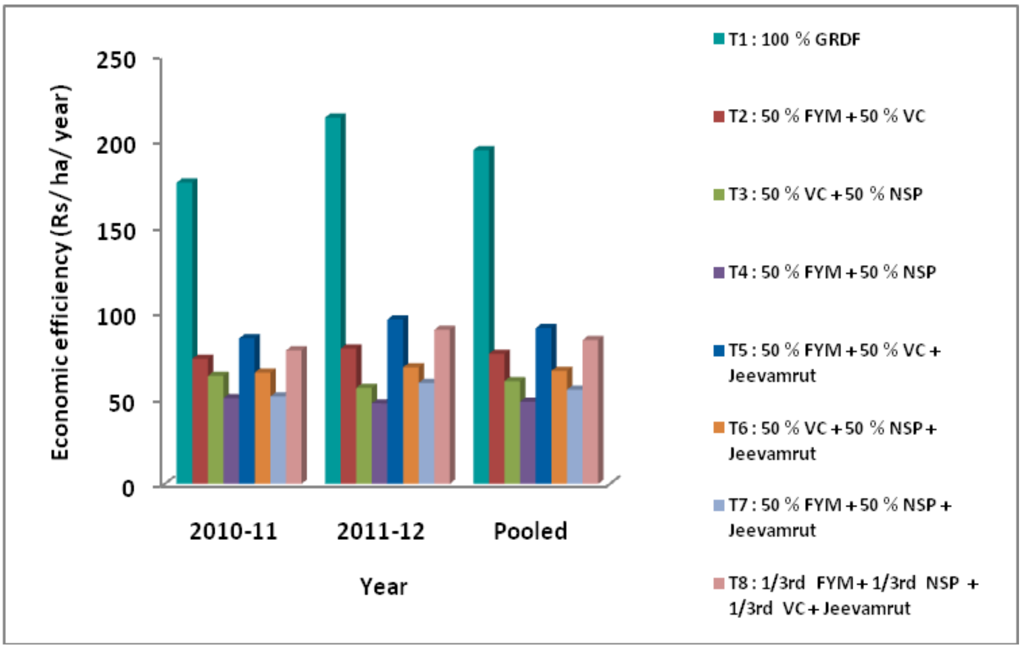

Fig. 20 : Economic efficiency (Rs./ha/year) of soybean-wheat cropping system as influenced by different treatments

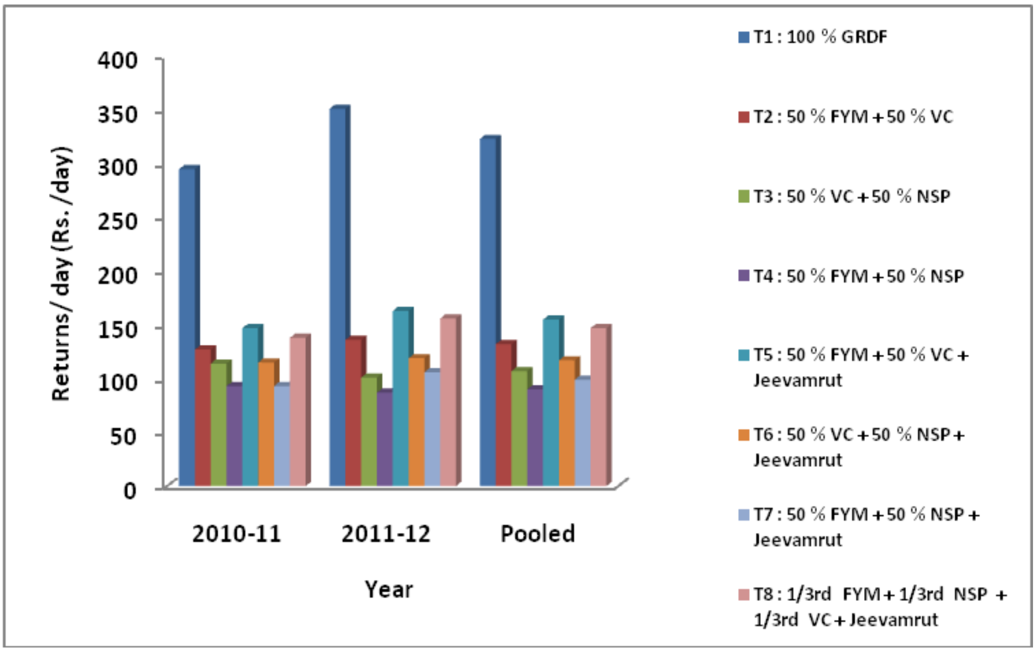

Fig. 21 : Returns/day (Rs./day) of soybean-wheat cropping system as influenced by different treatments

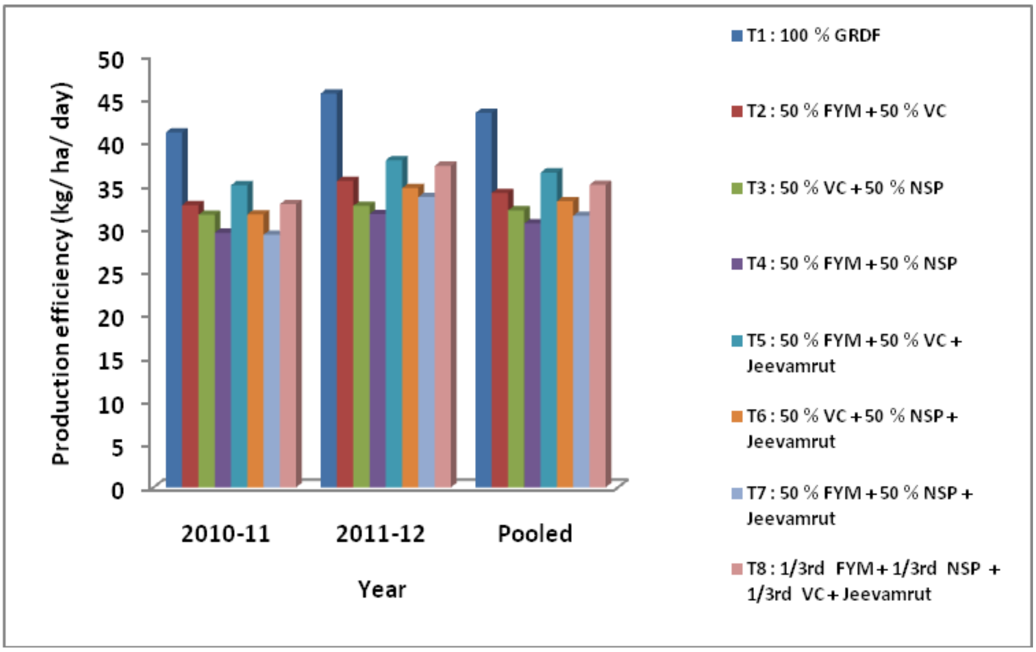

Fig. 22 : Production efficiency (Kg /a ha /day) of soybean-wheat cropping system as influenced by different treatments

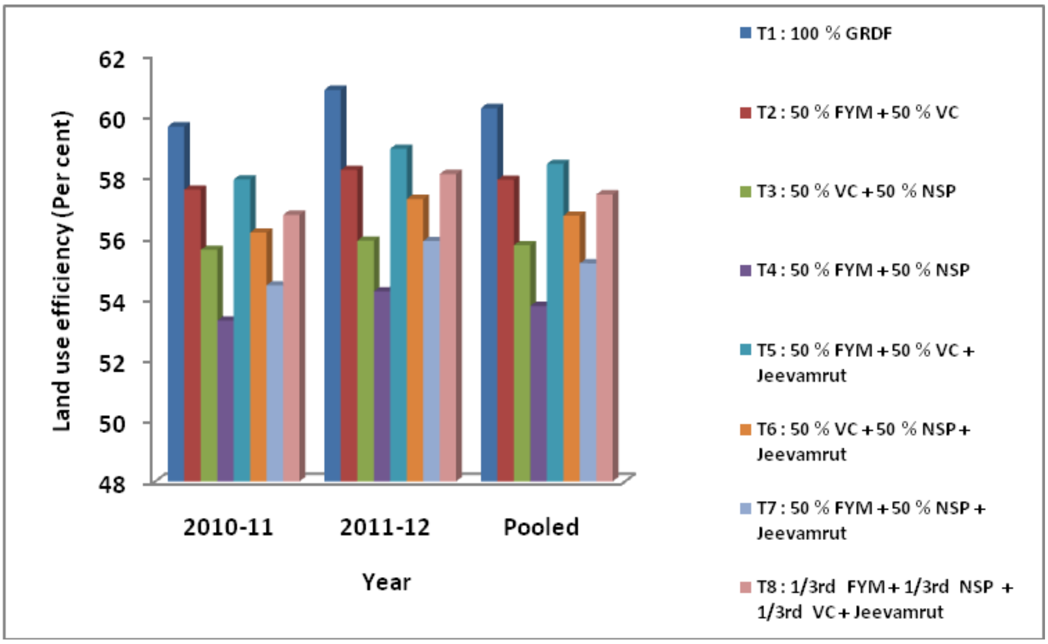

Fig. 23 : Land use efficiency (Per cent) of soybean-wheat cropping system as influenced by different treatments

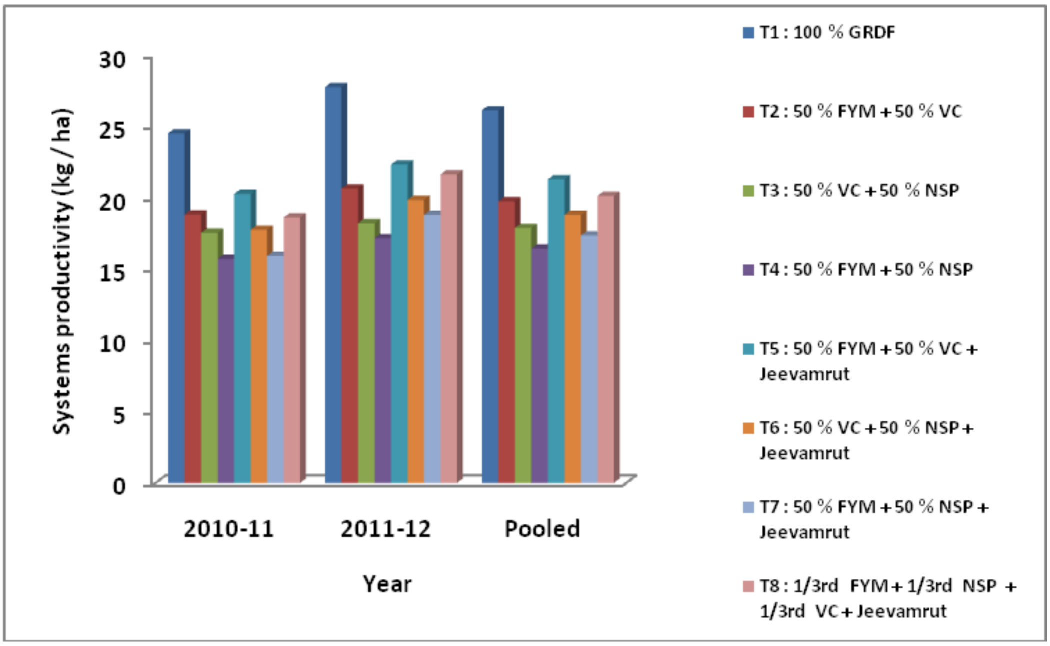

Fig. 24 : Systems productivity (kg/ ha) of soybean-wheat cropping system as influenced by different treatments

use efficiency, production efficiency, and systems productivity as influenced by different organic treatments applied in soybean-wheat cropping system are presented in Table 61.

4.5.4.1. Soybean seed equivalent yield

The data regarding seed equivalent yield was significantly influenced due to different treatments during both the years and in pooled mean are presented in Table 61.

The Table 61 showed that application of 100 % GRDF recorded significantly higher seed equivalent yield during both the years and in pooled mean.

Among the different organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher seed equivalent yield, during both the years and in pooled mean, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost during 2010-11 and with 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during 2011-12 and in pooled mean as compared with rest of the organic treatments.

4.5.4.2. Economic productivity/ efficiency

The economic efficiency was significantly influenced due to different treatments during both the years and in pooled mean. The data pertaining to it are presented in Table 61.

Application of 100 % GRDF recorded significantly higher economic efficiency or productivity during both the years and in pooled mean.

Among the different organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher economic productivity during both the years and in pooled mean, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during both the years and in and in pooled mean as compared with rest of the organic treatments.

4.5.4.3. Returns day^{-1}

The data regarding returns day^{-1} was significantly influenced due to different treatments during both the years and in pooled mean are presented in Table 61.

Application of 100 % GRDF recorded significantly higher returns day^{-1} during both the years and in pooled mean. However, among the different organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher returns day^{-1} during both the years and in pooled mean, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost in pooled mean and with 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times as compared with rest of the organic treatments during both the years of experimentation.

4.5.4.4. Production efficiency

The production efficiency was significantly influenced due to different treatments during both the years and in pooled mean. The data pertaining to it are presented in Table 61.

Application of 100 % GRDF recorded significantly higher production efficiency during both the years and in pooled mean.

Among the different organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher production efficiency during both the years and in pooled mean, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during both the years and in and in pooled mean as compared with rest of the organic treatments.

4.5.4.4. Land use efficiency

The data regarding land use efficiency was not subjected to statistical analysis and the interpretation was made on mean basis. The perusal of data in Table 61 indicated that application of 100 % GRDF recorded numerically maximum value for land use efficiency during both the years and in two years mean.

Among the different organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported numerically maximum value for land use efficiency during both the years and in two years mean. Numerically minimum value for land use efficiency was observed with the application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder as compared with rest of the organic treatments applied to soybean-wheat cropping system.

4.5.4.6. Systems productivity

The systems productivity was significantly influenced due to different treatments during both the years and in pooled mean. The data pertaining to it are presented in Table 61.

Application of 100 % GRDF recorded significantly higher systems productivity during both the years and in pooled mean.

Among the different organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher systems productivity during both the years and in pooled mean, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through farmyard manure + 1/3rd RDN through neem seed powder + 1/3rd RDN through vermicompost + jeevamrut two times during both the years and in and in pooled mean as compared with rest of the organic treatments.

CHAPTER - V

DISCUSSION

Organic crop production is expected to expand in response to increased demand for organic food. Organic crop production system can bring back the cultivation on sustainable basis without affecting environment. Organic crop production system involves organic manures, oilcakes, green manures, liquid manures, bio-fertilizers *etc.* agronomic practices, crop rotation, bio-pesticides *etc.*, apart from encouraging natural parasites, predators and parasitoids in the ecosystem. The management of soil organic matter and the rational use of organic inputs such as animal manures, crop residues, green manures, sewage, sludge and food industry waste would be major constraint in sustainable agriculture in forthcoming decades. However, since organic manures can not meet the total nutrients need of modern agriculture, integrated use of nutrients from fertilizers and organic sources seems to be a need of the time. The inclusion of legume in the cropping sequence is one of the important components of the system.

The soybean-wheat cropping sequence is predominant in India. Integrated nutrient management plays vital role in improving soil fertility and yield potential of crops through optimization of benefits from all possible sources in an integrated manner *i.e.* use of organic, inorganic fertilizers and biofertilizers, such practice is not only achieved sustained production and productivity but also economical and ecofriendly. Significant contribution has been made by many research workers on integrated nutrient management in respect of soybean and wheat crop alone; however, very meagre work has been done on integrated nutrient management for soybean-wheat cropping sequence.

Hence, to increase the production potential of soybean-wheat cropping sequence the present experiment entitled “Effect of different organic inputs with *Jeevamrut* on yield, quality and soil properties of soybean-wheat cropping sequence" was conducted during *kharif* and *rabi* season of 2010-11 and 20011-12 at Integraed Farming Systems Research Project, Mahatma Phule Krishi Vidyapeeth, Rahuri.

5.1. Soil and season

The soil in the experimental plot was deep black, well drained and clayey in texture. The topography of the land was fairly levelled. The soil was low in available nitrogen (181.32 kg ha^{-1}), medium in available phosphorus (15.17 kg ha^{-1}) and high in potassium content (288.85 kg ha^{-1}). Total soluble salt content in soil (Electrical conductivity) was normal (0.27 dSm^{-1}), the soil was moderately alkaline in reaction (pH 8.02) and the corresponding numerical values for bulk density, hydraulic conductivity and maximum water holding capacity are 1.21 mg m^{-3}, 1.63 cm hr^{-1} and 30.07 per cent, respectively.

The quality seed of soybean and wheat were treated. The seeds were dried in shade and used for sowing. The dibbling of seeds was done with 30 cm x 10 cm spacing for soybean and 22.5 cm row spacing for wheat during both the years. Organic manures like farmyard manure, vermicompost and neem seed powder were applied 7 days before sowing as per treatments and *jeevamrut* was applied to soybean-wheat at the time of sowing, at 30 and 45 DAS through irrigation during both the years. To protect soybean and wheat crops from the mild incidence of aphids, jassids; two sprayings of Neemark were taken at 15 days interval. While, to prevent the incidence of aphids and jassids in wheat two sprayings of Neemark were taken at 20 days interval.

5.2. Climate and weather

During cropping season of soybean-wheat cropping sequence, the corresponding values for weather parameters recorded at Meteorological Observatory of the Central Campus, MPKV, Rahuri, were as, total rainfall received (875.2 and 421.6 mm), rainy days (36 and 25), mean maximum temperature (30.7 and 30.9 ^{0}C), mean minimum temperature (17.2 and 16.9 ^{0}C), relative humidity at morning hours (77.4 and 68.6 per cent), evening hours (51.4 and 42.3 per cent), mean wind velocity (2.4 and 3.6 ms^{-1}) and mean bright sunshine hours per day (6.3 and 6.6 hrs) during 2010-11 and 2011-12, respectively.

The results of the present investigation on different quantitative parameters including growth attributes, yield contributing characters, yield, quality, growth functions, growing degree days, economic analysis, energy balance sheet, physico-chemical and biological parameters of soil fertility studies, nutrient balance sheet and cropping system evaluation study in soybean-wheat cropping sequence reported in the previous chapter are discussed herein with appropriate heads and subheads as under.

11.1. Effect of different organic inputs on crops

11.1.1. Performance of soybean

11.1.1.1. Emergence count and final plant stand

The emergence count and final plant stand of soybean was found to be non-significant during both the years of experimentation.

11.1.1.2. Growth and yield attributes

The data presented in Table 11, 12, 13, 14 and 15 on different growth attributing characters of soybean *viz.,* plant height, number of branches, number of functional compound leaves, leaf area, respectively and nodule count at flowering, days 50 % flowering, days to maturity (Table 16), weed count m^{-2} and weed dry weight (Table 17) at 21 DAS were found to be significantly higher with the application of 100 % GRDF at all the growth stages of observation as compared with rest of the treatments during both the years. Among the organic treatments applied to *kharif* soybean, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for different growth attributing characters of soybean (*viz.,* plant height, number of branches, number of functional compound leaves, leaf area), nodule count at flowering; days 50 % flowering, days to maturity, weed count m^{-2} and weed dry weight at 21 DAS, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times during both the years of experimentation. Similar results were reported by Lambade (2013) withh the application of farmyard manure and vermicompost in combination with each other in soybean.

Application of 100 % GRDF reported significantly higher values for total dry matter, number of pods, dry weight of pods, seed yield $plant^{-1}$ and test weight of soybean (Table 18) as compared with rest of the treatments during both the years. Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for total dry matter, number of pods, dry weight of pods, seed yield $plant^{-1}$ and test weight of soybean, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times during both the years. This might be due to mineralization FYM and vermicompost which had beneficial effect in improving the soil health leading to significant improvement in growth of soybean. The results are in conformity with those reported by Singh and Singh (2005).

Application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder reported significantly lower values for different growth attributes, weed count, weed dry weight, days to 50 % flowering, days to maturity, nodule count, yield attribute of soybean during both the years of experimentation.

11.1.1.3. Yield and quality

The seed yield, straw yield and biological yield of soybean (Table 19) reported significantly higher with the application of 100 % GRDF during both the years. Application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for seed yield, straw yield and biological yield of soybean, however it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times during both the years of experimentation. Such improvement in seed yield of soybean might be probably because of FYM improved the nodulation and rate of N_2 fixation and in turn stimulated the growth of plants thereby having beneficial effect on yield attributes and given higher yields. These results are in close conformity with the findings of Rakesh Kumar and Singh (1996).

Numerically, the mean maximum harvest index was recorded with the application of 100 % GRDF followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times as compared with rest of the treatment during both the years.

The application of 100 % GRDF and different organic inputs in combination with each other could not influence the protein and oil content (Table 20) in soybean seed. However, numerically the mean maximum value for protein and oil content in soybean seed was recorded with the application of 100 % GRDF followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times as compared with rest of the treatments during both the years.

Pooled mean data presented herein revealed that application of 100 % GRDF reported significantly higher value for soybean seed yield, straw yield, biological yield. Among the application of organic treatments, 50 % RDN through farmyard manure + 50 % RDN applied through vermicmpost + Jeevamrut two times reported significantly higher values for pooled mean seed yield, straw yield, biological yield. However, it was at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times during both the years.

Application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder reported significantly lower values of seed yield, straw yield, biological yield and quality of soybean during both the years.

Numerically, the mean maximum and minimum harvest index of two years mean was recorded with the application of 50 % RDN through vermicompost + 50 % RDN through neem seed powder and 50 % RDN through farmyard manure + 50 % RDN through neem seed powder respectively during both the years.

11.1.1.4. Growth analysis

The data reported in Table 21, 22, 23, 24, 25 and 26 showed the inconsistent results regarding the different growth functions during 2010-11 and 2011-12. However, application of 100 % GRDF reported significantly higher values for different growth functions (AGR for plant height, AGR for dry matter, RGR, CGR. NAR and LAI) during both the years. Among different organic treatments applied to soybean application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for AGR for dry matter, RGR, CGR and NAR, however, AGR for plant height and LAI was found to be significantly higher with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during both the years.

11.1.1.5. Growing degree days

The heat units required for soybean (Table 27) to attain the establishment to maturity or ripening stage indicated that at initial stage there is no more difference in the values reported for growing degree days, however thereafter, for vegetative stage, flowering, pod setting and pod filling stage, ripening, the cumulative growing degree days estimated during both the years revealed that application of 100 % GRDF reported significantly higher heat units during both the years. Among different organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN vermicompost + Jeevamrut two times was found at par with application of $1/3^{rd}$ RDN through FYM + $1/3^{rd}$ RDN through NSP + $1/3^{rd}$ RDN through VC + Jeevamrut two times at all the days of observation and at par with the application of 50 % RDN through farmyard manure + 50 % RDN neem seed powder + Jeevamrut two times during pod seeting, pod development and physiological maturity during both the years of experimentation. The results of application of farmyard manure and vermicompost in combination with each other were in conformity with those reported by Lambade (2013) in soybean.

11.1.2. Performance of wheat

11.1.2.1. Emergence count and final plant stand

The emergence count and final plant stand (Table 28) of wheat did not differ due to application of different organic inputs applied in combination with each other during both the years of experimentation.

11.1.2.2. Growth attributes

The plant height, number of tillers plant^{-1}, number of compound functional leaves, leaf area of wheat (Table 29, 30, 31, 32 and 33, respectively) were significantly higher with the application of 100 % GRDF as compared with rest of the organic treatments applied to wheat during both the years. Among organic treatments applied to wheat, application of 50 % RDN through farmyard manure + 50 % RDN vermicompost + Jeevamrut two times was found at par with application of 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times and 50 % RDN through farmyard manure + 50 % RDN vermicompost reported significantly higher values for different growth attributes (*viz.* plant height, number of tillers plant^{-1}, number of compound functional leaves, leaf area) of wheat at all the days of observations during both the years. This could be ascribed due to existence of favourable nutritional environment under the influence of organic manures which had a positive effect on vegetative and reproductive growth which ultimately led to realization of higher values for growth attributes leading to higher yield of crop. Similar results were reported by Virkar (2008).

The data on weed count m^{-2} and weed dry weight (Table 34) at 21 DAS and days to 50 % flowering, days to maturity (Table 35) were found to be significantly higher with the application of 100 % GRDF at all the growth stages of observation as compared with rest of the treatments during both the years. Among the organic treatments applied to wheat, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for days to 50 % flowering, days to maturity, weed count m^{-2} and weed dry weight at 21 DAS, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times during both the years.

11.1.2.3. Yield attributes and yield

Application of 100 % GRDF reported significantly higher values *viz.* total dry matter, number of grains per panicle, 1000 seed weight, grain yield plant^{-1} of wheat (Table 36) as compared with rest of the treatments during both the years. Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for total dry matter, number of grains per panicle, 1000 seed weight, grain yield plant^{-1}, however, it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times during both the years.

The seed yield, straw yield and biological yield of wheat (Table 37) reported significantly higher with the application of 100 % GRDF during both the years. Application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for seed yield, straw yield and biological yield, however it was found at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times during both the years of experimentation.

Application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder reported significantly lower values for different growth attributes, weed count, weed dry weight, days to 50 % flowering, days to maturity, yield attributes, yield and quality of wheat during both the years.

Pooled mean data on Table 37 presented herein revealed that application of 100 % GRDF reported significantly higher value for wheat grain yield, straw yield, biological yield. Among the application of organic treatments, 50 % RDN through farmyard manure + 50 % RDN applied through vermicmpost + Jeevamrut two times reported significantly higher values for pooled mean grain yield, straw yield, biological yield, however, it was at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and

1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times during both the years.

Numerically, the mean maximum and minimum harvest index of two years mean was recorded with the application of 50 % RDN through vermicompost + 50 % RDN through neem seed powder and 50 % RDN through farmyard manure + 50 % RDN through neem seed powder respectively during both the years.

11.1.2.4. Quality

The application of 100 % GRDF and different organic inputs in combination with each other could not influence the protein content in wheat seed. However, numerically the mean maximum value for protein content in wheat seed was recorded with the application of 100 % GRDF followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times as compared with rest of the treatments during both the years (Table 38).

11.1.2.4. Growth analysis

The growth analysis of wheat (Table 39, 40, 41, 42, 43 and 44) worked out at 28, 56, 84 and at harvest reported the inconsistent results regarding the different growth functions *viz.* absolute growth rate for plant height and dry matter, relative growth rate, crop growth rate, net assimilation rate, leaf area index *etc.* during both the years. However, application of 100 % GRDF reported significantly higher values for different growth functions during both the years. Among different organic manures applied in combinations with each other, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for different growth functions *viz.* AGR for plant height, AGR for dry matter, RGR for dry matter, NAR, CGR, LAI for wheat at all the days of observations and at harvest during both the years. Significantly lower values for growth functions were recorded with the application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder at all the growth stages of observations and at harvest during both the years.

11.1.2.5. Growing degree days

The data in Table 45 on heat units required for wheat to attain the establishment to maturity or ripening stage indicated that at initial stage up (establishment to vegetative stage) there is no more difference in the values reported for growing degree days, however, thereafter, for flowering, pod setting and pod filling stage the cumulative growing degree days estimated during both the years revealed that among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicmpost + Jeevamrut two times reported significantly higher values for cumulative growing degree days, however, it was at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times at all the days of obserrvations during both the years.

11.1.5. Soybean-wheat cropping system

11.1.5.1. Economic evaluation

Application of 100 % GRDF to soybean-wheat cropping system reported significantly higher gross and net monetary returns during both the years and in pooled mean (Table 48), however, among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN applied through vermicompost + Jeevamrut two times reported significantly higher values for gross and net monetary returns during both the years and in pooled mean, however, it was at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost for gross monetary returns during 2010-11 and in pooled mean and with application of 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times for gross monetary returns during 2011-12 and for net monetary returns during both the years and in pooled mean.

Application of 50 % RDN through farmyard manure + 50 % RDN applied through vermicmpost + Jeevamrut two times reported numerically maximum cost of cultivation (Rs. 64773, 65639 and 65206 ha^{-1}, respectively). The minimum cost of cultivation was noticed with the application of 50 % RDN through farmyard manure + 50 % RDN applied through neem seed powder during 2010-11, 2011-12 and two years mean (Rs. 56385, 58275 and 57330 ha^{-1}), respectively.

Numerically maximum value for benefit : cost ratio was noticed with the 100 % GRDF to soybean-wheat cropping system followed by application of 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times. The minimum value for benefit : cost ratio was reported with the application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder during both the years and in mean.

11.1.5.2. Energy balance studies

The data on energy balanace studies are presented in Table 51 and reported that application of 100 % GRDF to soybean-wheat cropping system showed significantly higher energy output during both the years and in pooled mean, however, among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN applied through vermicmpost + Jeevamrut two times reported significantly higher values for energy output during both the years and in pooled mean, however, it was at par with the application of 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times during both the years and in pooled mean.

Energy balance, energy balance per unit input and energy output input ratio was found significantly higher with the application of 100 % GRDF to soybean-wheat cropping system during both the years and in pooled mean. Among different organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicmpost + Jeevamrut two times reported significantly higher values for energy balance, energy balance per unit input and energy output input ratio during both the years and in pooled mean, however, it was at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost, 50 % RDN through vermicompost + 50 % RDN through neem seed powder + Jeevamrut two times and 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times during both the years and in pooled mean.

Numerically maximum energy input was noticed with the application of 100 % GRDF followed by 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during both the years and two years mean. The minimum energy input value was noticed with the application of 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times during both the years and in two years mean.

11.1.5.3. Physico-chemical and biological properties of soil

The physico-chemical and biological properties of soil (Table 52) were improved substantially with the application of 100 % GRDF to soybean-wheat cropping system followed by 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times

11.1.5.4. Nutrient balance

The nutrient balance at the end of the cropping sequence during both the year of experiment was worked out with the consideration of inherent soil fertility in respect of soil available N, P and K, nutrients added through organic inputs, nutrient uptake by crops in cropping sequence and left over soil available N, P and K at the harvest of each crop in sequence.

The data presented in Table 59 revealed that the application of 100 % GRDF to soybean-wheat cropping sequence reported maximum nutrients applied with maximum nutrient uptake indicated positive N, P and K balance at the end of two years of soybean-wheat cropping sequence. Clark *et al.* (1998) in his 4 year study stated similar findings indicated that organic and low input system had higher soil organic C, soluble P, exchangeable K. Higher availability of P in manured treatments might be attributed to P solubilization by organic acids released from organic manures on their decomposition, reduction of P fixation in soil due to chelation of P fixing cations like Ca, Mg, Fe, Al, Zn *etc*. Similar findings were also reported by Bhardwaj and Omanvar (1994).

11.1.5.5. Cropping system evaluation

The data pertaining to cropping system evaluation presented in Tale 61 revealed that application of 100 % GRDF reported significantly higher value for soybean seed equivalent yield, production efficiency, systems productivity, economic efficiency and returns day^{-1} during 2010-11, 2011-12 and in pooled mean. Among organic treatments applied to soybean-wheat cropping system, application 50 % RDN through farmyard manure + 50 % RDN through vermicmpost + Jeevamrut two times reported significantly higher values for soybean seed equivalent yield, production efficiency, systems productivity, economic efficiency and returns day^{-1}, however, it was at par with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times during both the years and in pooled. The results were in the line of those reported by Lambade (2013) due to application of FYM and vermicompost in combination with each other in soybean+pigeonpea-summer groundnut cropping system.

Application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder recorded significantly the lowest value for all the parameters of cropping system evaluation durng both the years of experimentation.

CHAPTER – VI

SUMMARY AND CONCLUSIONS

6.1. Summary

The present experiment entitled "Effect of different organic inputs with jeevamrut on yield, quality and soil properties in soybean-wheat cropping sequence" was conducted at Integrated Farming Systems Research Project Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahemadnagar (MS) in Survey No. 132 during 2010-11 and 2011-12.

The soil in the experimental plot was deep black, well drained and clayey in texture. The topography of the land was fairly levelled. The soil was low in available nitrogen (181.32 kg ha^{-1}), medium in available phosphorus (15.17 kg ha^{-1}) and high in potassium content (288.85 kg ha^{-1}). Total soluble salt content in soil (Electrical conductivity) was normal (0.27 dSm^{-1}), the soil was moderately alkaline in reaction (pH 8.02) and the corresponding numerical values for bulk density, hydraulic conductivity and maximum water holding capacity are 1.21 mg m^{-3}, 1.63 cm hr^{-1} and 30.07 per cent, respectively.

During cropping season of soybean-wheat cropping sequence, the corresponding values for weather parameters recorded at Meteorological Observatory of the Central Campus, MPKV, Rahuri, were as, total rainfall received (875.2 and 421.6 mm), rainy days (36 and 25), mean maximum temperature (30.7 and 30.9 ^{0}C), mean minimum temperature (17.2 and 16.9 ^{0}C), relative humidity at morning hours (77.4 and 68.6 per cent), evening hours (51.4 and 42.3 per cent), mean wind velocity (2.4 and 3.6 ms^{-1}) and mean bright sunshine hours per day (6.3 and 6.6 hrs) during 2010-11 and 2011-12, respectively.

The experiment was laid out in Randomized Block Design (RBD) with 8 treatments for soybean - wheat cropping system (*viz.* T_1 : 100 %

General recommonded dose of fertilizer (GRDF), T_2 : 50 % recommonded dose of nitrogen (RDN) through Farmyard manure (FYM) + 50 % RDN through Vermicompost (VC), T_3 : 50 % RDN through VC + 50 % RDN through Neem seed powder (NSP), T_4 : 50 % RDN through FYM + 50 % RDN through NSP, T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut two times (30 and 45 DAS @ 500 L ha^{-1} $time^{-1}$), T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut two times (30 and 45 DAS @ 500 L ha^{-1} $time^{-1}$), T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut two times (30 and 45 DAS @ 500 L ha^{-1} $time^{-1}$), T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times (30 and 45 DAS @ 500 L ha^{-1} $time^{-1}$) with 3 replications. The gross plot size was 5.40 m x 3.60 m; net plot size was 4.50 m x 3.00 m for soybean and wheat in cropping system during both the years. 1.50 m distance between replications and 0.75 m between each experimental unit was maintained.

The experiment was conducted on same site without changing the randomization of the treatments for the successive year to assess the soil residual effects. Organic manures like farmyard manure, vermicompost and neem seed powder were applied 7 days before sowing as per treatments and *jeevamrut* was applied to soybean-wheat at the time of sowing, at 30 and 45 DAS through irrigation during both the years.

The quality seed of soybean *(Cv.* JS-335) and wheat seed *(Cv. Trimbak :* NIAW 301) were inoculated with *Rhizobium* sp./ *Azetobactor,* respectively, PSB culture and *Trichoderma* 3 g kg^{-1}. The seeds were dried in shade and used for sowing. The dibbling of seeds was done with 30 cm x 10 cm spacing for soybean and 22.5 cm row spacing for wheat. during both the years.

First irrigation was applied immediately after sowing of crops to ensure the better germination of each crop and respective irrigations were applied to soybean-wheat cropping system as and when needed during both the years. To protect soybean crops from the mild incidence of aphids, jassids; two sprayings of Neemark were taken at 15 days interval. While, to prevent the incidence of aphids and jassids in wheat two sprayings of Neemark were taken at 20 days interval.

The data in respect of important periodical growth and yield attributes, yield and quality at harvest of soybean and wheat were recorded. The soybean-wheat cropping system was also assessed through economic evaluation, energy and nutrient balance along with the different cropping system parameters during both the years. The most important findings emerging from this investigation are summarized as below.

6.2. Effect of different organic inputs on crops

6.2.1. Performance of soybean in soybean-wheat

The emergence count and final plant stand of soybean was found to be non-significant during both the years.

The growth attributing characters of soybean *viz.,* plant height, number of branches, number of functional compound leaves, leaf area, respectively and nodule count at flowering, days 50 % flowering, days to maturity, weed count m^{-2} and weed dry weight at 21 DAS were found to be significantly higher with the application of 100 % GRDF at all the growth stages of observation as compared with rest of the treatments during both the years.

Among the organic treatments applied to *kharif* soybean, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for different growth attributing characters of soybean (*viz.,* plant height, number of branches, number of functional compound leaves, leaf area), nodule count at flowering; days 50 % flowering, days to maturity, weed count m^{-2} and weed dry weight at 21 DAS, during both the years.

Application of 100 % GRDF reported significantly higher values for total dry matter, number of pods, dry weight of pods, seed yield plant^{-1} and test weight of soybean as compared with rest of the treatments during both the years. Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for total dry matter, number of pods, dry weight of pods, seed yield plant^{-1} and test weight of soybean.

Application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder reported significantly lower values for different growth attributes, weed count, weed dry weight, days to 50 % flowering, days to maturity, nodule count, yield attribute of soybean during both the years.

The seed yield, straw yield and biological yield of soybean reported significantly higher values with the application of 100 % GRDF followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during both the years.

Numerically, the mean maximum harvest index was recorded with the application of 100 % GRDF followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times as compared with rest of the treatment during both the years.

The protein and oil content in soybean seed was not influenced significantly due to application of different treatments during both the years.

Application of 100 % GRDF followed by 50 % RDN through farmyard manure + 50 % RDN applied through vermicmpost + Jeevamrut two times reported significantly higher value for soybean seed yield, straw yield, biological yield during both the years.

Application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder reported significantly lower values of seed yield, straw yield and biological yield of soybean during both the years.

Numerically, the mean maximum and minimum harvest index of two years mean was recorded with the application of 50 % RDN through vermicompost + 50 % RDN through neem seed powder and 50 % RDN through farmyard manure + 50 % RDN through neem seed powder, respectively during both the years.

Application of 100 % GRDF reported significantly higher values for different growth functions during both the years. Among different organic treatments applied to soybean application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for AGR for dry matter, RGR, CGR and NAR, however, AGR for plant height and LAI was found to be significantly higher with the application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during both the years.

The application of 100 % GRDF followed by application of 50 % RDN through farmyard manure + 50 % RDN vermicompost + Jeevamrut two times reported significantly higher cumulative growing degree days (heat units) during both the years.

6.2.2. Performance of wheat in soybean-wheat

The emergence count and final plant stand of wheat did not differ due to application of different treatments during both the years.

The plant height, number of tillers plant^{-1}, number of compound functional leaves, leaf area of wheat were significantly higher with the application of 100 % GRDF followed by application of 50 % RDN through farmyard manure + 50 % RDN vermicompost + Jeevamrut two times reported significantly higher values for different growth attributes (*viz*. plant height, number of tillers plant^{-1}, number of compound functional leaves, leaf area) of wheat at all the days of observations during both the years.

The data on weed count m^{-2} and weed dry weight at 21 DAS and days to 50 % flowering, days to maturity were found to be significantly higher with the application of 100 % GRDF followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times as compared with rest of the treatments during both the years.

Application of 100 % GRDF reported significantly higher values *viz.* total dry matter, number of grains per panicle, 1000 seed weight, grain yield $plant^{-1}$ of wheat as compared with rest of the treatments during both the years. Among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for total dry matter, number of grains per panicle, 1000 seed weight, grain yield $plant^{-1}$ during both the years.

The seed yield, straw yield and biological yield of wheat reported significantly higher with the application of 100 % GRDF followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for seed yield, straw yield and biological yield during both the years.

Application of 100 % GRDF reported significantly higher value for wheat grain yield, straw yield, biological yield followed by application 50 % RDN through farmyard manure + 50 % RDN applied through vermicmpost + Jeevamrut two times reported significantly higher values for pooled grain yield, straw yield, biological yield, during both the years.

Numerically, the mean maximum and minimum harvest index of two years mean was recorded with the application of 50 % RDN through vermicompost + 50 % RDN through neem seed powder and 50 % RDN through farmyard manure + 50 % RDN through neem seed powder respectively during both the years.

Numerically mean maximum value for protein content in wheat seed was recorded with the application of 100 % GRDF followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times as compared with rest of the treatments during both the years.

The growth analysis of wheat reported the inconsistent results regarding the different growth functions during both the years. However, application of 100 % GRDF reported significantly higher values for different growth functions during both the years. Among different organic manures, application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher values for different growth functions *viz.* AGR for plant height, AGR for dry matter, RGR for dry matter, NAR, CGR, LAI for wheat at all the days of observations and at harvest during both the years.

The heat units required for wheat revealed that among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicmpost + Jeevamrut two times reported significantly higher values for cumulative growing degree days during both the years.

6.2.5. Performance of soybean – wheat cropping sequnce

Application of 100 % GRDF to soybean-wheat cropping system reported significantly higher gross and net monetary returns, however, among the organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN applied through vermicmpost + Jeevamrut two times reported significantly higher values for gross and net monetary returns during both the years and in pooled mean.

Application of 50 % RDN through farmyard manure + 50 % RDN applied through vermicmpost + Jeevamrut two times reported numerically maximum cost of cultivation (Rs. 64773, 65639 and 65206 ha^{-1}, respectively). The minimum cost of cultivation was noticed with the application of 50 % RDN through farmyard manure + 50 % RDN applied through neem seed powder during 2010-11, 2011-12 and two years mean (Rs. 56385, 58275 and 57330 ha^{-1}), respectively.

Numerically maximum value for benefit : cost ratio was noticed with the 100 % GRDF to soybean-wheat cropping system followed by application of 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times. The minimum value for benefit : cost ratio was reported with the application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder during both the years and in pooled mean.

The application of 100 % GRDF to soybean-wheat cropping system showed significantly higher energy output followed by application of 50 % RDN through farmyard manure + 50 % RDN applied through vermicmpost + Jeevamrut two times reported significantly higher values for energy output during both the years and in pooled mean.

Energy balance, energy balance per unit input and energy output input ratio was found significantly higher with the application of 100 % GRDF to soybean-wheat cropping system. Among different organic treatments, application of 50 % RDN through farmyard manure + 50 % RDN through vermicmpost + Jeevamrut two times reported significantly higher values for energy balance, energy balance per unit input and energy output input ratio during both the years and in pooled mean,

Numerically maximum energy input was noticed with the application of 100 % GRDF followed by 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during both the years and two years mean. The minimum energy input value was noticed with the application of 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times during both the years and in two years mean.

The physico-chemical and biological properties of soil were improved substantially with the application of 100 % GRDF to soybean-wheat cropping system followed by 50 % RDN through farmyard manure + 50 % RDN through vermicompost and 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut two times

The application of 100 % GRDF to soybean-wheat cropping sequence reported maximum nutrients applied with maximum nutrient uptake indicated positive N, P and K balance at the end of two years of soybean-wheat cropping sequence.

Application of 100 % GRDF followed by application 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times reported significantly higher value for soybean seed equivalent yield, production efficiency, systems productivity, economic efficiency and returns day^{-1} during both the years and in pooled mean. Application of 50 % RDN through farmyard manure + 50 % RDN through neem seed powder recorded significantly the lowest value for all the parameters of cropping system evaluation during both the years and in pooled mean.

The results obtained during the investigation are concluded as under…

- The growth attributes, yield attributes, yield, quality, gross monetary returns, net monetary returns and benefit : cost ratio in soybean and wheat were found significantly higher with the application of 100 % GRDF followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during both the years.

- Application of 100 % GRDF followed by application of 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during both the years reported significantly higher values for different growth functions, growing degree days at all the days of observations during both the years.

- Soybean-wheat cropping system was found highly remunerative with the application of 100 % GRDF followed by 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during both the years and registered significantly higher gross and net monetary returns during both the year and in pooled mean.

- Significantly higher energy output value, energy balance, energy balance per unit input and energy output per input ratio in soybean-wheat cropping system was found with the application of 100 % GRDF followed by 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during both the years.

- Application of 100 % GRDF applied to soybean-wheat cropping system reported highly positive N, P and K balance during both the years.

- The physico-chemical and biological properties of soil were improved substantially with the application of 100% GRDF applied to soybean-wheat cropping system during both the years.

- Among different cropping system evaluation parameters, soybean seed equivalent yield, production efficiency, systems productivity, economic efficiency, returns day^{-1} and numerically higher value for land use efficiency was observed with the application of 100 % GRDF followed by 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times during both the years

Thus, for higher productivity and profitability of soybean-wheat cropping system, application of 100 % GRDF, followed by 50 % RDN through farmyard manure + 50 % RDN through vermicompost + Jeevamrut two times to soybean-wheat cropping system is advisible.

FUTURE LINE OF WORK

It is imperative to give priority in the research agenda on the following aspects...

- Considering the present trends and future concerns, organic farming systems are likely to dominate in our future research agenda. Therefore, role of legumes, organic manures, green manures, use of crop specific strains of microorganisms as biofertilizers in association or in rotation and recycling of crop residues deserves attention to diversify the existing agricultural system to harvest quality produce.

- The research should be in a holistic manner, site specific, long term evaluation of different organic inputs with adequate quantity to harvest potential yield of the crops.

- This/Such investigation(s) should be continued at least for five years for firm recommendation.

CHAPTER - VII

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***Originals are not seen**

APPENDIX

App. i : Details of prices used for economics evaluation

Sr. No.	Particulars	Unit	Rates (Rs.)	
			2010-11	**2011-12**
1.	Ploughing	Rs ha^{-1}	2000	2200
2.	Harrowing	Rs ha^{-1}	1200	1250
3.	Labour charges	Rs day^{-1} $head^{-1}$	150	150
4.	Cost of seed			
	Soybean (JS-335)	Rs kg^{-1}	30	30
	Wheat (Trimbak)	Rs kg^{-1}	25	25
5.	Cost of biofertilizers			
	Rhizobium	Rs $packet^{-1}$	10	10
	Azotobacter	Rs $packet^{-1}$	10	10
	PSB	Rs $packet^{-1}$	15	15
6.	Organic inputs			
	Farm yard manure	Rs kg^{-1}	1	1.2
	Vermicompost	Rs kg^{-1}	3	3.5
	Neem seed powder	Rs kg^{-1}	4	4.5
	Jeevamrut	Rs lit^{-1}	0.4	0.5
7.	Chemical fertilizers			
	Urea	Rs kg^{-1}	5.0	5.2
	Single super phosphate	Rs kg^{-1}	4.0	4.4
	Murriate of potash	Rs kg^{-1}	9.8	10.3
8.	Plant protection			
	Neem seed extract (Neemark)	Rs lit^{-1}	1.2	1.3
9.	Land rate	Rs ha^{-1}	450	450
10.	Irrigation charges	Rs ha^{-1} $turn^{-1}$	250	250
11.	Main product			
	Soybean seed	Rs kg^{-1}	24	26
	Wheat grain	Rs kg^{-1}	14	14.5
12.	By products			
	Soybean straw	Rs kg^{-1}	0.7	0.7
	Wheat straw	Rs kg^{-1}	0.3	0.3

App. ii : Details of energy values of input and output used

Sr. No.	Particulars	Unit	Energy value (MJ)
A)	**Input**		
1.	Self propelled machine Tractor (Plough/Cultivator/ Rotavator)	MJ ha^{-1}	64.80
	Animal (Bulluck pair-medium)	MJ ha^{-1}	10.10
2.	Human labour	MJ ha^{-1}	1.96
3.	Fuel (Diesel)	MJ L^{-1}	56.31
4.	Electricity	KW hr^{-1}	11.93
5.	Seed		
	Soybean (JS-335)	MJ kg^{-1}	14.70
	Wheat (Trimbak)	MJ kg^{-1}	14.70
6.	Biofertilizer		
	Rhizobium	MJ kg^{-1}	10.00
	Azotobacter	MJ kg^{-1}	10.00
	PSB	MJ kg^{-1}	10.00
7.	Organic inputs		
	Farm yard manure	MJ kg^{-1}	0.30
	Vermicompost	MJ kg^{-1}	0.30
	Neem seed powder	MJ kg^{-1}	0.30
	Jeevamrut	MJ L^{-1}	0.30
8.	Chemical fertilizers		
	Nitrogen	MJ kg^{-1}	60.0
	P_2O_5	MJ kg^{-1}	11.1
	K_2O	MJ kg^{-1}	6.7
9.	Plant protection		
	Neem seed extract (Neemark)	MJ L^{-1}	120.00
B)	**Output**		
1.	Main product		
	Soybean seed	MJ kg^{-1}	14.70
	Wheat grain	MJ kg^{-1}	14.70
2.	By products		
	Soybean straw	MJ kg^{-1}	12.50
	Wheat straw	MJ kg^{-1}	12.50

Source : Devasenapathy *et al.* (2009).

App. iii. : Treatment wise cost of cultivation

Treatment	Common cost of cultivation (Rs ha^{-1})		Treatment wise expenditure (Rs ha^{-1})		Total cost of cultivation (Rs ha^{-1})	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Soybean (Base crop)						
T_1	12277	12527	8168	9378	20445	21905
T_2	12277	12527	10349	12885	22626	25412
T_3	12277	12527	10158	11983	22435	24510
T_4	12277	12527	9188	10074	21465	22601
T_5	12277	12527	10749	13385	23026	25912
T_6	12277	12527	10558	12483	22835	25010
T_7	12277	12527	9588	10574	21865	23101
T_8	12277	12527	10298	12147	22575	24674
Wheat (Sequence crop)						
T_1	13135	13385	14208	16443	27342	29828
T_2	13135	13385	28212	25842	41347	39226
T_3	13135	13385	25058	25864	38193	39248
T_4	13135	13385	21786	22290	34920	35675
T_5	13135	13385	28612	26342	41747	39726
T_6	13135	13385	25458	26364	38593	39748
T_7	13135	13385	22186	22790	35320	36175
T_8	13135	13385	25419	25165	38553	38550

App. iv. : Treatment wise input energy values

Treatment	Common input energy (Mj ha^{-1})		Treatment wise input energy (Mj ha^{-1})		Total input energy (Mj ha^{-1})	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Soybean (Base crop)						
T_1	14909	14909	5460	5460	20369	20369
T_2	14909	14909	1980	2028	16889	16937
T_3	14909	14909	961	1003	15871	15912
T_4	14909	14909	1757	1704	16666	16613
T_5	14909	14909	2280	2328	17189	17237
T_6	14909	14909	1261	1303	16171	16212
T_7	14909	14909	2057	2004	16966	16913
T_8	14909	14909	1866	1878	16775	16787
Wheat (Sequence crop)						
T_1	20104	20104	11261	11261	31366	31366
T_2	20104	20104	5322	4066	25427	24170
T_3	20104	20104	2331	2067	22435	22172
T_4	20104	20104	4452	3553	24557	23658
T_5	20104	20104	5622	4366	25727	24470
T_6	20104	20104	2631	2367	22735	22472
T_7	20104	20104	4752	3853	24857	23958
T_8	20104	20104	4335	3529	24440	23633

App. v : Quantity of nutrient sources applied to soybean in soybean – wheat cropping sequence during 2010-11

Treatments	Treatmentwise Quantity of Nutrient Source added in soil (kg ha^{-1})														
	Chemical fertilizer			Farmyard manure			Vermicompost			Neem seed powder			Jeevamrut		
	Urea	SSP	MoP	N	P	K	N	P	K	N	P	K	N	P	K
Nutrient content (%)	**46.0 (N)**	**16.0 (P_2O_5)**	**60.0 (K_2O)**	**0.56**	**0.44**	**0.96**	**1.38**	**0.71**	**0.92**	**2.34**	**0.76**	**1.21**	**0.02**	**0.01**	**0.20**
T_1 : 100 % GRDF	109	469	--	5000			--	--	--	--	--	--	--	--	--
T_2 : 50 % RDN through FYM + 50 % RDN through VC	--	--	--	4464			1812			--	--	--	--	--	--
T_3 : 50 % RDN through VC + 50 % RDN through NSP	--	--	--	--	--	--	1812			1068			--	--	--
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	--	--	--	4464			--	--	--	1068			--	--	--
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut	--	--	--	4464			1812			--	--	--	1000		
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut	--	--	--	--	--	--	1812			1068			1000		
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut	--	--	--	4464			--	--	--	1068			1000		
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut	--	--	--	2976			1208			712			1000		

App. vi : Quantity of nutrient sources applied to wheat in soybean – wheat cropping sequence during 2010-11

Treatments	Treatmentwise Quantity of Nutrient Source added in soil (kg ha^{-1})														
	Chemical fertilizer			Farmyard manure			Vermicompost			Neem seed powder			Jeevamrut		
	Urea	SSP	MoP	N	P	K	N	P	K	N	P	K	N	P	K
Nutrient content (%)	**46.0 (N)**	**16.0 (P_2O_5)**	**60.0 (K_2O)**	**0.49**	**0.34**	**0.72**	**1.16**	**0.54**	**0.92**	**2.64**	**0.66**	**1.37**	**0.01**	**0.01**	**0.19**
T_1 : 100 % GRDF	261	375	67	10000			--	--	--	--	--	--	--	--	--
T_2 : 50 % RDN through FYM + 50 % RDN through VC	--	--	--	12245			5172			--	--	--	--	--	--
T_3 : 50 % RDN through VC + 50 % RDN through NSP	--	--	--	--	--	--	5172			2273			--	--	--
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	--	--	--	12245			--	--	--	2273			--	--	--
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut	--	--	--	12245			5172			--	--	--	1000		
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut	--	--	--	--	--	--	5172			2273			1000		
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut	--	--	--	12245			--	--	--	2273			1000		
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut	--	--	--	8163			3448			1515			1000		

App. vii : Quantity of nutrient sources applied to soybean in soybean – wheat cropping sequence during 2011-12

Treatments	Treatmentwise Quantity of Nutrient Source added in soil (kg ha^{-1})														
	Chemical fertilizer			Farmyard manure			Vermicompost			Neem seed powder			Jeevamrut		
	Urea	SSP	MoP	N	P	K	N	P	K	N	P	K	N	P	K
Nutrient content (%)	**46.0 (N)**	**16.0 (P_2O_5)**	**60.0 (K_2O)**	**0.57**	**0.41**	**0.74**	**1.22**	**0.73**	**0.86**	**2.58**	**0.71**	**1.42**	**0.01**	**0.02**	**0.23**
T_1 : 100 % GRDF	109	469	--	5000			--	--	--	--	--	--	--	--	--
T_2 : 50 % RDN through FYM + 50 % RDN through VC	--	--	--	4386			2049			--	--	--	--	--	--
T_3 : 50 % RDN through VC + 50 % RDN through NSP	--	--	--	--	--	--	2049			969			--	--	--
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	--	--	--	4386			--	--	--	969			--	--	--
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut	--	--	--	4386			2049			--	--	--	1000		
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut	--	--	--	--	--	--	2049			969			1000		
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut	--	--	--	4386			--	--	--	969			1000		
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut	--	--	--	2924			1366			646			1000		

App. viii : Quantity of nutrient sources applied to wheat in soybean – wheat cropping sequence during 2011-12

Treatments	Treatmentwise Quantity of Nutrient Source added in soil (kg ha^{-1})														
	Chemical fertilizer			Farmyard manure			Vermicompost			Neem seed powder			Jeevamrut		
	Urea	SSP	MoP	N	P	K	N	P	K	N	P	K	N	P	K
Nutrient content (%)	**46.0 (N)**	**16.0 (P_2O_5)**	**60.0 (K_2O)**	**0.66**	**0.43**	**0.84**	**1.45**	**0.67**	**0.89**	**2.47**	**0.91**	**1.31**	**0.02**	**0.02**	**0.23**
T_1 : 100 % GRDF	261	375	67	10000			--	--	--	--	--	--	--	--	--
T_2 : 50 % RDN through FYM + 50 % RDN through VC	--	--	--	9091			4138			--	--	--	--	--	--
T_3 : 50 % RDN through VC + 50 % RDN through NSP	--	--	--	--	--	--	4138			2429			--	--	--
T_4 : 50 % RDN through FYM + 50 % RDN through NSP	--	--	--	9091			--	--	--	2429			--	--	--
T_5 : 50 % RDN through FYM + 50 % RDN through VC + Jeevamrut	--	--	--	9091			4138			--	--	--	1000		
T_6 : 50 % RDN through VC + 50 % RDN through NSP + Jeevamrut	--	--	--	--	--	--	4138			2429			1000		
T_7 : 50 % RDN through FYM + 50 % RDN through NSP + Jeevamrut	--	--	--	9091			--	--	--	2429			1000		
T_8 : 1/3rd RDN through FYM + 1/3rd RDN through NSP + 1/3rd RDN through VC + Jeevamrut	--	--	--	6061			2759			1619			1000		

CHAPTER - IX

VITA

NITIN SHIVAJIRAO UGALE

A candidate for the degree of

DOCTOR OF PHILOSOPHY (AGRICULTURE)

In

AGRONOMY

Title of Thesis : "Effect of different organic inputs on yield, quality and soil properties of soybean-wheat cropping sequence".

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Personal data : Born on 20.05.1971 in Devsade, Tq. Newasa, Dist. Ahmednagar; Son of Shri. Shivajirao Tukaram Ugale and Smt. Ashabai Shivajirao Ugale.

Educational : Attended Primary and Secondary School (1987) at Gautam Public School, Kolpewadi, Tq. Kopargaon, Dist. Ahmednagar and Higher Secondary School (1989) at Padmshri Vikhe Patil College of Arts, Science and Commerce, Loni Tq. Shrirampur, Dist. Ahmednagar (First class).

: Received B.Sc. (Agri.) degree (First Class) from College of Agriculture, Amravati, PDKV, Akola (1993) and M.Sc. (Agri.) degree in Agronomy (First Class) from MPKV, Rahuri, Dist. Ahmednagar (1993).

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