Effect of Organics and Inorganics Application on Productivity and Chemical Composition of Soybean Grown in Semi- arid Vertisols

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By

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CERTIFICATE-I

This is to certify that the thesis entitled **"Effect of Organics and Inorganics Application on Productivity and Chemical Composition of Soybean Grown in Semi-arid Vertisols''** submitted in partial fulfillment of the requirements for the **Degree of MASTER OF SCIENCE in Agriculture (Soil Science and Agricultural Chemistry)** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, **Gwalior (M.P.) is a record of the bona-fide research work carried out by Ms. JYOTI BANGRE,** ID.No. RA/IN/108/2010 under my guidance and supervision. The subject of the thesis has been approved by the student's advisory committee and the Director of Instruction**.**

No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of this investigation has been acknowledged by the scholar

Signature

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DATE: **Chairman of the Advisory Committee**

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CERTIFICATE-II

This is to certify that the thesis entitled **"Effect of Organics and Inorganics Application on Productivity and Chemical Composition of Soybean Grown in Semi-arid Vertisols''** submitted by **Ms. JYOTI BANGRE,** ID.No. RA/IN/108/2010 to the RajmataVijayarajeScindia Krishi VishwaVidyalaya, Gwalior (M.P.) in partial fulfillment of the requirements for the Degree of **Master of science** in **Agriculture** in the **Soil Science and Agricultural Chemistry,** College of Agriculture, Indore has been accepted after evaluation by the External Examiner and approved by the Student's Advisory Committee after an oral examination of the same.

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Place: Indore
Date: *(Jyoti Bangre)*

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LIST OF SYMBOL

S.NO	Symbol	Abbreviation
1	S.No.	Serial number
2	AICRPDA	All India Coordinated Research Project for Dryland Agriculture
3	CD	Critical difference
4	i.e.	That is (in reference to)
5	*et al.*	Allied (and other)
6	ANOVA	Analysis of variance
7	OC	Organic carbon
8	N	Nitrogen
9	P	Phosphorus
10	K	Potassium
11	S	Sulphur
12	Zn	Zinc
13	FYM	Farm yard manure
14	SOC	Soil organic carbon
15	Kg	Kilogram
16	g	gram
17	cv.	Cultivar
18	C.V.	Coefficient of variance
19	MSS	Mean sum of square
20	ESS	Error sum of square
21	S.S	Sum of square
22	Fig.	Figures
23	&	And
24	ppm	parts per million
25	INM	Integrated nutrient management
26	RBD	Randomized block design
27	D.F.	Degree of freedom
28	S.V.	Source of variance
29	SE(m)±	Standard error of mean
30	viz.	Wide list
31	SMW	Standard meteorological week
32	RH	Relative humidity
33	Rs.	Rupees
34	%	Percent
35	ha	Hectare

36	EC	Electrical conductivity
37	@	at the rate of
38	cm	centimeter
39	DAS	Day after sowing
40	^{0}C	Degree Celsius
41	t ha^{-1}	Tonnes per hectare

CHAPTER-I

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is an important leguminous and oilseed crop of India. It is recognized as the efficient producer of the two scare quality traits i.e. the protein (40%) and oil (20%). Soybean is extensively grown all over Madhya Pradesh because of its wide adaptability to agro- climatic conditions and high market value of the produce; hence Madhya Pradesh is designated as 'soya-state' of India. It is now the second largest oilseed in India after groundnut. In all India soybean is grown in 12.20 million hectare with total production of 11.99 million tonnes and 6.38 million hectares with total production of 5.37 million tonnes in Madhya Pradesh 842 kg ha^{-1} yield (Anonymous 2013-2014).

In India soybean is grown in 10.18 million ha with total production of 12.28 million tonnes and 5.67 million ha with total production of 6.28 million tonnes in Madhya Pradesh (Anonymous 2011-2012).

Soybean, commonly known as **"Golden Bean"** or **"Miracle Crop"** of the 20^{th} century, is one of the most important legume crops in the world. The crop is grown on an estimated 6% of the world's arable land, and since the 1970s, the area in soybean production has the highest increase compared with other major crops (Hartman *et al*., 2011). Nutrient imbalance is one of the important factors affecting the productivity of soybean. Therefore, keeping the above points in view, the present study investigated the effects of farmyard manure, vermicompost and chemical fertilizer on the germination and growth of this important legume crop.

Soybean is able to obtain its own nitrogen (N) through the process of N fixation. N fixation is achieved through an intricate biological relationship between soybean and a particular species of soil bacteria, *Brady rhizobium japonicum*. The bacteria obtain sugars from soybean to use as their energy source, and soybean obtains N from the bacteria. This is a fair deal for soybean and a great deal for farmers, given that N is generally a major input cost in crop production.

Soil microbes that digest crop residue use the carbon (C) remaining in plant materials as an energy source. As microbial populations increase in the presence of carbon-rich residues, they also require N for cellular growth and metabolism. Because most crop residues are high in C but not in N (C: N ratio is high), microbes use N that is available in the soil. This temporarily "ties up" the N, making it unavailable for other uses, including crop uptake. Eventually, however, N is released back to the soil as crop residues are decomposed and microbial populations decline. Soybean crop residue contains considerably more nitrogen than corn residue, which speeds up the process of residue decomposition and ties up less N in the subsequent corn crop.

Intensive land cultivation to meet the food and fiber needs of fast growing population, and removal or burning of crop residues after crop harvest cause losses of organic matter and nutrients from agricultural soils. Burning of crop residues not only results in losses of organic matter and nutrients but also cause atmospheric pollution due to the emission of toxic and greenhouse gases like CO, CO_2 and CH_4 that pose a serious threat to human and Environmental health.

The use of manures from livestock and the composts prepared from farm wastes is an important way of recycling nutrients to the soil. The management of manures within a crop rotation can have large effects on yield and crop quality (Stein-Bachinger and Werner 1997). Organic manures influence soil productivity through their effect on soil physical, chemical and biological properties (Watson *et al*., 2002).

The almost complete reliance on the use of chemical fertilizer, ignoring the organic material has, in the course of time brought in focus a number of problems such as wide spread deficiencies of secondary and micronutrients, decline productivity of crops and increasing environmental pollution (Day *et al.*1978).

Looking to the above mentioned statements, it is obvious that integrated use of chemical fertilizers and organics may minimize the imbalanced nutrients in soil and may boost the crop production and ultimately the sustainable production and pollution free environment. Therefore an experiment is planned with the following objectives:

Objectives of the investigation are given below

- To study the effect of organics and inorganics on yield and yield attributes of soybean.
- To study the effect of organics and inorganics on physico-chemical properties (soil texture, bulk density, EC, pH and organic carbon) and nutrient availability (N, P, K, and S).
- To evaluate the economics of different fertility treatments.

CHAPTER-II

REVIEW OF LITERATURE

In this chapter an attempt has been made to bring together the available literature related with the **"Effect of Organics and Inorganics Application on Productivity and Chemical Composition of Soybean Grown in Semi-arid Vertisols"** The review is being presented under the following heads.

(A) Effect of organics and Inorganics application on

i. Yield and their attributes
ii. Content and uptake of nutrients

(B) Effect of organics and Inorganics on soil quality

iii. Soil physical properties
iv. Chemical properties
v. Soil biological properties

(C) Effect of organics and inorganics application on

i) Yield and their attributes

Anonymous (1983) reported that maximum soybean seed yield (1800 kg ha^{-1}) was recorded from 10 kg N ha^{-1} given through FYM which was statistically at par with the yield obtained due to 20 kg N ha^{-1} applied through urea in a clay soil. Decreasing N levels caused a marked reduction in soybean yield.

Jayapaul and Ganesaraja (1990) reported that application of 40 kg N ha^{-1} gave a marked increase in seed yield (3034 kg ha^{-1}) of soybean over control but was comparable with 20 kg N ha^{-1} (3034 kg ha^{-1}). The higher seed yield could be attributed to cumulative effect of taller plants and increased number of pods per plant, seeds per pod and 100 grain weight (g) of soybean.

Sabale (1992) reported that the application of 50 kg N P_2O_5 ha^{-1} half through FYM favorably increased the yield contributory characters and significantly increased the yield of soybean than rest of the treatments tried. When data were pooled, maximum yield of soybean seed (32.87 q ha^{-1}) and haulm (55.58 q ha^{-1}) was obtained in the treatment of 50 kg N ha^{-1} half through urea and half through FYM.

Halvankar *et al.* (1994) reported that in soybean highest seed yield was obtained with 40 kg N ha^{-1}. Similarly application of 90 kg P_2O_5 ha^{-1} gave highest seed yield and was significantly superior over rest of the treatments. The interaction effect between N and P_2O_5 were found to be non-significant. The highest yield was obtained with the application of 40 kg N and 90 kg P_2O_5 ha^{-1}, closely followed by 20 kg N and 90 kg P_2O_5 ha^{-1}.

Mausumi *et al*. (1997) conducted an experiments in 1994-95 at Imphal to study the effect of seed inoculation with Rhizobium japonicum strain TAL-102 and phosphorus fertilizer application (0, 13, or 26 kg P ha^{-1}) on soybean cv. Pusa-16 Rhizobium inoculation increased seed by 35-43%. P fertilizer application significantly increased the seed yield.

Mandal *et al.* (2007) in a long- term experiment observed that a balanced application of NPK + FYM gave the highest value of measured parameters (plant height, no. of flowering, test weight, LAI) and lowest at the control. Values were generally highest at tillering, followed by the flowering and dough stages. A significant positive interaction between fertilizer treatments and physiological stages of wheat growth was observed, being highest at maximum tillering due to application of NPK + FYM. Stepwise regressions have revealed that grain yield of wheat was significantly associated with mineralizable nitrogen at tillering (R^2=0.80), MBC at flowering (R^2=0.90) and alkaline phosphate activity (R^2=0.70) at dough stages of wheat growth.

Dhage *et al.* (2008) reported that 100 % RDF with dual inoculation (Rhizobium + PSB) resulted in the highest grain (1363 kg ha^{-1}) and straw yields (1798 kg ha^{-1}) in soybean. Biofertilizer increased nodule number, fresh and dry weight of nodule per plant and also improved the soil fertility by increasing organic carbon content and effective bacterial population in soil. The yield and nutrient (N, P and K) uptake also increased due to dual inoculation in presence as well as absence of chemical fertilizers.

Dixit and Khatik (2009) conducted an experiment with selected technology module: INMS i.e. [RDF=20:60:30+20 kg S/ha] which was recommended by AICRP, 2007 on various farmers' fields of Ujjain district under on farm testing programme of KVK to assess the sulphur requirement in soybean. It was observed that the yield of soybean increased by 37% with the application of 20 kg sulphur/ha, giving an overall net profit of Rs.10150 over the farmers practice. A balanced fertilizer management practice is, thus, imperative to mitigate the effect of sulphur deficiency and to break the plateau of soybean yield stagnation of the gold bean of this century. Higher S use efficiency in soybean–wheat and/or chickpea based cropping system can only be obtained when S is applied to high responsive crop in the sequence coupled with best land management practice.

Gajbhiye and Mail (2009) reported that the application of FYM at 10 t ha^{-1} showed higher soil moisture and maximum nodulation as compared to other treatment in soybean. The number of pods per plant was higher with RDF+Purna-11. The highest grain yield was obtained with application of RDF along with organics. The application of RDF in with combination of Purna-11 produced highest 100 seed weight (12.40 g), protein content (40.62 %), oil content (20 %) and oil yield in soybean.

Nawale *et al.* (2009) conducted a field experiment to assess the effect of integrated nutrient management system on *kharif*forage sorghum (cv. PhuleAmruta)-chickpea (cv. Digvijay) cropping sequence on Vertisols during 2006-07. The results indicated that significantly higher values were observed for growth and yield attributes with highest grain and straw yield (22.4 qha^{-1} and 24.2 q ha^{-1}) of succeeding chickpea cv.Digvijay in *rabi* season, due to the residual effect of application of 25 % N through FYM + 25% N through vermicompost + 50 % N through RDF applied to preceding forage sorghum in kharif season followed by 100 % RDF (21.2 q ha^{-1} and 23.6q ha^{-1}) application, respectively. Significantly lowest grain yield (13.3 q ha^{-1}) and straw yield (16.0 q ha^{-1}) was recorded by absolute control. Residual effect of 25 % N through FYM + 25 N through vermicompost + 50 % N through RDF applied to forage sorghum also recorded significantly highest value for nutrient uptake, gross returns (Rs.51655 ha^{-1}), net returns (Rs.32364 ha^{-1}) and maximum value for benefit: cost ratio (2.60) of succeeding chickpea compared to the application of reduced or higher value of RDF in combination with the organic manures or alone inorganic fertilizer to preceding forage sorghum.

Rathi *et al*. (2009) reported that application of Rhizobium along with S @ 60 kg ha^{-1}, Zn @ 4 kg ha^{-1}, B @ 0.6 kg ha^{-1} and Mo @ 0.1 kg ha^{-1} significantly increased the grain yield of black gram. Number of pods, 100 grain weight and harvest index also increased to a great extent by the application of Rhizobium along with sulphur and micronutrients.

Chaturvedi *et al.* (2010) reported that integrated use of RDF with FYM or soil application of Fe/ B being at par increased the seed yield of soybean significantly over RDF alone. Highest net returns were recorded with the application of RDF + 10 t FYM and micronutrients helped in maintaining soil fertility and rhizospheric microbial population.

Farhad *et al.* (2010) reported that potassium showed significant effect on yield and yield attributes of soybean. Application of potassium @ 40 kg ha^{-1} produced the highest plant height, seed yield, 1000-seed weight and straw yield and yield attributes of soybean.

Nagaraju and Mohankumar (2010) reported that soybean responded significantly to micronutrients (Zn, B and Mo) and bio inoculants (Rhizobium and PSB). Application of 100 percent NPKS +Zn + B+ Mo + Rhizobium + PSB recorded higher plant height (40.2 cm), dry matter accumulation (21.9 g $plant^{-1}$), and leaf area (1177.2 cm^2 $plant^{-1}$), seed yield (2165 kg ha^{-1}), maximum net returns (Rs.27262 ha^{-1}).

Koushal and Singh (2011) studied the impact of integrated nutrient management in soybean on residual fertility status of soil. The highest number of pods per plant (80.40) and highest test weight (17.02 g) was recorded in the treatment where 50 percent recommended N applied through urea + 50 percent N through FYM + PSB and the lowest of these were found in the control treatment.

Guriqbal Singh *et al*. (2012) conducted a field experiments to study the effects of farm yard manure (FYM), phosphorus, zinc sulphate, vermicompost and nitrogen + phosphorus application on the growth and yield of chickpea. On the basis three-year mean, as compared to no application of nutrients, the application of 5 t FYM ha^{-1} improved chickpea grain yield by 14.89%, 30 and 60 kg P_2O_5 ha^{-1} by 14.81 and 21.85% and 25 kg $ZnSO_4$ ha^{-1} by 5.18%. Chickpea grain yield increased with successive increase in dose of vermicompost from 0 to 3 and 2 t ha^{-1} seemed to be the optimum dose. Application of 10 kg N + 20 kg P_2O_5 ha^{-1} and 20 kg N + 40 kg P_2O_5 ha^{-1} increased the grain yield by 18.97 and 24.20%, respectively over no application of various nutrients was due to improvement in plant growth and yield attributes. The study highlights the importance of using nutrients through various sources for realizing high productivity of chickpea.

Jain and Parmar (2012) carried out experiment to evaluate the effects of different levels of the phosphorus supplied through the single super phosphate (SSP) and the Jhabua Rock Phosphate (JRP) in combinations with and without farmyard manure (FYM), Phosphorus Solubilizing Material (PSM) on the productivity, nutrient uptake, water use and water use efficiency of soybean crop grown on the black clay soils. The highest seed yield of 1253 kg ha^{-1} and water use efficiency of 3.21 kg ha^{-1}mm of soybean were recorded under the treatment of JRP equivalent to 90 kg ha^{-1} of P_2O_5 applied in conjunction with 5 t ha^{-1} of FYM, 3 kg ha^{-1} of PSM, seed treatment with PSM followed by the seed yield of 1158 kg ha^{-1}, 1175 kg ha^{-1} and 1136 kg ha^{-1}, obtained under the treatments: SSP- P_{60} (T2), JRP-P_{60} + 5 t ha^{-1} FYM + 10 g PSM kg^{-1} seed treatment + 3 kg PSM blended with 50 kg of FYM ha^{-1} (T11), JRP-P_{90} + 5 t ha^{-1} FYM + 10 g PSM kg^{-1} seed treatment (T10), JRP-P_{60} + 5 t ha^{-1} FYM +10 g PSM kg^{-1} seed, and treatment (T9), respectively. The differences were statistically non-significant among them. The nitrogen, phosphate, potassium and sulphur content in soybean seeds varied from 5.64 to 6.11 %, 0.116 to 0.394 %, 1.40 to 2.22 % and 0.311 to 0.457 %, respectively. The treatments where both, PSM and FYM, were applied with JRP either @ 60 kg P ha^{1} or @ 90 P kg ha^{-1}, good responses were observed with respect to crop yield, nutrient uptake and water use efficiency suggesting beneficial effects of PSM and FYM application. The highest water use efficiency of 3.21kg ha^{-1} mm by soybean was found under the treatment T12 (90kg P ha^{-1} through JRP+ seed inoculation by PSM + Blended PSM + FYM). The results of this study lead to the conclusion that the treatments involving PSM and FYM increased the water use efficiency and seed yield.

Khursheed *et al.* (2013) reported that the application of poultry manure and vermicompost along with chemical fertilizers for supply of nitrogen, phosphorus and potassium (NPK) resulted in higher grain yield of rice. Soil carbon, liable carbon and water soluble carbon contents also improved with application of organic sources of N application.

Sharma *et al.* (2014) reported that based on long-term study, half of the RDF ($N_{20}P_{13}$) for each of soybean and subsequent Rabi crops in conjunction with FYM 6 t ha^{-1} for soybean is recommended for achieving highest sustainable productivity of rainfed soybean based cropping system in Vertisols.

Singh *et al.* (2015) conducted an experiment in Vertisols to maintain the soil fertility for sustaining the desired crop productivity by the application of organics, chemical fertilizers and their conjoint use. The different fertility treatments were designed in ra46ndomized block design with the four replication with the 5 treatment combination results revealed that all the treatment combination gave significantly higher yield as compared to control where no fertilizer was applied and T5. The growth parameters were revealed that all the growth parameters were significantly affected by different treatments. All the growth parameters were statistically at par in case of treatments T2, T3 and T4. The lowest growth parameters were recorded in case of T1 control followed by T5 (farmer's practice). Test weight was affected significantly by different treatments, the highest test weight was recorded in the treatment T4 (10.40 g) followed by T3 (10.20 g), T2 (10.11g). From this data it is clear that organics and inorganics fertilizers in combination can be used as the potential sources of nutrients. It seems to be the only options to option to maintain soil fertility crop productivity for long term improved and sustainable utilization of nutrients in soybean cropping system.

Kanton *et al* (2016) conducted a study on organic and inorganic fertilizer effects on the growth and yield of maize in a Dry Agro-Ecology in Northern Ghana. The results of the study revealed that the inorganic fertilizers with micro-nutrients, such as S, Zn, and Mg, (i.e., Actyva and 21:10:10:2 S) produced taller plants, caused earlier tasseling and silking and produced higher grain yields on account of increased straw yields, plant height, stem girth, grain size and harvest indices than organic fertilizers. Poultry manure and sheep manure were the best among the organic sources evaluated. whereas most of the fertility management options accrued net benefits of more than $150.00, the goat droppings and down waste had low net benefits of $44.30 and $17.00, respectively, indicating low gains on investment and therefore, not profitable for field application.

ii) Content and uptake of nutrients

Shinde *et al.* (1982) reported that P and S content in soybean plants increased at all stages by phosphate and sulphate application, respectively. The rate of dry matter accumulation was similar to the rate of uptake of Ca alone. The rate was the highest at 50 days growth. The cumulative percentage of maximum and the rate of nutrient uptake per day revealed that S, Ca and 1 C were needed at sowing while N and P could be profitably applied in splits or as late as upto 50 days growth.

Sharma (1992) reported that the highest N, P, K and S uptake and water use efficiency were obtained with the application of FYM + fertilizer N.

Sharma and Mishra (1997) concluded that the uptake of N, P, K, Ca and Mg contents were highest with application of FYM+ 20 Kg N ha^{-1}. Sharma (1997) also reported that the uptake of N, P, K and S were highest with FYM + 20 kg N and 13 kg P ha^{-1}.

Ngoc Son *et al*. (2001) reported that the application of organic and biofertilizer could be substantiated for the N inorganic fertilizer to an extent of 40 kg N ha^{-1}. The quantity of nutrient contents and uptake of soybean with reference to N, P, and K and soil available P and K were significantly improved by the application of composted paddy straw and inoculants viz. Rhizobium ferdii and Brady rhizobium sp.

Vyas *et al*. (2003) reported that the combined application of 5 kg Zn and 10 t FYM ha^{-1} increased grain yield, NPK contents in and uptake by soybean seed. The highest grain yield (1790 kg ha^{-1}) was recorded in Zn + FYM treatment with a record of 18.2 percent increase over control (1515 kg ha^{-1}) while the application of B + FYM (13.6 %) was on par with seed treatment with Na molybdate (13.1 %). There was positive balance of available N, P_2O_5 and K_2O in soil when soybean fertilized either with FYM alone or along with micronutrients.

Ravankar *et al.* (2005) a field experiment in the year 1997 (kharif) on Vertisols at highway Block, Central Research Station, Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India involving the use of NPK fertilizers with and without organic amendment on soybean-wheat sequence. The experiment consisted of 12 treatments replicated four times in randomized block design. Four-year results indicated highest grain yield and nutrient uptake under the treatment with the application of 150% recommended dose of NPK + S + $ZnSO_4$ followed by the treatment with the application of 50% N through Leucaena loppings. Significantly lowest yield and uptake of nutrients were obtained under control. Inclusion of S and Zn in the treatment significantly increased their uptake by both soybean and wheat.

Singh *et al*. (2007) reported that sole or dual inoculation of soybean with biofertilizer, application of FYM and recommended dose of fertilizer (RDF) significantly increased the plant growth, nodulation, seed and straw yields as well as N and uptake over the control. Application of Rhizobium + Azotobacter + PSB + FYM showed significantly higher number and weight of nodules, but it was on par with that of Rhizobium +PSB + FYM and RDF.

Rathod *et al.* (2012) conducted field experiment to study the effect of N management on soil fertility and nutrient uptake in soybean. The study revealed that both seed and straw yield were significantly increased with increase in N dose with declining yield response at higher level. However, NPK uptake by soybean increased significantly with increasing levels of nitrogen. Integration of chemical fertilizer with Rhizobium increased seed yield and NPK uptake. Splitting half of N at 50 days after sowing (DAS) was found significantly better over 80 DAS.

B) Effect of organics and Inorganics on soil quality

iii) Soil physical properties

Prasad *et al*. (1983) reported that an increasing trend of bulk density had been observed with increasing dose of inorganic fertilizers (50 to 150% NPK). Whereas, FYM incorporation with 100% NPK lowered the bulk density of soil as compared to 100% NPK application and control. Continuous application of ammonium sulphate alone raised the bulk density of soil.

Resend (1987) conducted a trial in clayey rice soils of Brazil and found that the addition of FYM and decomposed rice straw increased the infiltration rate (2.26 to 2.18 mm hr^{-1} respectively) over the control plots (1.30 mm hr^{-1}). Further corroborated an increase in hydraulic conductivity and moisture content due to incorporation of different amendments.

Maheswarappa *et al*. (1999) reported that the FYM and vermicompost application alone decreased the bulk density, improved soil porosity, organic carbon and maximum water holding capacity to a great extent whereas, under

NPK alone and control there was no change in physical and chemical properties of soil.

Bandyopadhyay *et al*. (2004) reported that the field experiments was conducted in a deep Vertisols during the rainy season of 2000 and 2001 at Bhopal, Madhya Pradesh, India to study the root growth, seasonal evapotranspiration and productivity of soybean (G. max) and sorghum (S. bicolor) as sole and intercrop in 6 nutrient combinations. Integrated use of farmyard manure at 5 t ha^{-1} or phosphocompost at 5 t ha^{-1} or poultry manure at 1.5 t ha^{-1} along with 75% NPK improved the root length density (42.4%), root mass density (95.9%) and root volume density (80.8%) and registered higher seasonal evapotranspiration (4.4%), total dry matter yield (12.9%) and seed yield (12.7%) over application of 100% NPK irrespective of the cropping systems. Also there was an improvement in the root length density of intercrop sorghum (111.5%) over its sole crop in the 0 to 15 cm soil layer.

Wandile *et al*. (2005) reported that the residual effect of long- term (*kharif*1991 to *Rabi* 1995) use of fertilizers alone and in combination with farmyard manure (FYM) on the swelling – shrinkage properties of a Vertisols and yield of soybean were studied after five years of soybean–based cropping system in Nagpur, Maharashtra, India. Results indicated a significant improvement in soil properties and the highest yield of soybean was recorded with the application of 7.5 tonnes FYM ha^{-1} with half dose of N and P fertilizers, which saved 50 % N and P and full dose of Zinc. Soybean followed by gram was superior over other cropping sequences with respect to seed and straw yields, protein and oil contents and soil fertility.

Jha and Rattan (2007) in a study found that upon mineralization crop residue also supply essential nutrients. Organic matter greatly influences the availability of N, P, K, and several other plant nutrients. The author used single exponential decay model in process of decomposition of organic residues.

Singh (2007) concluded from a comparative study of INM and the farmer’s practice based on changes in relative soil quality index (RSQI) and quality changes that soil quality in INM trial was increased by 12-19 units as compared to 7-9 units in farmer's practice. The soil quality in terms of CEC, pH, N, P, K, organic matter, soil structure etc. increased up to 5 percent. A review of over 300 published reports 41 showed that out 18 environmental impact indicators (floral diversity, faunal diversity, habitat diversity, landscape, soil organic matter, soil biological activity, soil structure, and soil erosion, nitrate leaching, pesticide residues, CO_2, N_2O, CH_4, NH_3, nutrient use, water use and energy use), INM/OF systems performed significantly better in 12 and performed worse in none.

Kotangale *et al*. (2009) reported that an application of organic manure in combination with inorganic fertilizers was found to be more effective than inorganic fertilizers alone. Among the different treatments significantly highest content of organic carbon and available nutrient content (N, P, K, S) of the soil were obtained under the treatments of 100% RDF + 10 t FYM ha^{-1} followed by 150% RDF. Application of FYM alone also increased the organic carbon and available nutrient content of soil over the control in both sorghum–wheat crops respectively.

Thakur *et al*. (2009) conducted a study under the All India Coordinated Research Project on a long–term fertilizer experiment with soybean – wheat – maize cropping sequence initiated during 1972 at J.N.K.V.V., Jabalpur (Madhya Pradesh, India) with the aim to investigate the effect of continuous application of different agricultural inputs on the soil health and dynamics of nutrients of medium black soil (Vertisols). The study was designed with 10 treatments, namely: (T1) 50% NPK; (T2) 100% NPK; (T3) 150% NPK; (T4) 100% + HW (hand weeding); (T5) 100% NPK + Zn (ZnSO4); (T6) 100% NP; (T7) 100% N; (T8) 100% NPK + farmyard manure (FYM); (T9) 100% NPK-S (sulphur free) and (T10) control plot. Organic carbon content in the surface soil was found to be higher as compare to the lower layers in different treatments and the highest and significantly higher values at different depths were noted in the treatment that received recommended dose of fertilizer along with FYM (T8). The contents were higher in all soil layers of the treatments receiving balanced applications as compared to the treatments where imbalanced application is being practiced.

Bandyopadhyay *et al*. (2010) conducted an experiments to study the effect of sole application of inorganic fertilizers (NPK) (N: P: K: 30:26:25 kg/ha) and combined application of farmyard manure (FYM) @ 4 Mg ha^{-1} and inorganic fertilizers (NPK + FYM) vis-à-vis non application of fertilizers and manures (control) on changes in soil physical properties and plant growth characteristics of soybean (cv. JS-335) in a deep Vertisols at the Indian Institute of Soil Science, Bhopal during the year 2001-2004. The results indicated that conjunctive use of recommended dose of fertilizer and FYM (NPK+FYM) resulted in significant (P<0.05) decrease of bulk density (9.3%), soil penetration resistance (42.6%) and increase in hydraulic conductivity (95.8%) and mean weight diameter of the water stable aggregates (13.8%) and soil organic carbon content (45.2%) compared to control. Among the aggregates, in macro-aggregates fraction (250-500 micro meter and 500-1000 micro meter size fraction) and in large macro-aggregates fraction (>2000 mm) maximum soil organic carbon concentration was recorded under NPK + FYM. The root mass of soybean was mostly (98%) confined to 15 cm soil depth. Combined application of NPK and FYM recorded significantly higher (P<0.05) root length density and root mass density of soybean in the 0-15 cm soil layer at flowering stage over NPK (28 and 65%) and control (63 and 175%). The root length density of soybean was significantly negatively correlated with the penetration resistance (r=0.98, P<0.05). Improved the biomass partitioning toward pod over NPK and control. The grain yield, water use efficiency and nitrogen use efficiency of soybean under NPK + FYM were significantly (P<0.05) higher than NPK and control. The total above ground biomass and the leaf area index at R8 stage could account for respectively, 89 and 63% variation in grain yield of soybean. Therefore in every crop season, integrated use of farmyard manure at 4 Mg ha^{-1} and recommended dose of chemical fertilizers may be practiced in Vertisols for improving soil physical environment and achieving higher soybean productivity through efficient utilization of water and nutrients.

Nandapure *et al*. (2011) conducted a study to assess the long term effects of fertilizers and FYM on soil physical properties and crop productivity after 19th cycle of sorghum- wheat cropping sequence in a Vertisols. The combined use of inorganic fertilizers (100% NPK) along with FYM @ 10 t ha^{-1} significantly improved the bulk density, hydraulic conductivity, available water capacity, water stable aggregates and coefficient of linear extensibility of soil and yield of crops. Total productivity (sorghum+wheat) was found to be positively correlated with these properties.

Ortas and Lal (2014) reported that long term experiment on a Vertisols in the Mediterranean coast of Turkey, to assess the effects of four rates of application of inorganic phosphorus (P) fertilizers (0, 50, 100 and 200 kg P2O5 ha-1) on soil bulk density, carbon (C) and nitrogen (N) concentrations, SOC and N pools, C and N sequestration rate, aggregates fractions, water-stable aggregates, and the mean weight diameter (MWD). Increase in the rate of application of P fertilizers significantly increased bulk density and reduced porosity (%). The SOC concentration was significantly more in the treatment receiving 200 kg P_2O_5 ha^{-1} than in the control. The carbon- nitrogen ratio was less than 10 in control and greater than 10 in high P fertilizer treatments. Total amount and rate of C and N sequestration increased with increased with increase in the rate of application of P fertilizers.

Sankar *et al*. (2014) conducted a Long-term fertilizer experiments on cotton for 21 years with eight fertilizer treatments in a fixed site during 1987-2007 to identify an efficient treatments to ensure maximum yield, greater sustainability, monetary returns, rainwater-use efficiency, and soil fertility over years. The results indicated that the yield was significantly influenced by fertilizer treatments in all years except 1987, 1988, and 1994. The mean cotton yield ranged from 492 kg ha^{-1} under the control to 805 kg ha^{-1} under 25 kg nitrogen (N) [farmyard manure (FYM)] + 25 kg N (urea) + 25 kg P $ha^{-1.}$ Among the nutrients, soil N builds up was observed with all treatments, whereas application of 25 kg N + 12.5 kg P ha^{-1} exhibited increase in P status. Interestingly, depletion of potassium (K) was recorded under all the fertilizer treatments as there was no K application in any of the treatments.

iv) Chemical properties

Nalatwadmath *et al*. (2003) a field experiments was conducted in Bellary, Karnataka, India during 1978-79-93 to monitor the changes in the soil properties and yield responses of maize-safflower and maize–Bengal gram (chickpea) cropping system as a result of long-term fertilizer management practices. The treatments comprised application of the recommended rate of NPK (T_1), application of N (T_2); N and P (T_3); and N, P and K based on soil tests (T_4), application of (T_5) or 5t farmyard manure ha^{-1} (T_6) and T_1 + T_5 (T_7) and T_4 +T_5 (T_8). T_7 gave the highest average grain yield of maize (3916 kg ha^{-1}), whereas T_4 gave the highest average grain yield of safflower (796 kg ha^{-1}) and Bengal gram (1262 kg ha^{-1}). Soil pH after 15 years was lowest with T_1, whereas the total N and P were highest with T_7 treatment.

Pothare *et al.* (2007) conducted a long- term fertilizer experiment started since 1988 at Dr. P.D.K.V., Akola. There were 14 treatments replicated four times indicated that all the soil properties such as pH, EC, organic matter, total and available NPK and S etc. were favourably influenced with the conjunctive use of organics and inorganics. Highest values were observed in the treatment of 100% NPK + 10 t FYM ha^{-1}. The influence on soil properties ultimately reflected in higher yield of sorghum and wheat and in the same treatment it is also observed that all the soil properties except pH, EC were highly significantly correlated with yield.

Hati *et al.* (2007) carried out an investigation to study the long-term impact of fertilizer and manure application in a soybean-wheat–maize (fodder) crop rotation on soil organic carbon status and physical properties of a Vertisols (TypicHaplustert or Pellic Vertisols) in sub-humid sub-tropical India. Five treatments namely, control (no fertilizer and manure), 100% of the optimum rate for nitrogen (100% N) 50% of the optimum rate for nitrogen, phosphorus and potassium (50% NPK), 100% of the optimum rate for NPK (100% NPK) and 100% NPK + farmyard manure at 15 Mg ha^{-1} (100% NPK + FYM) from a long-term fertilizer experiment continuing at Jabalpur, India were chosen for this study. Soil samples were collected from top soil horizon (0-15 cm) of all the four replications of the selected five treatments in April 2000 after 28 crop cycles and analyzed for physical and chemical properties. The results showed that the soil organic carbon (SOC) content in 100% NPK and 100% NPK + FYM treatments increased, respectively, by 22.5 and 56.3% over the initial level (1.14 kg m^{-2}). The electrical conductivity, SOC content, aggregation, water retention, micro porosity and available water capacity of the soil were increased while the bulk density was reduced significantly with the 100% NPK +FYM treatments over all other treatments. However, the use of imbalanced (100% N) and suboptimal rate of inorganic fertilizer (50% NPK) as compared to the unfertilized control showed no significant effect on the physical properties of the soil. The study indicates that application of balanced rate of fertilizers in combination with organic manure could sequester soil organic carbon in the surface layer.

Thakur *et al.* (2011) studied the status of nutrients-their depletion and build-up in soil, and crop productivity after 36 years (1972-73 to 2008-09) of intensive cropping under continuous use of various inorganic fertilizers and organic manure in a Vertisols. Results showed that the application of recommended dose of N, P, and K the soil physical environment and sustain higher crop productivity under this intensive cropping system. (20:80:20 kg ha^{-1} to soybean and 120:80:40 kg ha^{-1} to wheat) with organic manure @ 15 t FYM ha^{-1} resulted in 145 and 292% increase in soybean and wheat yields, respectively over control. Conjoint use of FYM with 100% NPK substantially improved the organic carbon status by 3.9 g kg^{-1}, as well as available N, P and S by 126.8, 25.5 and 28.5 kg ha^{-1} in soil over its initial values, there by indicating significant contribution towards sustaining the soil health. On the other hand, omission of S in 100% NPK-S treatment caused a continuous depletion (5.8 %) in soil S status over initial value. A declining trend (179 to 314.8 kg ha^{-1}) from its initial value (370.0 kg ha^{-1}) of available K status was also observed as a result of continuous cropping; this indicates considerable mining of available K from the soil. However, the decline of K was of lower magnitude with 100 % NPK + FYM (14.9 %) and 150 % NPK (20.0 %) treatments indicating the need to raise the level of K fertilizer application to meet the demand of crops. However, the fertility of the soil appears to be adversely affected due to the imbalanced use of nutrients viz. NP or N alone. Thus, the balanced use of fertilizers continuously either alone or in combination with organic manure is necessary for sustaining soil fertility and productivity of crops.

Sharma *et al.* (2014) conducted a long term experiment to study the long-term impact of conjunctive nutrient use treatments on soil quality indicators and soil quality indices under three cropping system: (i) sole soybean, (ii) soybean + maize, and (iii) sole maize cropping systems at the Indore centre of the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) using Navjot and JS-335 as cultivars of maize and soybean, respectively. In 2005, the soil quality assessment study under this experiment was undertaken after 8 years of experimentation. Soil quality assessment was done by identifying the key indicators using principal component analysis (PCA) and linear scoring technique (LST). Soil quality indices (SQI) and relative soil quality indices (RSQI) were also computed.
Results revealed that most of the soil quality parameters were significantly influenced by the conjunctive nutrient management treatments. The common key indicators that emerged in all the treatments were pH, organic carbon (OC), exchangeable magnesium (Mg), available zinc (Zn), copper (Cu), manganese (Mn), and boron (B). The soil quality indices across the management treatments under sole maize system varied from 1.70 to 2.40 and application of 20 kg nitrogen (N), (compost) + 20 kg N through urea as top dressing emerged as one of the most superior treatments with SQI value of 2.40. The soil quality indices in maize+soybean system varied from 1.12 to 1.47 and application of 20 kg N (compost) + 20 kg N through urea + azotobacter at 2 kg ha^{-1} proved to be significant with the greatest SQI value of
1.47. In the case of the sole soybean system, the SQI varied from 1.21to1.61. After considering all the systems together, the average best performance SQI score (ABP-SQI score) was computed, which varied from 1.14 to 1.56. The greatest value was recorded in the treatment with 20 kg N (compost) + 20 kg N (*gliricidia*) + 10 kg N (urea). The quantitative relationship developed in this

study between mean soybean and maize yields (Y) and RSQI values (X), irrespective of the management treatments, could be quite useful to predict the yield quantitatively with respect to a given change in key indicators for these rainfed Vertisols.

Srinivasarao *et al.* (2014) reported that enrichment of soil organic carbon (SOC) stocks through sequestration of atmospheric CO_2 in agricultural soils is important because of its impact on improving soil quality and agronomic production, and also for adaptation and mitigation of climate change. Thus a 15 years soil fertility management experiment was conducted in the semi-arid tropical region of central India to evaluate the impact of crop residue C input on soybean (*Glycine max* L.)–safflower (*Carthamus tinctorius* L.) cropping sequence and SOC sequestration in soils of vertisolic order (Vertisols). Retention of crop residues of soybean/safflower, and application of farmyard manure (FYM) at 6 t ha^{-1} alone or in combination with 20 kg N and 13 kg P ha^{-1} supplied through chemical fertilizers or comparatively higher dose of chemical fertilizer (60 kg N and 35 kg P ha^{-1}) either maintained or increased the SOC stock. However, the combination of FYM and chemical fertilizer increased the profile SOC stock (69.6 Mg ha^{-1}), overall SOC build up (37.1%) and also sequestrated high amount of SOC (11.9 Mg C ha^{-1} or 0.79 Mg C ha^{-1} yr^{-1}) compared with control and chemical fertilizer alone. Higher grain yield (2.10 and 1.49 Mg ha^{-1} of soybean and safflower, respectively) was obtained through the application of FYM at 6 Mg ha^{-1} + $N_{20}P_{13.}$ For every Mg C ha^{-1} increase in the root zone, there was 0.145 and 0.059 Mg ha^{-1} increase in grain yield of soybean and safflower, respectively. Stabilization of the SOC stock requires a minimum input of 3.47 Mg C ha^{-1} yr^{-1}. Application of 40 kg N + 26 kg P ha^{-1} through chemical fertilizer also maintained the SOC stock at the antecedent based on the SOC stocks in 1992. Therefore, the combined use of organic manure (crop residues and FYM) along with chemical fertilizer is essential to enhancing the SOC sequestration in a soybean – safflower sequence under rainfed conditions on Vertisols in central India.

v) Biological properties

Khaddar and Yadav (2006) conducted a field trial for two consecutive years (1999 and 2000) at Research Farm, College of Agriculture, Indore (India) in factorial randomized block design with sixteen treatments replicated three times in a soybean-wheat cropping sequence. The microbial population in soil was estimated by dilution plate count method. Application of biofertilizer significantly showed higher bacterial population during both the years of study. The fungal population increased in treated plot over control. Among the organics, biofertilizer increased fungal population at 25 day stage of the crop, while there was slight decrease in fungal population. Integrated use of chemical fertilizer with organics could ameliorate the soil and improve the productivity of a soybean wheat cropping sequence resulting in eco-friendly farming system.

Arbad and Ismail (2011) conducted a field experiment on Vertisols at Departmental Farm, Marathwada Agricultural University, Parbhani during kharif, 2007-08 and 2008-09. The experiment was laid out in randomized block design using twelve treatment combinations of inorganic fertilizers and organic manures which were replicated four times in soybean–safflower copping system. The surface soil was collected after harvest of each trail and was analyzed for biological and chemical properties following standard procedures. The results emerged indicated that bacterial population was maximum (173*10-5 CPU g^{-1} soil) in treatment plot receiving 100 % NPK along with FYM after harvest of soybean followed by the plots receiving only FYM @ 10 Mg ha^{-1} (161*10-5 CPU g^{-1} soil). After harvest of safflower, bacterial population in soil decreased in both the years. Inorganic treatments showed lower bacterial count as compared to plot treated with organic sources. Maximum actinomycetes population was recorded in treatment having 100% NPK + FYM during both the years after harvest of soybean and safflower. Maximum population of soil fungi was recorded in treatment plots treated with FYM @ 10 Mg ha^{-1} after both crops during both the years of experimentation. There was slight decrease in soil pH and EC, after the harvest soybean and safflower in FYM treated plot and increase in chemically fertilized plot during both the years, but the results were statistically non-significant. Significant increase in organic carbon was observed as compared to initial value of experimental field. The highest organic carbon was observed in treatments treated with chemical fertilizers incorporated with FYM or FYM alone. There was good build-up of available N, P, K, S and Zn after harvest of each crop in sequence except 50 % NPK and control plot. The treatments which contain FYM with chemical fertilizers, super-optimal dose of chemical fertilizer were at par with treatments recurring 100 % N fertilizers.

Thakare and Bhoyar *et al.* (2012) reported that the integrated use of crop residues, biofertilizer and inorganic fertilizers in Vertisols improved fertilizer use efficiency and nutrient turnover through augmentation of biological activity specially enzyme activity which is step toward sustainable agricultural production. Highest soil microbial biomass C (340.25 micro g Cg^{-1} soil) and biomass N (30.15 micro g N g^{-1} soil) were recorded in Brady rhizobium + 100 % RDF i.e. 30 kg N + 75 kg P_2O_5 ha^{-1} treatment followed by incorporation of wheat straw @ 4 t ha^{-1} + 100 % RDF. Incorporation of wheat straw and sugarcane trash along with chemical fertilizer significantly increased SMBC and SMBN content over their alone application. There was significant influence of crop residues and biofertilizer on soil enzyme activity i.e. dehydrogenase activity over control. Incorporation of wheat straw @ 4 t ha^{-1} + 100 % RDF significantly increased soil dehydrogenase activity as compared to all other treatments. Bacterial and actinomycetes population were found maximum i.e. 29.6 CFU g^{-1}x107 and 25.0 CFU g^{-1}x106, respectively in seed treatment with Brady rhizobium + 100 % RDF, whereas, fungal population was found to increase (21.46 CFU g^{-1}x104) with the incorporation of wheat straw @ 4 t ha^{-1} + 100 % RDF followed by sugarcane trash with 100 % RDF seed incorporation with Brady rhizobium with 100 % RDF recorded highest grain yield (24.59 ha^{-1}) and was followed by wheat straw + 100 % RDF, SMBC, SMBN, dehydrogenase activity and soil biota were significantly correlated with soybean yield.

Chauhan and Bhatnagar (2014) reported that the long-term integrated nutrient management trails in wheat on Vertisols conducted for 33 years at

J.N.K.V.V., Research farm, Jabalpur revealed that highest sustainability yield index (SYI) was observed in 100% NPK+FYM, while lowest was observed in 100 % N treatment.

Meena *et al.* (2015) examined the soil microbial population, dehydrogenase activity and chemical properties of soil under different doses of farmyard manure (FYM), leaf compost and vermicompost at the research farm of the Indian Agriculture Research Institute (IARI), New Delhi, India during 2008-09 and 2009-10. Results indicated the higher value of microbial population, dehydrogenase activity; organic carbon, available nitrogen (N), phosphorus (P), potassium (K) and lower bulk density were observed in farmyard manure applied equivalent to 120 kg N ha^{-1} followed by vermicompost equivalent to 120 kg N ha^{-1}. Grain yield of popcorn was significantly higher in the treatments of recommended dose of fertilizers and vermicompost equivalent to 120 kg N ha^{-1}.

CHAPTER-III

MATERIAL AND METHODS

The investigation entitled, **"Effect of Organics and Inorganics Application on Productivity and Chemical Composition of Soybean Grown in Semi-arid Vertisols''** was conducted during the *kharif* season of the year 2015-16 in the Department of Soil Science and Agricultural Chemistry, RVSKVV, Gwalior. The details of the experiment conducted, the methods adopted and followed for the soil and plant analysis have been given in the following pages.

3.1 Experimental site

To carry out the present investigation an experiment was conducted during kharif season of 2015-16 at AICRPDA Research Farm, College of Agriculture, Indore. The area has almost uniform topography with light to medium black soils. Indore is situated in Malwa Plateau in western parts of Madhya Pradesh on 22.43^0N latitude and 75.66^0E longitudes with an altitude of 555.5 meters above the mean sea level.

3.2 Climatic Features

The AICRPDA Research Farm, Indore is situated in central India in semi-arid (Hot moist) climatic of Malwa Plateau in M.P. (5.2). Summers are dry with the rising temperature up to 44^0C or even higher during April-May. The winters are normal with temperature descending up to 10^0C or even more during December and January. The average annual rainfall varies from 750 mm to 1000 mm and 90 % of this is received during the last week of June, July, August, September and first week of October through South-West monsoon. The meteorological data regarding the temperature, relative humidity and rainfall was recorded during the cropping season from the meteorological observatory located at AICRPDA; Indore is presented in Table 3.1.

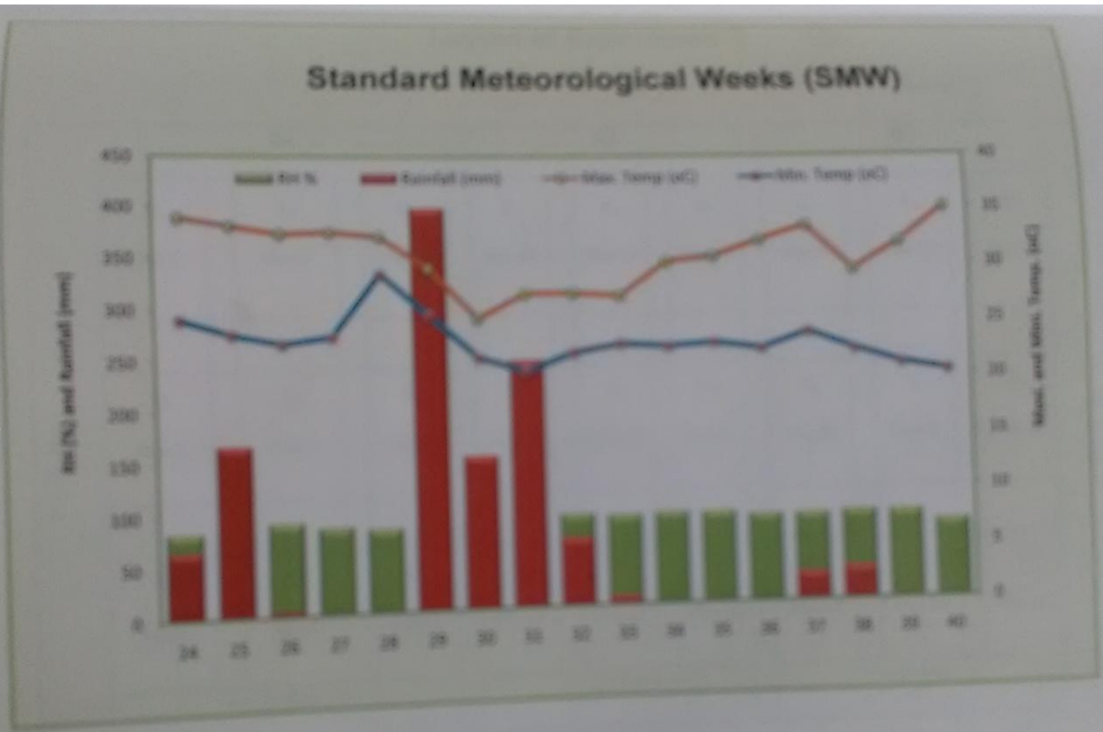

Fig. 3.1 Weekly weather data during crop growth period (2015)

Layout of Experiment

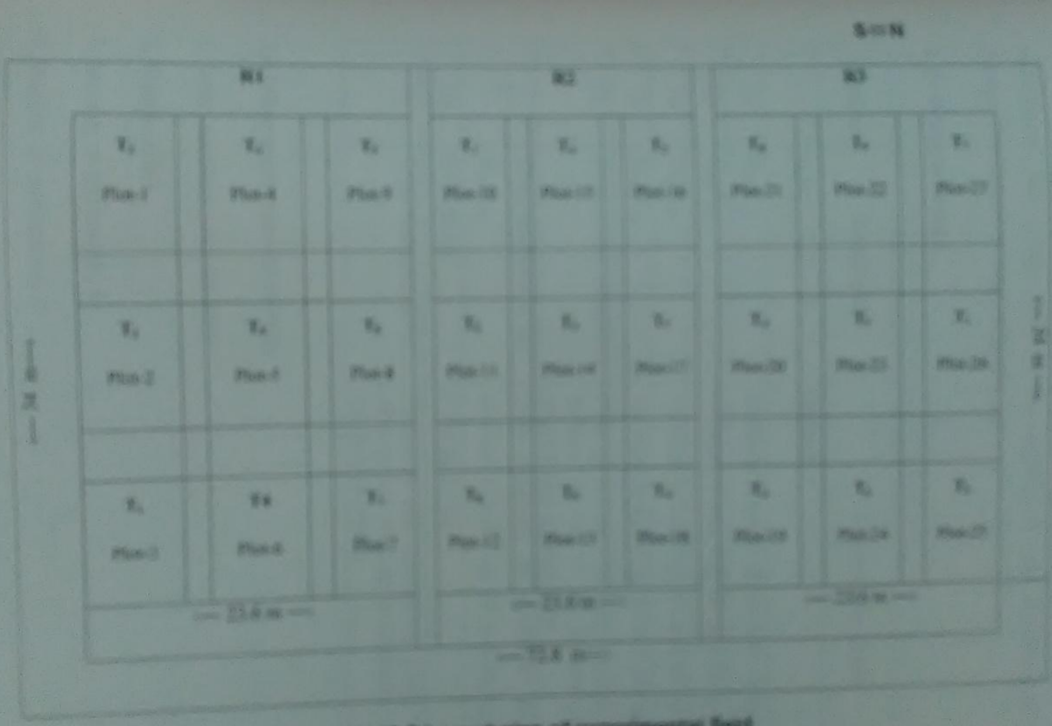

Fig. 3.2 Layout plan of experimental field

3.3 Details of field Experiment

The present experiment was carried out with 9 treatments and 3 replications. The design used in the experiment was Randomized Block Design. The details of treatments are as:

3.1Treatment details:

Symbol	Treatment	Treatments detail
T1	N_0P_0	Control
T2	$N_{20}P_{13}$	Fertilizer N and P @ 20 and 13 kgha^{-1}
T3	$N_{30}P_{20}$	Fertilizer N and P@ 30 and 20 kgha^{-1}
T4	$N_{40}P_{26}$	Fertilizer N and P@ 40 and 26 kgha^{-1},
T5	N $_{60}P_{35}$	Fertilizer N and P @ 60 and 35 kgha^{-1}
T6	FYM 6 t ha^{-1}+N20P13	FYM @ 6 t ha^{-1}, in rainy season only plus fertilizer N and P @ 20 and 13 kgha^{-1}, respectively to each crop.
T7	Crop residues 5t ha^{-1} $N_{20}P_{13}$	Crop residues of soybean @ 5t ha^{-1}, fertilizer N and P @ 20 and 13 kg ha^{-1}
T8	FYM 6t ha^{-1}	FYM @ 6 t ha^{-1}
T9	Crop residues 5t ha^{-1}	Residues are applied to each crop after emergence of crop in between crop rows as surface mulch.

3.4 Other experimental details

1. Crop: soybean (var. JS-335)

2. Design: RBD

3. Number of treatments: 9

4. Number of replications: 3

5. Plot size: Gross: 10m X 07.20m, Net: 09m X 06.40m

6. Total number of plots: 27

7. Seed rate: 80 kg ha^{-1}

8. Date of sowing: 18/06/2015

9. Date of harvesting: 30/09/2015

3.5 Field preparation

In order to get a good tilth of soil for sowing, the experimental field was given one ploughing. The field was leveled before sowing. Soybean seed @ 80 kg ha^{-1} were sown at row to row spacing 45 cm and plant to plant spacing 5 cm.

3.6 Application of fertilizer

FYM was applied in prescribed treatments at the time of field preparation during rainy season. The requisite quantity of nitrogen and phosphorus were applied for different prescribed treatments as basal dose at the time of sowing. Crop residues were applied in prescribed treatments as surface mulch after emergence of the crop and incorporated after harvesting of crop.

3.7 Observations

Height of plant at 20 days, 40 days, 60 days and at harvest, number of branches, number of pods per plant, number of seeds per plant, thousand grain weight, seed and Straw yields were noted at crop harvest.

3.8 Soil

The information regarding characteristics of the soil of the Experimental field is given in (Table 3.2.).

Table 3.2: Physico-chemical characteristics of the experimental field

S.No	Components	Value
1	Soil mechanical analysis (%)	
	(a) Sand	14.15
	(b) Silt	31.75
	(c) Clay	55.25
2	Bulk density (Mgm^{-3})	1.47
3	Soil pH (2:1)	7.66
4	EC (dSm^{-1})	0.55
5	Organic carbon (%)	0.25
6	Available N kg ha^{-1}	183
7	Total N (%)	4.62
8	Available P kg ha^{-1}	8.07
9	Total P (%)	0.39
13	Available K kg ha^{-1}	460
14	Total K (%)	1.26
15	Available S kg ha^{-1}	6.91
16	Total S (%)	0.233

Table 3.3 Microbial counts in experimental field

S.No	Components	Value
1	Enumeration of bacteria	$21*10^{7}$
2	Enumeration of fungi	$12*10^{3}$
3	Enumeration of actinomycetes	$8*10^{3}$

3.9 Collection of Soil and Plant sample

Representative composite soil samples (0-15 cm depth) were collected with the help of stainless steel auger from the experimental plot before sowing and after harvesting of crop. The samples were mixed thoroughly and dried in air, crushed, sieved through 2mm plastic sieve. The samples were analyzed for physico-chemical properties.

The soybean crop was harvested on 30thsep. 2015, after drying then threshing was completed. The seed and straw samples were collected for chemical analysis. Plant samples were dried in an oven at 60^{0}C temperature for 48 hours. Final grinding of these oven dried plant samples were powdered and preserved for nutrient analysis.

3.10 Analysis of soil sample

The soil samples were analyzed for mechanical analysis, bulk density, pH, EC, organic carbon, available nitrogen, available phosphorus, available potassium and sulphur. The standard methods used for determination are given in (Table 3.4.1.)

Mechanical composition of soil

The sand, silt and clay were determined by mechanical analysis of soil. All the collected samples were analyzed by Bouyoucos Hydrometer method (Bouyoucos, 1962).

In this analysis, 50 g soil was treated with 100 ml of 5% solution of sodium hexa Meta phosphate. Percentage of silt and clay was estimated with the help of hydrometer while the percentage of sand was calculated by subtracting percentage of silt and clay from 100.

Table 3.4.1: Methods used in determinations of physico-chemical properties

S.No.	Soil Characteristics	Methods
1	Soil mechanical analysis (%)	Hydrometer method (Bouyoucous, 1962)
2	Bulk density (Mgm^{-3})	Core method
3	Soil pH	Glass electrode (Piper 1950)
4	EC (dSm^{-1})	Piper(1950)
5	Organic carbon (%)	(Walkley and Black 1934)
6	Available N kg ha^{-1}	Alkaline permanganate method (Subbiah and Asija1956)
8	Available P kg ha^{-1}	Olsen's method (Olsen *et al.,*1954)
9	Available K kg ha^{-1}	Flame photometer method (Jackson 1973)
10	Available S kg ha^{-1}	Turbidimetric method (Bardsley & Lancaster 1960).

Bulk density

To determine the bulk density, soil cores were collected with manually operated core sampler 0-15 cm depth. The samples were dried in the oven at 105^0C for 24 hours and then dry weights were recorded. The bulk density was calculated by using the following relation (Richards *et al*., 1954).

$$BD = \frac{\text{Weight of oven dry soil}}{\text{Total volume of soil}}$$

Soil Moisture content

The soil samples from various treatments were collected with 10 cm increments up to a depth of 30 cm, with the help of a soil sampling tube. The moisture content was determined by gravimetric method.

Soil moisture content (%) = weight of wet soil- weight of dry soil
x100 Weight of dry soil – weight of box

Soil pH

Soil pH was determined in (1:2) soil: water suspension using pH meter with glass electrode (Piper, 1950).

Electrical conductivity (dSm^{-1})

Electrical conductivity was determined in the supernatant solution 1:2 soil: water suspension using electrical conductivity meter (Piper, 1950).

Organic carbon

Organic carbon was estimated by the (Walkley and Black, 1934) method. In this method organic matter in the soil is oxidized with a mixture of potassium dichromate ($K_2Cr_2O_7$) and concentrated H_2SO_4 utilizing the heat of dilution of H_2SO_4. $K_2Cr_2O_7$ is back titrated with ferrous ammonium sulphate in presence of diphenylamine indicator, which makes the colour distinct because of their flocculating effects. At the end point colour of the suspension changes from violet through blue, to bright green.

Available N

Soil available nitrogen was estimated by alkaline permanganate method. Alkaline permanganate is used to oxidize the available organic matter present in soil. It reacts with water to form ammonium compound and then ammonia gas is being liberated. This gas is observed by boric acid solution by using mixed indicator (Subbiah and Asija, 1956).

Available P

The determination of available phosphorus was done by using Olsen's reagent (0.5N sodium bicarbonate solution of pH 8.5) as stannous chloride reduced to blue colour, which is proportion to the concentration of phosphate, is read on the spectrophotometer at a wave length (Olsen *et al.,* 1954).

Available K

Available potassium was determined by using 1N neutral ammonium acetate solution using flame photometer (Jackson, 1973).

Available S

Available sulphur was determined the method given by Bradley and Lancaster, 1960. Soil is shaken with 0.15% $CaCl_2$ solution. Chloride ions displace adsorbed sulphate during extraction. The filtrate is analyzed for sulphur in which the turbidity produced due to precipitation of sulphate as barium sulphate is measured on a spectrophotometer at a wave length of 420nm.

Table 3.4.2: Methods used in determinations of microbial analysis

S.No.	Determination	Methods
1	Enumeration of bacteria	Serial dilution plate count method (Allen 1957)
2	Enumeration of fungi	Martin's rose Bengal agar method (Martin 1950)
3	Enumeration of actinomycetes	Kuznetsov method (Kuznetsov and Arjunarao 1972)

Determination of soil microbial population (bacteria, fungi and actinomycetes)

The soil samples were analyzed for population of soil bacteria, fungi and actinomycetes by the standard serial dilution plate count method using nutrient agar bacteria (Allen, 1957), Martin's Rose Bengal agar for fungi (Martin, 1950), Kuznetsov medium for actinomycetes (Kuznetsov, 1972). Plates were incubated at 28 ± 2^{0}Cin an incubator and colony counts were recorded after six days incubation. The population was expressed as number of colony forming units (CFU) per g dry weight of soil.

3.11 Chemical Analysis of Plant Samples:

The soybean plants were analyzed to determine various constituents. The methods used for estimation are mentioned in (Table 3.5.)

Table 3.5 Method used in determinations of plant analysis

S.No.	Determination	Methods
1	Total N (%)	Micro Kjeldahl method (Piper, 1967)
2	Total Phosphorus (%)	Chapman and Prett (1961),
3	Total Potassium (%)	Flame photometer method Black (1965)
4	Total Sulphur (%)	Tabatabai and Bremner (1970)

Total nitrogen

Nitrogen was determined by Kjeldhal's method using digestion mixture of K_2SO_4, $CuSO_4$, selenium powder (50:10:1) and H_2SO_4. Half a gram plant sample was digested in a block digestion unit. After complete digestion the samples were distilled using Micro-Kjeldhal unit and the liberated ammonia was trapped in boric acid containing mixed indicator and titrated against 0.01N H_2SO_4 (Piper, 1967).

Total phosphorus

Wet digestion for plant sample

Wet digestion of one gram oven dry samples was done by a di-acid (3:1 *viz.,* HNO_3 and $HClO_3$) on a hot plate. After the complete digestion. The material was allowed to cool and was filtered and the volume was made up to 100 ml mark. This extract was preserved for all the determination except nitrogen.

Phosphorus

phosphorus was determined by vanado-molybdo phosphoric acid yellow colour method and the colour intensity of yellow colour was recorded on spectrophotometer at 470 nm wave length (Chapman and Prett, 1961).

Total potassium

Potassium in the plant sample was estimated by atomizing the diluted plant extract in the flame photometer as described by (Jackson, 1973)

Total sulphur

10 ml of aliquot of the filtrate was taken in a 25 ml volumetric flask; 1 ml of 6N HCl and 1ml of 0.25 percent gum acacia solution were added to it and shaken. Final volume was made up to mark with distilled water. Contents of the flask were transferred to a beaker and 0.5 g of barium chloride crystals (30 mesh) were added and swirled gently for two minutes. Turbidity produced was measured as transmittance percent on spectrophotometer at 420 nm (Tabatabai and Bremner, 1970)

Uptake of nutrients

Nutrient uptake by soybean was worked out using the equation.

$$\text{Uptake of NPK (Kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%)}}{\text{matter 100}} \text{ x dry}$$

3.12 Qualitative Studies

The grain and straw samples collected treatment wise were ground and stored in polythene bags. These samples were analyzed for N, P, K and S.

3.13 Economic Analysis

Harvest index

Economical and biological yield were recorded from each plot. Then harvest index was worked out by using the following formula:

$$\textbf{Harvest index (HI)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Gross monetary return (Rs.)

Gross monetary returns = market rates of grain and straw

Net monetary return (Rs.)

Net return = gross monetary return-total cost of cultivation

B: C ratio

$$\text{B:C ratio} = \frac{\text{Gross monetary}}{\text{Total cost of cultivation}}$$

3.14 Statistical analysis

The data were analyzed by method of analysis of variance described by (Fisher, 1950). The design of experiment was randomized block design with three replications.

The significant differences between different treatments were judged by using critical differences (C.D.) which was calculated as follows:

S.Em± = MSE/r

S.Ed = S.Em.* 2

C.D .=S.Ed.*t' (0.05)

Table 3.6 Skeleton of ANOVA table

Sources of variance	Degree of freedom	Sum of Square	Mean sum of square	F cal. value	Table value at 5%
Replications	(r-1) 3-1=2	RSS	RMSS	RMSS/EMSS	2.12 at 5 %
Treatment	(t-1) 9-1=8	TrSS	TMSS	TMSS/EMSS	
Error	(r-1)(t-1) 2x8=16	ESS	EMSS		
Total	(rt-1) 9x3-1=26	TSS			

Where,

S.Em± = standard error means

S.E.d = standard error of differences between two treatments means

MSE = Error mean sum of square i.e. Error variance

t' (0.05) = Tabulated 't' value at error degree of freedom at p = 0.05

C.D. = critical difference (for treatment at 5%)

CHAPTER-IV

RESULT

The present experiment was carried out to investigate the **"Effect of Organics and Inorganics Application on Productivity and Chemical Composition of Soybean Grown in Semi-arid Vertisols''.**

The data of experimental observations were subjected to statistical analysis in order to find out the significance of different treatments by using analysis of variance technique. The experimental findings are presented here under different heads for showing superiority of one treatment over another.

4.1 Growth and yield of soybean

The data presented in Tables 4.1 to 4.4 on the influence different treatments on growth parameters, plant height, number of branches, number of pods, seed yield and straw yield, test weight and harvest index of soybean.

4.1.1 Plant height (cm) of soybean as influenced by different treatments at various stages

20 DAS

Height of the plant as influenced by different treatments was recorded at 20 DAS and the data have been summarized in Table 4.1.1. and Fig 4.1.

All the treatment recorded significantly higher plant height than control. The highest plant height was recorded in T6 (14.57 cm), followed by T8 (13.33 cm), T7 (13.32 cm) and T9 (13.31 cm) the differences between plant height among treatment T8, T7, and T9 being statistically non significant between them. Treatments involving FYM and crop residues along with $N_{20}P_{13}$ were observed to be superior as compared with recommended dose of fertilizer alone.

Table 4.1.1: Plant height (cm) of soybean as influenced by different treatments at various stages

Treatments	Plant height (cm)				
	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
T1-N_0P_0	11.58	29.00	34.67	35.00	41.33
T2-$N_{20}P_{13}$	13.00	30.52	35.63	38.67	42.00
T3-$N_{30}P_{20}$	12.34	31.47	36.67	42.00	43.67
T4-$N_{40}P_{26}$	12.33	32.00	36.68	42.33	44.00
T5-$N_{60}P_{35}$	13.29	33.33	37.33	45.00	44.62
T6-FYM6t+T2	14.57	40.00	42.67	47.00	51.65
T7-Residues 5t+T2	13.32	35.00	36.58	45.68	44.61
T8-FYM6t	13.33	36.00	42.00	43.33	45.00
T9- Residues 5t	13.31	39.65	38.56	44.00	47.64
SE(m)±	**0.78**	**3.26**	**3.04**	**2.45**	**1.33**
CD at 5%	**2.25**	**9.42**	**8.78**	**7.07**	**3.86**

40 DAS

The data presented in Table 4.1.1 and Fig 4.1 showed that the plant height of soybean significantly increased with different treatments at 40 DAS. The application of T6 (FYM 6t ha^{-1} + $N_{20}P_{13}$) recorded the highest plant height (40.00 cm) over control.

60 DAS

The data presented in Table 4.1.1 and Fig 4.1 showed that the plant height of soybean significantly increased with different treatments at 60 DAS. The application of T6 (FYM 6t ha^{-1} + $N_{20}P_{13}$) recorded the highest plant height

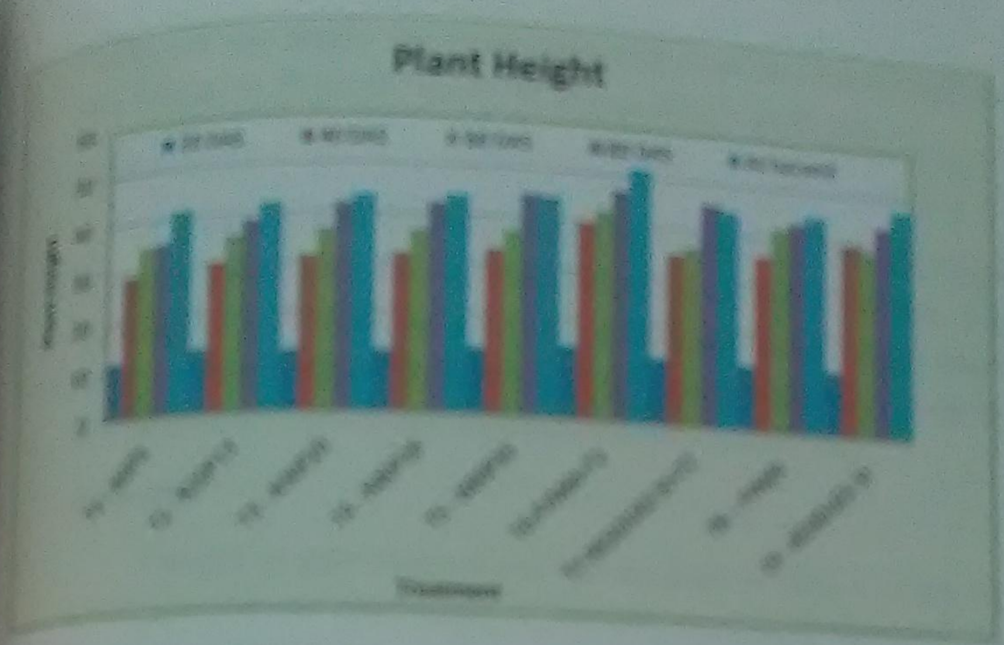

Fig. 4.1: Plant height (cm) of soybean as influenced by different treatments at various stages

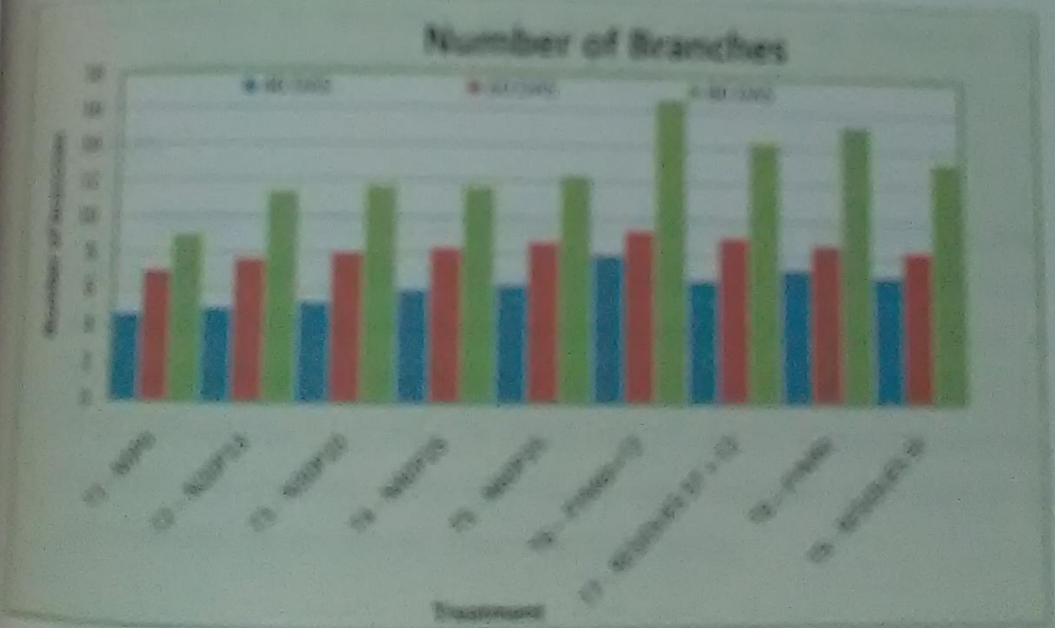

Fig. 4.2: Number of branches per plant of soybean as influenced by different treatments at various stages

(42.67 cm) over control. The highest plant height was recorded in T6 (43.84 cm), followed by T8 (42.00 cm), T9 (38.56 cm), and T7 (36.58 cm).

80 DAS

The result given in Table 4.1.1 and Fig 4.1 showed that the plant height of soybean significantly increased with different treatments at 80 DAS. The application of T6 (FYM 6t ha^{-1}+ $N_{20}P_{13}$) recorded the maximum plant height (47.00 cm) over control. The highest plant height was recorded in T6 (47.00 cm), followed by T7 (45.68 cm), T9 (44.00 cm) and T8 (43.33 cm).

At harvest

The data on plant height of soybean are given in Table 4.1.1 and Fig 4.1 showed that the plant height of soybean significantly increased with different treatments at harvest. The application of T6 (FYM 6t ha^{-1} + $N_{20}P_{13}$) recorded the highest plant height (51.65 cm) over control. The highest plant height was recorded in T6 (51.65 cm), followed by T9 (47.64 cm), T8 (45.00) and T7 (44.61).

4.1.2 Number of branches per plant of soybean as influenced by different treatments at various stages

40 DAS

Number of branches of soybean as influenced by different treatments was recorded at 40 DAS and the data have been summarized in (Table 4.2.1. and Fig 4.2). All the treatment recorded significantly higher number of branches than control. The highest number of branches was recorded in T6 (8.00), followed by T8 (7.33), T9 (7.00) and T7 (6.67). Treatments involving FYM and crop residues along with $N_{20}P_{13}$ were observed to be superior as compared with recommended dose of fertilizer alone.

60 DAS

The data presented in Table 4.2.1 and Fig 4.2 showed that the number of branches of soybean significantly increased with different treatments at 60 DAS. The application of T6 (FYM 6t ha^{-1} + $N_{20}P_{13}$) recorded the highest number of branches (9.33) over control. The highest number of branches was recorded in T6 (9.33), followed by T7 (9.00), T8 (8.67) and T9 (8.35).

Table 4.1.2: Number of branches per plant of soybean as influenced by different treatments at various stages

Treatments	Number of branches per plant		
	40 DAS	**60 DAS**	**80 DAS**
T1-N_0P_0	4.67	7.00	9.00
T2-$N_{20}P_{13}$	5.00	7.67	11.33
T3-$N_{30}P_{20}$	5.33	8.00	11.67
T4-N40P26	6.00	8.33	11.67
T5-N60P35	6.33	8.67	12.33
T6-FYM6t+T2	8.00	9.33	16.67
T7-Residues 5T + T2	6.67	9.00	14.33
T8-FYM 6t	7.33	8.67	15.33
T9-Residues 5t	7.00	8.35	13.33
SEm±	**0.66**	**0.81**	**0.82**
CD at 5%	**1.91**	**2.35**	**2.37**

Effect of T1 (Control)on soybean crop

Effect of T2-N20P13 on soybean crop

Effect of T3-N30P20 on soybean crop

Effect of T4-N40P26 on soybean crop

Effect of T5-N 60P35 on soybean crop

Effect of T6-FYM 6 t ha-1+ N20P13 on soybean crop

Effect of T7-Residues 5t ha-1 N20P13 on soybean crop

Effect of T8-FYM 6t ha-1 on soybean crop

Effect of T9-Residues

At 80 DAS

The result given in the Table 4.2.1 showed that the application of different treatments significantly higher number of branches are observed in T6 (FYM 6t + $N_{20}P_{13}$) over control. The highest number of branches was recorded in T6 (16.67), followed by T8 (15.33), T7 (14.33), and T9 (13.33). Treatments involving FYM and crop residues along with $N_{20}P_{13}$ were observed to be superior as compared with recommended dose of fertilizer alone.

4.1.3 Number of pods per plant of soybean as influenced by different treatments at various stages

60 DAS

Number of pods per plant recorded at 60 DAS significantly increased with application of different treatments Table 4.1.3. Application of T6 (FYM 6t ha^{-1} +$N_{20}P_{13}$) significantly increased the number of pods per plant Over control T1. The maximum number of pods was recorded with T6 (22), followed by T7 (18.00), T9 (17.67) and T8 (16.33). Treatments involving FYM and crop residues along with $N_{20}P_{13}$ were observed to be superior as compared with recommended dose of fertilizer alone.

80 DAS

A perusal of data presented in Table 4.3 indicated that the number of pods per plant differed significantly due to different treatments. All the treatments recorded significantly more number of pods per plant over control. The highest number of pods per plant (25.67) was recorded due to conjunctive use of 6t FYM +$N_{20}P_{13}$, which was significantly higher as compared to other treatments.

At harvest

The result given in the Table 4.3 showed that the application of different treatments significantly higher number of pods per plant are observed in T6 (FYM 6t ha^{-1} + $N_{20}P_{13}$) over control. The highest pods per plant was recorded in T6 (42.00), followed by T9 (33.67), T8 (31.67) and T7

(28.00). Treatments involving FYM and crop residues alone were observed to be superior as compared with recommended dose of fertilizer alone.

Table 4.1.3 Number of pods per plant of soybean as influenced by different treatments at various stages

Treatments	Number of pods per plant		
	60 DAS	**80 DAS**	**At harvest**
T1-N_0P_0	12.00	16.33	19.67
T2-$N_{20}P_{13}$	14.67	18.33	26.00
T3-$N_{30}P_{20}$	16.33	20.00	26.33
T4-$N_{40}P_{26}$	17.00	20.67	27.00
T5-$N_{60}P_{35}$	17.33	22.67	26.00
T6-FYM6t+T2	22.00	25.67	42.00
T7-Residues 5t+T2	18.00	20.67	28.00
T8-FYM6t	16.33	22.00	31.67
T9-Residues 5t	17.67	23.00	33.67
SE(m)±	1.77	2.73	1.73
CD at 5%	5.11	7.90	5.00

4.2 Effect of organics and inorganics on seed yield, straw yield, bundle weight (kg ha^{-1}), test weight (g) and harvest index (%)

4.2.1 Seed yield (kg ha^{-1})

The data on the impact of different treatments on yield of soybean as influenced by different treatments have been presented in (Table 4.2.1). The highest seed yield of (1367 kg ha^{-1} was recorded due to treatment FYM 6t ha^{-1}+ $N_{20}P_{13}$ over control.

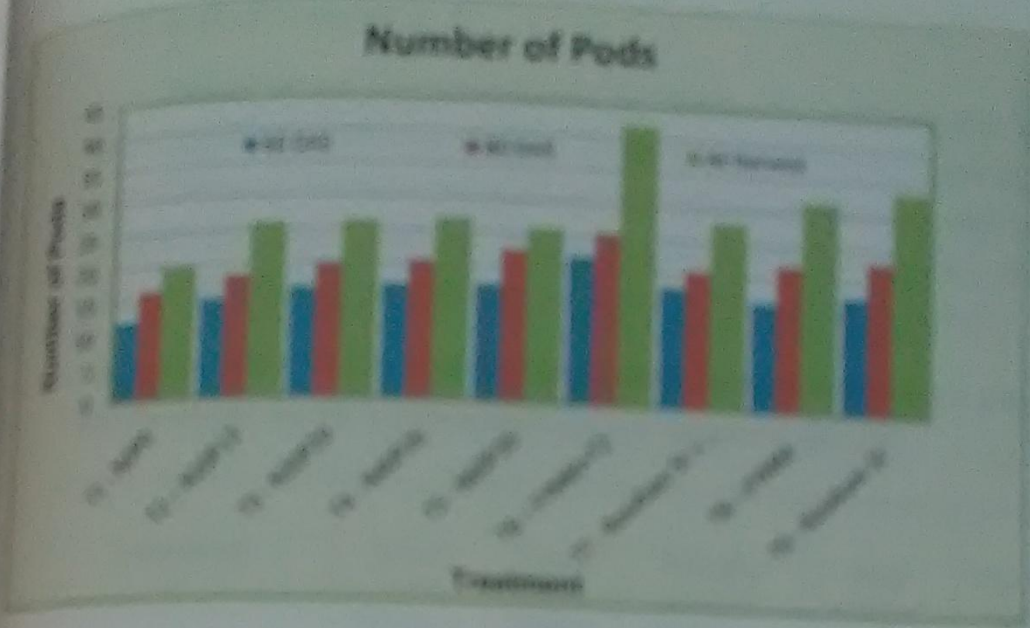

Fig. 4.3: Number of Pods per plant as influenced by different treatments at different growth stages

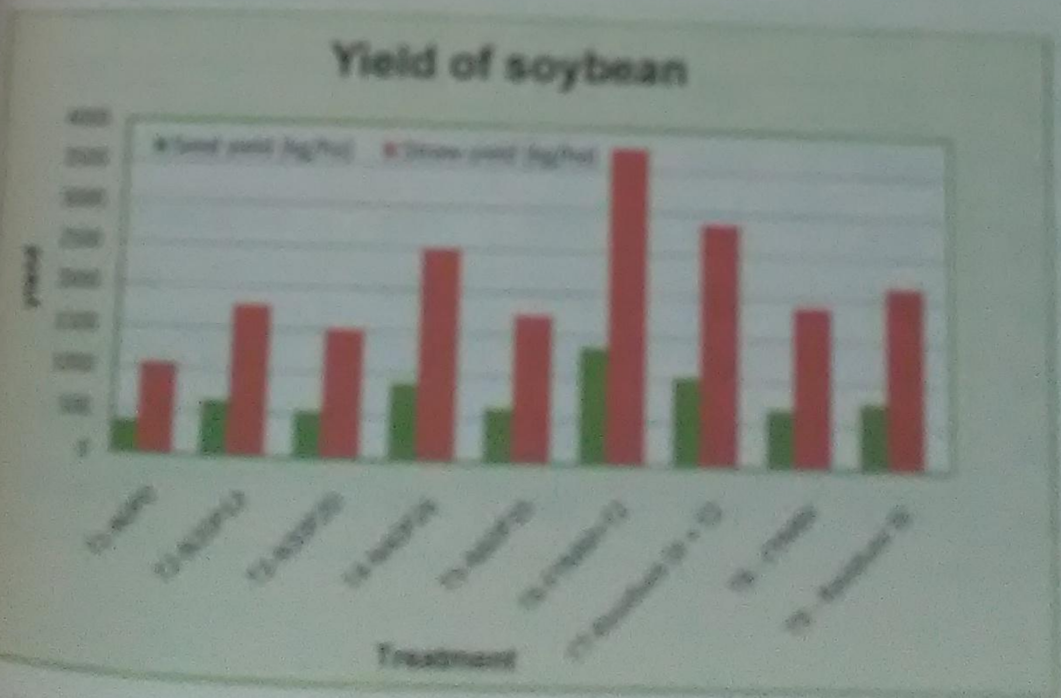

Fig.4.4: Yield of soybean seed and straw as influenced by different treatments at harvest

4.2.2 Straw yield (kg ha^{-1})

Perusal of the data presented in the Table 4.2.1 indicated that there was no significant difference between the treatments in increasing the stover yield of soybean. However, the application of different treatments numerically increased the stover yield over control. The highest (3774.0 kg ha^{-1}) stover yield of soybean was found with application of T6 (FYM 6t ha^{-1}+ $N_{20}P_{13}$).

Table 4.2.1 Effect of organics and inorganics on seed yield, straw yield, bundle weight (kg ha^{-1}), test weight (g) and harvest index (%)

Treatments	Seed yield (kgha^{-1})	Straw yield (kgha^{-1})	Bundle weight (kgha^{-1})	Test weight (g)	Harvest index (%)
T1-N_0P_0	387	1068	1455	8.70	16.54
T2-$N_{20}P_{13}$	645	1780	2425	8.77	17.11
T3-$N_{30}P_{20}$	550	1519	2070	9.33	17.58
T4-$N_{40}P_{26}$	903	2492	3395	9.37	13.86
T5-$N_{60}P_{35}$	628	1733	2361	9.33	15.09
T6-FYM6t+T2	1367	3774	5141	10.53	15.74
T7-Residues 5t+T2	1041	2872	3913	9.40	20.88
T8-FYM6t	688	1899	2587	9.10	14.22
T9-Residues 5t	783	2160	2943	9.10	15.25
SE(m)±	**33**	**90**	**123**	**0.32**	**0.32**
CD at 5%	**93**	**256**	**348**	**0.96**	**0.96**

4.2.3 Bundle weight (kg ha^{-1})

The result given in the Table 4.2.1 showed that there was no significant difference between the treatments in increasing the bundle weight are observed in T6 (FYM 6t + $N_{20}P_{13}$) over control. The highest bundle weight was recorded in T6 (5141.4 kg ha^{-1}).

4.2.4 Test weight (g)

The data on 100 seed weight (g) of soybean are given in Table 4.2.1 indicated that the 100 seed weight significantly increased with the application of different treatments. The application of T6 (FYM 6t ha^{-1}+$N_{20}P_{13}$) recorded the highest 100 seed weight (10.53 g) over control.

4.2.5 Harvest index (%)

The result given in the Table 4.2.1 showed that harvest index (%) of soybean was not significantly affected due to different treatments. The highest harvest index 15.74% was recorded due to treatment T6 (FYM 6t ha^{-1} + $N_{20}P_{13}$) while the lowest harvest index 16.54% was obtained in T1 (control).

4.3 Nutrient content (%) in seed and stover

The data given in Table 4.4.1. N, P, K and S content in seed and stover of soybean at different treatments at harvest.

4.3.1 Nitrogen content (%)

The data on nitrogen content in seeds and stover are given in Table 4.4. It is evident from the data that the addition of different treatments significantly increased the nitrogen content in seed and stover at harvest over control. The application of T6 (FYM 6 t ha^{-1} +$N_{20}P_{13}$) the highest nitrogen content 6.19% in seeds and 0.97% in stover of soybean.

4.3.2 Phosphorus content (%)

The data on phosphorus content in seeds and stover are given in Table 4.4.1. and Fig 4.4.1 It is evident from the data that the addition of different treatments significantly increased the phosphorus content in seed and stover at harvest over control. The application of T6 (FYM 6 tha^{-1} $+N_{20}P_{13}$) the highest phosphorus content 0.50% in seeds and 0.071% in stover of soybean.

Table 4.3.1 Effect of different treatments on N, P, K and S content (%) on seed and straw of soybean

Treatments	Nutrient content in soybean (%)							
	Seed				Straw			
	N	P	K	S	N	P	K	S
T1-N_0P_0	4.62	0.39	1.26	0.233	0.54	0.037	0.129	0.12
T2-$N_{20}P_{13}$	5.47	0.50	1.29	0.267	0.68	0.046	0.129	0.15
T3-$N_{30}P_{20}$	5.16	0.44	1.29	0.277	0.73	0.057	0.225	0.14
T4-$N_{40}P_{26}$	5.94	0.47	1.23	0.303	0.77	0.055	0.230	0.12
T5- $N_{60}P_{35}$	5.90	0.42	1.40	0.303	0.93	0.063	0.239	0.16
T6-FYM6t+T2	6.19	0.50	1.53	0.340	0.97	0.071	0.243	0.14
T7-Residues 5t + T2	5.23	0.44	1.36	0.243	0.84	0.057	0.221	0.15
T8-FYM6t	5.58	0.48	1.38	0.283	0.85	0.063	0.211	0.13
T9-Residues 5t	5.81	0.43	1.33	0.260	0.73	0.054	0.210	0.15
SE(m)±	**0.17**	**0.02**	**0.02**	**0.030**	**0.02**	**0.004**	**0.004**	**0.02**
CD at 5%	**0.50**	**0.05**	**0.06**	**0.085**	**0.07**	**0.012**	**0.013**	**0.04**

4.3.3 Potassium content (%)

The data on potassium content in seeds and stover are given in Table 4.4.1. and Fig 4.4.2. It is evident from the data that the addition of different treatments significantly increased the potassium content in seed and stover at harvest over control. The application of T6 (FYM 6 t ha^{-1} $+N_{20}P_{13}$) the highest potassium content 1.53% in seeds and 0.243% in stover of soybean.

4.3.4 Sulphur content (%)

The data on sulphur content in seeds and stover are given in Table 4.4.1. and Fig 4.4.3. It is evident from the data that the addition of different treatments significantly increased the sulphur content in seed and stover at harvest over control. The application of T6 (FYM 6 t ha^{-1} +$N_{20}P_{13}$) the highest sulphur content 0.340% in seeds and 0.14% in stover of soybean.

4.4 Uptake of nutrients

4.4.1 Uptake of nutrients by soybean

The data on nutrient content in soybean seeds and Stover was determined and nutrient uptake was given in Table 4.5.1. The data revealed that the uptake of N,P, K and S by soybean seed, stover and total uptake of these nutrients in relation to different treatments under consideration was mainly governed by biomass yield as expected. Treatment T6-FYM 6t ha^{-1} + $N_{20}P_{13}$ recorded highest uptake of N, P, K and S as compared to other level of application of fertilizer. Lowest uptake of all the nutrients was recorded in the control T1.

Table 4.4.1 Effect of organics and inorganics on nutrient uptake (kg ha^{-1}) by soybean seed and straw

Treatments	Nutrient uptake by soybean (kg ha^{-1})							
	Seed				Straw			
	N	P	K	S	N	P	K	S
T1-N_0P_0	29.08	2.65	18.44	0.41	4.70	0.54	5.44	0.61
T2-$N_{20}P_{13}$	43.86	3.12	24.24	0.77	5.67	0.57	5.46	2.13
T3-$N_{30}P_{20}$	51.80	5.18	29.97	2.33	6.72	1.26	7.31	4.20
T4-$N_{40}P_{26}$	52.62	5.26	30.07	2.95	7.20	0.72	6.93	4.05
T5-$N_{60}P_{35}$	50.11	5.18	28.80	3.46	5.66	1.06	6.16	3.54
T6-FYM6t+T2	78.39	11.32	45.29	6.10	8.35	2.30	7.31	5.22
T7-Residues 5t+T2	62.04	7.75	34.55	3.53	7.28	1.13	5.75	3.24
T8-FYM6t	58.55	6.73	34.32	3.43	7.55	1.76	5.88	4.20
T9-Residues 5t	63.38	8.84	35.38	3.54	5.91	1.10	5.32	4.22

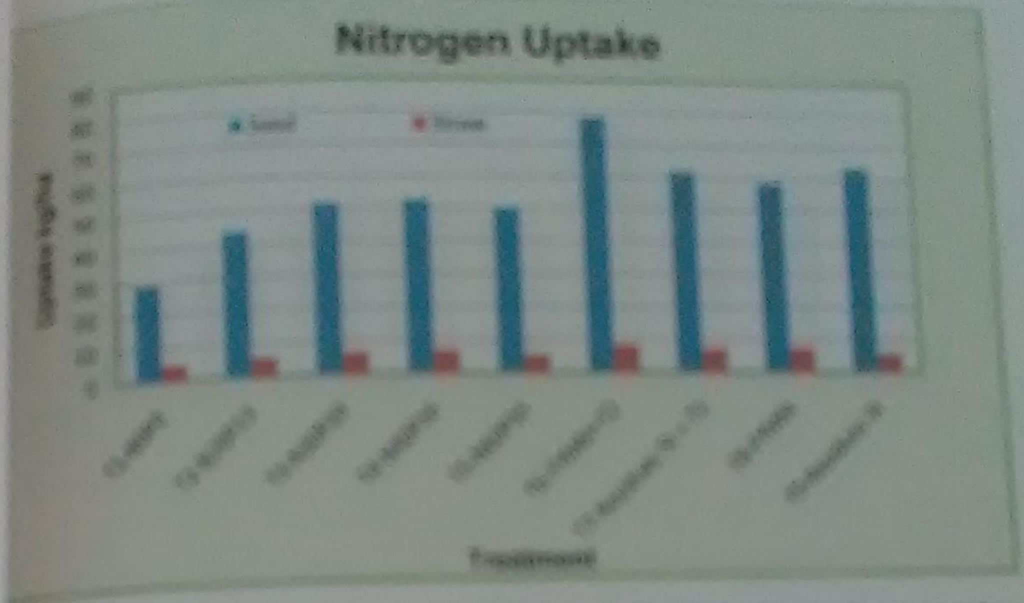

Fig. 4.5: Effect of organics and inorganics on N uptake by soybean seed and straw as influenced by different treatments at harvest at harvest

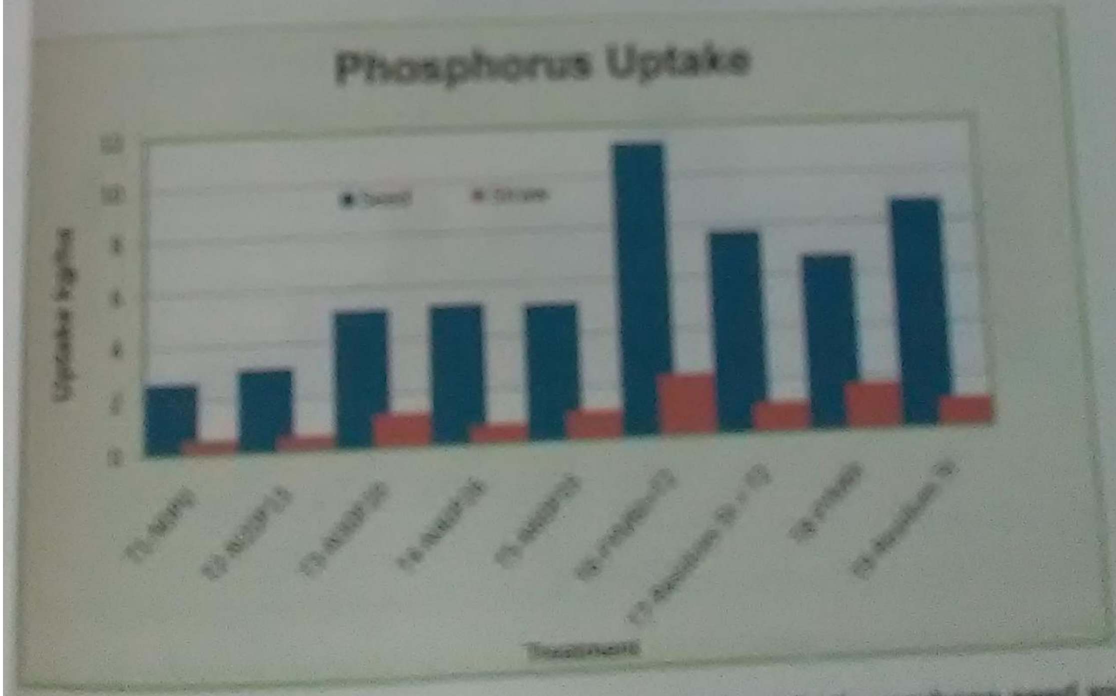

Fig. 4.6: Effect of organics and inorganics on P uptake by soybean seed and straw as influenced by different treatments at harvest

Fig. 4.7: Effect of organics and inorganics on K uptake by soybean seed and straw as influenced by different treatments at harvest

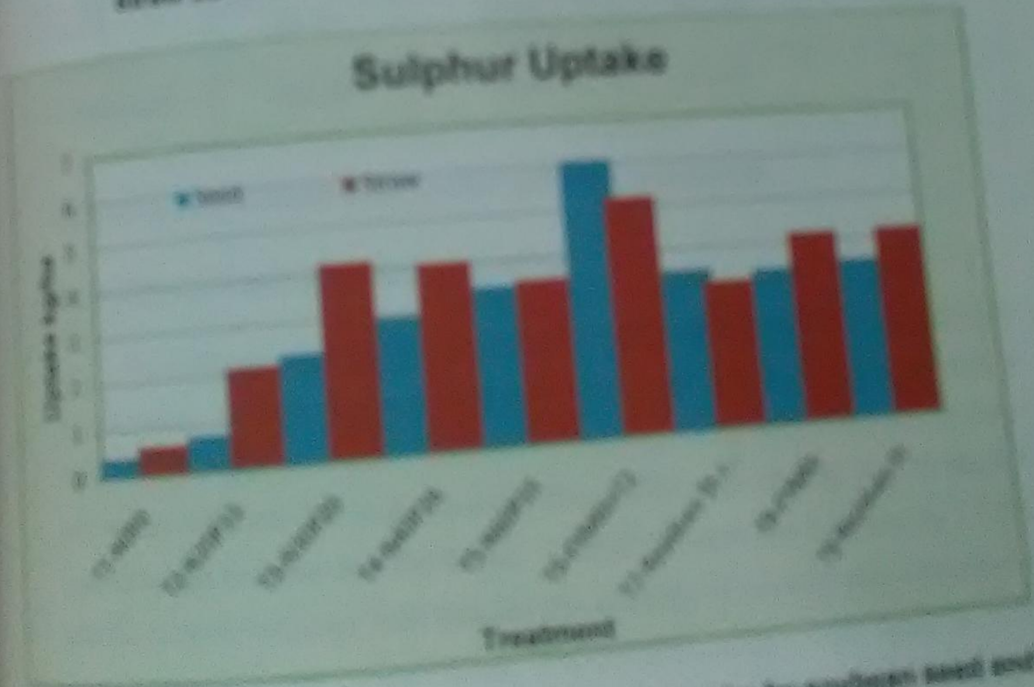

Fig.4.8: Effect of organics and inorganics on S uptake by soybean seed and straw as influenced by different treatments at harvest

4.4.2 Effect of organics and inorganics on total nutrient uptake (kg ha^{-1}) by soybean seed and straw

Treatments	Total nutrient uptake (kg ha^{-1})			
	N	P	K	S
T1-N_0P_0	33.78	3.19	23.87	1.01
T2-$N_{20}P_{13}$	49.53	3.68	29.70	2.89
T3-$N_{30}P_{20}$	58.52	6.44	37.28	6.53
T4-$N_{40}P_{26}$	59.82	5.98	37.00	7.00
T5-$N_{60}P_{35}$	55.77	6.25	34.96	7.00
T6-FYM6t+T2	86.74	13.62	52.60	11.32
T7-Residues 5t + T2	69.32	8.89	40.29	6.76
T8-FYM6t	66.11	8.49	40.20	7.63
T9-Residues 5t	69.29	9.94	40.69	7.76

4.5 Soil quality assessment under different treatments

4.5.1: Effect on soil physical properties

To evaluate the effect of various treatments on soil bulk density and soil porosity, surface soil samples were analyzed and data are presented in Table 4.6.1., revealed that addition of organic along with chemical fertilizer and alone reduced the bulk density. The lowest bulk density of 1.15 Mg m^{-3} was obtained in case of FYM 6t ha^{-1} + N20P13 treatment followed by T7, T8, and T9. Due to reduced bulk density the porosity of soil has also increased in organic amendments treated plots. The porosity ranged from 44.53 to 56.98 % in different treatments and was highest in the treatment T6 (FYM 6t ha^{-1} + N20P13) and lowest in case of control. Similar trend was observed at the harvest of crop Table 4.6.1.

Table: 4.5.1 Effect of various treatments on physical properties of soil before sowing and after harvesting of soybean

Treatment	Before sowing of soybean		After harvesting of soybean	
	Bulk density (Mg m^{-3})	Porosity (%)	Bulk density (Mg m^{-3})	Porosity (%)
T1-N_0P_0	1.47	44.53	1.49	43.77
T2-$N_{20}P_{13}$	1.46	44.91	1.47	44.53
T3-$N_{30}P_{20}$	1.41	46.79	1.43	46.04
T4-$N_{40}P_{26}$	1.38	47.92	1.38	47.92
T5-$N_{60}P_{35}$	1.38	47.92	1.39	47.55
T6-FYM6t+T2	1.15	56.6	1.14	56.98
T7-Residues 5t+T2	1.17	55.85	1.16	56.23
T8-FYM6t	1.16	56.23	1.17	35.85
T9-Residues 5t	1.26	52.45	1.29	51.32

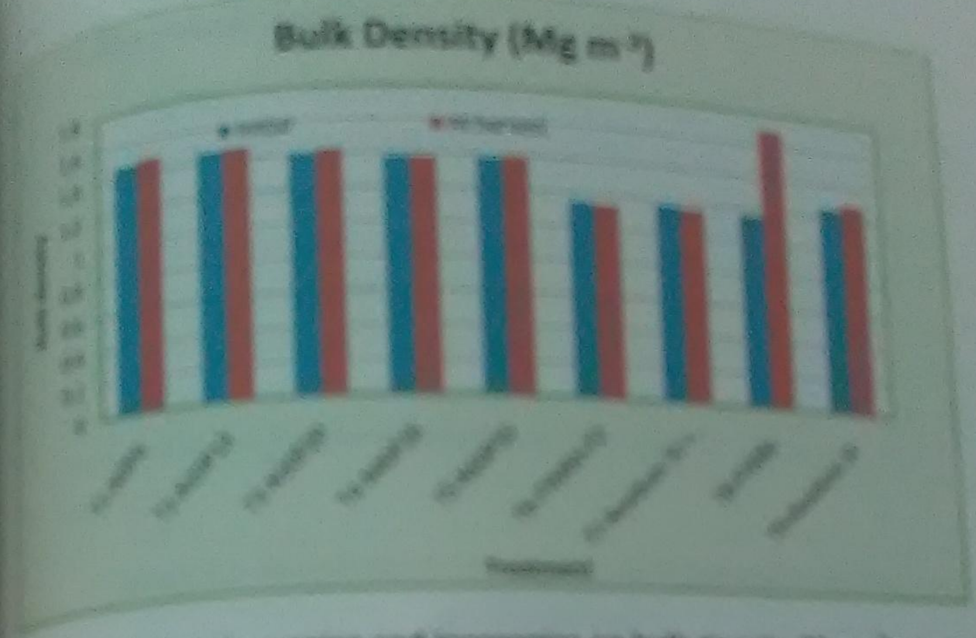

Fig. 4.9: Effect of organics and inorganics on bulk density (Mg m⁻³) of soil before sowing and harvesting of soybean

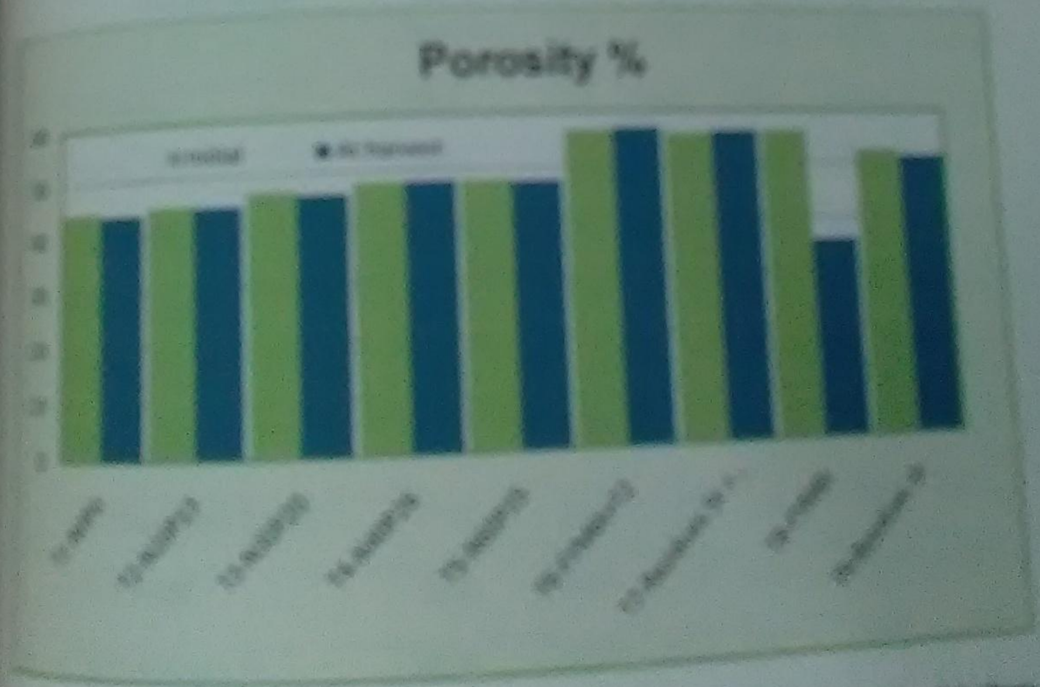

Fig. 4.10: Effect of organics and inorganics on porosity (%) of soil before sowing and harvesting of soybean

4.6 Soil moisture content

The data on moisture content on weight basis are presented in Table 4.7.1. The variation of surface soil moisture revealed that it varies with respect to amount of rainfall received and also by the addition of organics. It is apparent from the table that the moisture content is higher in organically amended soils when moisture availability is low. While when there is a higher rainfall due to higher porosity and better drainage the soil moisture content id comparatively lower in organics added treatments viz. T6, T7, T8 and T9 as compared to the treatments where organics were not applied (T1, T2, T3, T4 and T5).

Table 4.6.1 Soil moisture content (%) on weight basis during crop growth of period

Treatments	Moisture content (%)					
	Before Sowing	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
T1-N_0P_0	28.5	17.5	43.0	35.2	21.3	17.4
T2-$N_{20}P_{13}$	29.0	16.5	45.2	37.1	23.4	19.6
T3-$N_{30}P_{20}$	27.8	18.3	43.1	36.2	22.0	18.4
T4-$N_{40}P_{26}$	28.3	17.9	44.0	34.9	20.1	19.5
T5-$N_{60}P_{35}$	28.2	19.3	44.3	35.6	22.6	19.2
T6-FYM6t+T2	30.2	22.2	39.5	32.4	28.3	22.4
T7-Residues 5t+T2	31.0	21.2	40.1	37.2	27.4	21.3
T8-FYM6t	30.3	20.9	41.4	32.4	25.6	19.5
T9-Residues 5t	30.5	20.3	40.3	33.2	25.3	18.6

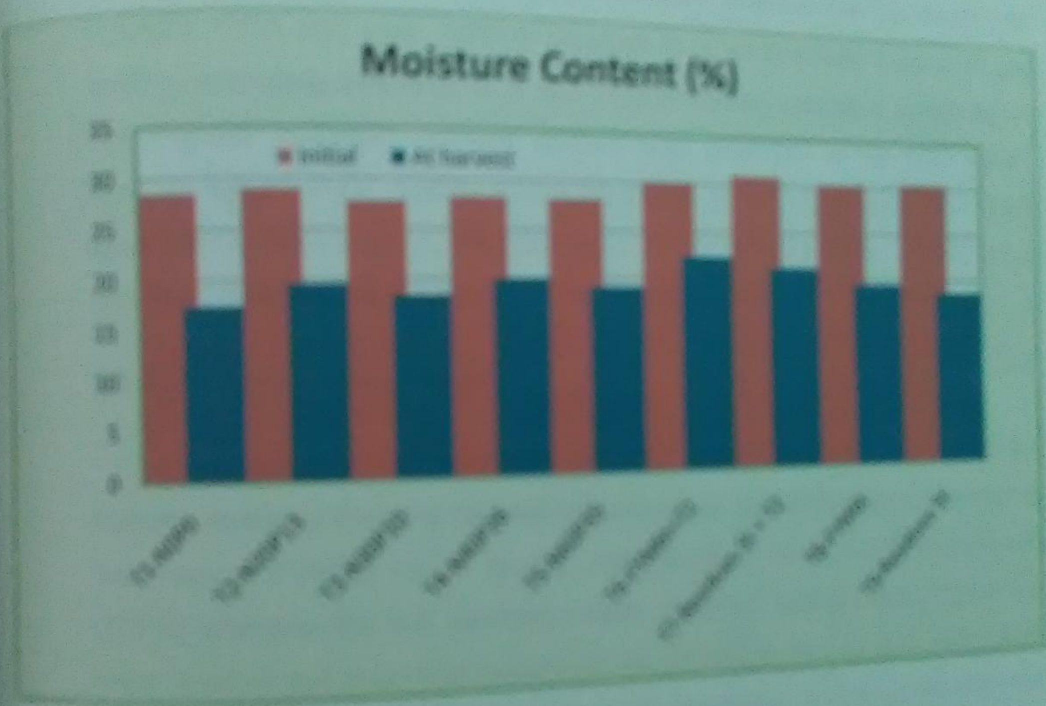

Fig. 4.11: Effect of organics and inorganics on Moisture Content (%) of soil before sowing and harvesting of soybean

4.7 Effect of different treatment on soil Chemical properties

Table 4.8.1 presents the data on the changes in some soil properties as influenced by different treatment. The data revealed that the treatments involving FYM and crop residue resulted in a considerable buildup of soil fertility particularly available N, P and organic carbon content in plough layer. The highest available nutrient content was observed in T6 (307 $kgha^{-1}$ N,13.53 $kgha^{-1}$ P_2O_5, 0.87% O.C.). Followed by T7 (292 $kgha^{-1}$ N, 12.80 $kgha^{-1}$ P_2O_5, 0.83% O.C), T8 (287 $kgha^{-1}$N, 12.60 $kgha^{-1}$$P_2O_5$, 0.81% O.C.) and T9 (249 $kgha^{-1}$ N, 12.53 $kgha^{-1}$ P_2O_5, 0.67% O.C.).

4.8 Soil microbial population

The data on soil microbial population are presented in Table 4.8.1 Results revealed that the highest soil microbial population were recorded in treatment of FYM 6t ha^{-1} + $N_{20}P_{13}$, and lowest in case of control treatment (N0P0) whereas the soil samples under chemical fertilizer use showed the lower level of soil microbial population as compared to amended treatments. From the above results on the microbial population it is analysed that the highest microbial count was observed in the treatment were the FYM is implemented with the inorganic fertilizer. Inorganic fertilizer maintain the Nutrient availability at the initial stage (few days after sowing) but later on depending physicochemical parameters of the soil nutrient availability declines due to formation of metal complexes, but the addition of FYM Maintains the soil organic carbon pool & which helps In maintenance of soil biological activities. Addition of inorganic fertilizer in conjunction with the organic fertilizer is the appropriate rescue system for maintenance of soil quality & productivity in long term use.

Plate Effect of different treatments on the soil microbial population

Table 4.7.1: Effect of different treatments on soil chemical properties O.C. (%), N, P, K and S (kg ha^{-1}) before sowing and at harvest of soybean

Treatment	Before sowing of soybean (2015-16)						
	O.C. (%)	kg ha^{-1}				pH (2:1)	EC dSm^{-1}
		N	P_2O_5	K_2O	S		
T1-N_0P_0	0.25	183	8.07	460	6.91	7.66	0.55
T2-$N_{20}P_{13}$	0.36	242	11.27	542	7.76	7.65	0.54
T3-$N_{30}P_{20}$	0.44	215	11.40	555	8.65	7.62	0.44
T4-$N_{40}P_{26}$	0.52	209	11.73	560	10.54	7.63	0.56
T5-$N_{60}P_{35}$	0.54	216	13.87	576	7.20	7.58	0.54
T6-FYM6t+T2	0.87	307	13.53	708	18.07	7.58	0.62
T7-Residues 5t+T2	0.83	292	12.80	664	16.70	7.60	0.55
T8-FYM 6t	0.81	287	12.60	641	15.09	7.65	0.54
T9-Residues 5t	0.67	249	12.53	591	14.06	7.64	0.57
Treatment	After harvesting of soybean (2015-16)						
	O.C. (%)	kg ha^{-1}				pH (2:1)	EC dSm^{-1}
		N	P_2O_5	K_2O	S		
T1-N_0P_0	0.27	182.00	8.97	471	6.76	7.55	0.20
T2-$N_{20}P_{13}$	0.37	240.00	10.83	521	6.13	7.66	0.20
T3-$N_{30}P_{20}$	0.43	214.33	12.53	543	7.05	7.79	0.22
T4-$N_{40}P_{26}$	0.52	208.00	13.30	552	7.74	7.60	0.22
T5-$N_{60}P_{35}$	0.55	217.67	14.53	584	8.18	7.72	0.23
T6-FYM6t +T2	0.87	289.67	21.60	646	18.39	7.65	0.22
T7-Residues 5t+T2	0.83	291.00	18.47	637	15.07	7.97	0.18
T8-FYM 6t	0.81	288.33	15.97	608	16.07	7.75	0.22
T9-Residues 5t	0.66	249.00	14.57	605	17.07	7.83	0.20

4.8.1 Effect of different treatments on the soil microbial population

Treatment	Bacteria	Fungi	Actinomycetes
T1-N_0P_0	$21x10^7$	$6 x 10^4$	$9x 10^4$
T2-$N_{20}P_{13}$	$24x10^7$	$10 x10^4$	$13 x 10^4$
T3-$N_{30}P_{20}$	$33x10^7$	$16 x 10^4$	$18 x10^4$
T4-$N_{40}P_{26}$	$53x10^7$	$25x 10^4$	$14x10^4$
T5-$N_{60}P_{35}$	$55x10^7$	$30x 10^4$	$24x 10^4$
T6-FYM6t+T2	$65x10^7$	$37x 10^4$	$33x10^4$
T7-Residues 5t + T2	$60x10^7$	$35 x 10^4$	$21 x10^4$
T8-FYM6t	$59x10^7$	$25x 10^4$	$18x10^4$
T9-Residues 5t	$50x10^7$	$28x 10^4$	$22x10^4$

4.9 Economics analysis

The data on economic analysis was presented in Table 4.3.1 Economic analysis revealed that the highest net returns of Rs.105276 Rsha^{-1} and benefit: cost ratio of 4.23 was obtained due to the application of T6 (FYM 6t ha^{-1} + $N_{20}P_{13}$) followed by T7 (residues + $N_{20}P_{13}$) with a net return of Rs.84865 Rs.ha^{-1} and benefit: cost ratio of 5.98.

Table 4.9.1 Economic appraisal of soybean as affected by different treatments

Treatments	Soybean yield (kg ha^{-1})	RWUE (kg ha^{-1} mm)	Cost of Cultivation (Rs.ha^{-1})	Returns (Rs.ha^{-1})		B:C ratio
	Grain			Gross	Net	
T1-N_0P_0	387	0.42	23700	36842	13142	0.55
T2-$N_{20}P_{13}$	645	0.70	23900	61404	37504	1.57
T3-$N_{30}P_{20}$	550	0.60	24100	52398	28298	1.17
T4-$N_{40}P_{26}$	903	0.98	24400	85966	61566	2.52
T5-$N_{60}P_{35}$	628	0.68	25600	59767	34167	1.33
T6-FYM6t+T2	1367	1.48	24900	130176	105276	4.23
T7-Residues 5t + T2	1041	1.13	14200	99065	84865	5.98
T8-FYM6t	688	0.75	15800	65498	49698	3.15
T9-Residues 5t	783	0.85	15200	74503	59303	3.90
SEm (±)	**33**	-	-	-	-	-
CD 5%	**93**	-	-	-	-	-

CHAPTER-V

DISCUSSION

The present investigation was carried out to assess **"Effect of Organics and Inorganics Application on Productivity and Chemical Composition of Soybean Grown in Semi-arid Vertisols''.** This chapter deals with the discussion on the possible reasons of the treatment effect obtained from the experiment, which is corroborated below in the light of research work done in the past by various researchers.

5.1 Yield attributing characters

Data presented in Table 4.1.1 to 4.1.3. Revealed that the growth parameters of soybean crop were significantly affected by different treatments. The highest value of most of the growth parameters were recorded from the treatment T6 (FYM 6t ha^{-1} + $N_{20}P_{13}$) and lowest in T1 (control). The results presented clearly that the addition of organics with 50% RDF enhances crop growth significantly; in general all the growth parameters were higher in the treatments which comprised of organics (T6, T7, T8 and T9) as compared to the treatments where only chemical fertilizers were applied except control. The highest plant height was recorded in T6 (14.57 cm), followed by T5 (13.33 cm), T7 (13.31 cm) and T9 (13.32 cm). Almost similar trend was observed in case of number of branches per plant, number of pods per plant and seed yield per plant and test weight (g). The better growth of soybean might be influenced by the root development of soybean under different fertility treatments. Similar results were reported by Hati *et al.* (2005), Bandyopadhyay *et al.* (2010) and Mandal *et al*. (2007).

5.2 Seed yield

The data on the impact of different treatments on yield of soybean by different treatments have been presented in Table 4.2.1. The highest seed yield of 1367 kg ha^{-1} was recorded due to treatment FYM 6t ha^{-1}+ $N_{20}P_{13}$

over control. T6 was found superior to rest of the treatments during 2015. The treatment T1 i.e. control was found statistically inferior to all the treatments.

The better crop yields under integrated nutrient management may be argued on the basis of better soil quality which was obtained helped in improving soil amended (Table.4.2.1) addition of organics helped in improving soil quality in terms of soil texture, bulk density, availability of N, P, K, S and organic carbon, etc (Table.4.2.1 and Fig 4.2).

Patil *et al.* (1995) observed that the highest grain yield of sorghum and wheat was recorded due to application of 50 percent N through FYM + 50% recommended dose of NPK to wheat over only application of chemical fertilizers. Seed and straw yields of soybean were higher with organics and 50% inorganics (More and Waghmare, 1995). Wheat grown after the soybean in soybean-wheat sequence were produced the higher seed and straw yield with inorganic fertilizer than organic manure. Sharma (1997) studied the effects of different levels of N, P, FYM Manure and crop residues and combined application of organic manures and fertilizers on productivity of soybean-safflower crop in sequence and showed that the highest productivity of both crops could be realized by combine use of 6t ha^{-1} FYM and fertilizer N and P @ 20 and 13 kg ha^{-1}. Fertilizer N and P could be saved without scarifying yield and quality of soybean-safflower by using FYM and crop residues along with reduced level of fertilizers. The treatment of integration was significantly better than control and farmers practice. Many researches (Patil *et al.* 1995) have suggested for the addition of organic manures for enhanced crop productivity, water use efficiency, improvement in soil quality.

5.2 Economics

To assess the impact of fertility treatments on the economics of soybean cultivation the gross returns, net returns and B:C ratio were calculated and data are presented in Table 4.3.1. It is evident from the data that either use of RDF or higher dose of N and P or 50% of RDF when applied with organics are found economically viable as they monitory returns and B:C ratio. The treatments T6- FYM 6t ha^{-1} + $N_{20}P_{13}$ gave the highest gross return (130176 $Rs.ha^{-1}$), Net return (105276 $Rs.ha^{-1}$) which was found statistically superior to control and treatments were at par. Similar results have been found by Prasad, B. (1983). Results of more than 300 on-farm trials in 9 target districts across 7 states of the country on different rainfed oilseed based cropping systems at different agro-ecosystems, conducted over 3 years, clearly showed that integrated nutrient management involving different sources of organic manure has been found to maximize yield as well as income in different oilseed based cropping systems. Application of FYM in soybean-chickpea system and in fallow-sunflower system; lime along with FYM in groundnut + pigeon pea intercropping system; green manuring in safflower, castor and mustard has been found beneficial in increasing yield as well as income over farmers practice as well as RDF.

5.3 Soil properties

Bulk density data revealed that addition of organic along with chemical fertilizer and alone reduced the bulk density Fig.4.6. Soil physical properties viz., bulk density, aggregate stability, water retention characteristics and hydraulic conductivity were changed by long term manuring and intensive cropping over the year (1971-85) under the All India Co-ordinated long term fertilizer experiments at Delhi, Coimbatore, Jabalpur, Hyderabad, Bhubaneswar and Palampur. The study revealed that the use of farmyard manure @ 10-15 t ha^{-1} annually (along with NPK dose) for 7-13 years brought about lowering in bulk density in soil at all the locations (Nambiar, 1994).

The data revealed that the treatments involving FYM and crop residue resulted in a considerable build up of soil fertility particularly available N, P and organic carbon in plough layer.

Different nutrient management options showed substantial impact on organic carbon in surface layer. There was a buildup of organic carbon in the organics along with inorganics treatment like T6: 6t ha^{-1} FYM + 50 % RDF, T7, T8 and T9. Highest depletion of organic carbon, N, P, K and S was obtained in control plots followed by inorganic treatments. Control plots showed higher negative carbon sequestration rate followed by inorganic treatments at lower rate of application. Application of higher dose of N, P application of N, P along with organic manure enhanced organic carbon sequestration rate in soil. Hati *et al.* (2005) also found that the application of 10t FYM and recommended NPK (NPK + FYM) to soybean for three consecutive years improved the organic carbon of the surface (0-15cm) soil quality evaluations results indicate that the quality of soil had improved as compared to control as the values of RSQI was above zero. The relative soil quality index under different treatments was increased by 11. Unit in the treatments which comprised of addition of organics as compared to 7.75 units in treatments where chemical fertilizers were applied in case of treatments t2 the increase was 1.75 units only. Under all the treatments soil belongs to class III having minimum value 66.5 under control. This value increased due to other treatments the maximum improvement was observed due to addition of organics in the soil. This indicates that addition of organic matter improved soil quality as compared to chemical fertilization alone. The soil quality assessment study on the basis of the criteria given by Pierce and Larson (1993) and Larson and Pierce (1994) conclude that there was a great increase in soil quality in the treatments T6, T7, T8 and T9 due to addition of organics, while this increase was moderate in the treatments T3, T4 and T5. The increase in soil quality in case of inorganic fertilization with 50% of RDF was slight.

Malewar and Hasnabade (1995) also observed that combined use of organic manures and fertilizers in the proportion of 50:50 for longer time, build up of organic carbon was more than two times over its initial value. Tiwari *et al*. (2002) revealed that the application of recommended dose of N, P and K with manure @ 15t ha^{-1} improved the organic carbon status and available N, P, K and S in soil there by sustaining the soil health. Imbalance nutrition is one of the important constraints of soybean productivity in the North Indian plains (Chandel, 1989; Tiwari, 2001). Continuous use of high level of chemical fertilizers has led to problems of soil degradation, which is proving detrimental to soybean production. A crop producing 6720 kg ha^{-1} biomass removed about 614 kg N, 148 kg P and 486 kg K ha^{-1} (Nelson, 1989). Therefore, adequate and balanced fertilization and addition of organics is necessary to increase soybean productivity.

The data on the impact of different treatments on soil microbial population as influenced by different treatments have been presented in Table 4.8.1. The highest bacteria, fungi and actinomycetes were recorded due to treatment FYM 6t ha^{-1} + $N_{20}P_{13}$ as compare to control (T1). T6 was found superior to rest of the treatments.

Arbad and Ismail (2011) observed that bacterial population was maximum ($173x10^{-5}$ CPU g^{-1} soil) in treatment plot receiving 100% NPK along with FYM after harvest of soybean followed by the plots receiving only FYM @ 10 Mg ha^{-1} ($161x10^{-5}$ CPU g^{-1} soil). After harvest of safflower, bacterial population in soil decreased in both the years. Inorganic treatments showed lower bacterial count as compared to plot treated with organic sources. Maximum actinomycetes population was recorded in treatment having 100% NPK+FYM during both the years after harvest of soybean and safflower. Maximum population of soil fungi was recorded in treatment plots treated with FYM @ 10 Mg ha^{-1} after both crops during both the years of experimentation.

Similar results were reported by Khaddar and Yadav (2006) the fungal population increased in treated plot over control. Among the organics, biofertilizer increased fungal population at 25 day stage of the crop, while there was slight decrease in fungal population. Integrated use of chemical fertilizer with organics could ameliorate the soil and improve the productivity of a soybean wheat cropping sequence resulting in eco-friendly farming system.

CHAPTER-VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTHER WORK

6.1 Summary

The present investigation entitled **"Effect of Organics and Inorganics Application on Productivity and Chemical Composition of Soybean Grown in Semi-arid Vertisols"**. Importance of present investigation were, it is obvious that integrated use of chemical fertilizers and organics may minimize the imbalanced nutrients in soil and may boost the crop production and ultimately the sustainable production and pollution free environment. Therefore an experiment is planned with the following objectives:

- To study the effect of organics and inorganics on yield and yield attributes of soybean.
- To study the effect of organics and inorganics on physico-chemical properties (soil texture, bulk density, EC, pH and organic carbon) and nutrient availability (N, P, K, and S).
- To evaluate the economics of different fertility treatments.

The experiment was carried out in *kharif* season during the years 2015-16 under All India Co-ordinated Research Project for Dryland Agriculture, College of Agriculture, Indore. A field experiment was laid out in Randomized Block design. There were 9 treatments with 3 replications. The treatments comprises of 9 treatments viz. T1-N_0P_0(control), T2-$N_{20}P_{13}$ fertilizer

N and P @ 20 and 13 kg ha^{-1}, T3-$N_{30}P_{20}$ fertilizer N and P @ 30 and 20 kg ha^{-1}, T4-$N_{40}P_{26}$ fertilizer N and P @ 40 and 26 kg ha^{-1}, T5-$N_{60}P_{35}$ fertilizer N and P @ 60 and 35 kg ha^{-1}, T6-FYM 6t ha^{-1} + $N_{20}P_{13}$ farmyard manure @ 6t ha^{-1} prior to sowing of soybean plus fertilizer N and P @ 20 and 13 kg ha^{-1}, T7-residues 5t ha^{-1} + $N_{20}P_{13}$ crop residues of soybean @ 5t ha^{-1} as surface mulch in between crop rows + fertilizer N and P @ 20 and 13 kg ha^{-1}, T8-FYM 6t ha^{-1}manure alone @ 6t ha^{-1}, T9-Crop residues 5t ha^{-1} (after emergence in between crops rows as surface mulch). The gross plot size was 10m x 7.2m and after leaving non-experimental margin on both sides, the net experimental plot size was 9.0m x 6.4 m. Soybean crop (cv. JS-335) was grown on June 18, 2015 and harvested on September 30, 2015. Soybean seed @ 80 kg ha^{-1} was sown at row to row distance of 40 cm.

The effect of organic manures along with inorganic fertilizers on physical-chemical properties of vertisols and yield attributes of soybean during 2015-16 in AICRPDA Farm, revealed that soybean responded to organic manures when used in integration with inorganic fertilizers. Yield of soybean 1367 kg ha^{-1} was highest with the application of organic manures + RDF over RDF alone. Increase in organic carbon, available N, P, K and S with the application of FYM 6t ha^{-1} + $N_{20}P_{13}$ over the initial soil values. Whereas, the maximum uptake by soybean crop was observed in FYM along with RDF.

The results obtained in this study as elucidated in chapter IV lead to the following

6.2 Conclusions

- Growth parameters and yield attributing characters of soybean were improved significantly by the use of 6t ha^{-1} FYM + N_{20} and P_{13}.
- The highest soybean seed yield was recorded due to half of the recommended dose of N and P + 6t ha^{-1} of FYM (1367 kg ha^{-1}), followed by the other treatments T5, T7, T8 and T9 were at par among themselves and treatment T6 (1367 kg ha^{-1})was found superior to rest of the treatments. The treatment T1 i.e. control (387kg ha^{-1}) was found statistically inferior to all the treatments.
- The highest gross return (Rs. 130176.00) and net return (Rs. 105276.00 was obtained due to T6-FYM 6t +T2 and lowest in case of control (Rs.36842.00 and Rs.13142). There was a non significant differences in the B:C ratio of the treatments T2, T4, T5 and T6 lowest B:C ratio was observed in control treatment.

- Addition of organic along with chemical fertilizer and alone reduced the bulk density.
- Application of crop residues as surface mulch @ of 5t ha^{-1} alone and along with reduced level of $N_{20}P_{13}$ resulted in an increase of water use efficiency of soybean crop.
- Treatment involving FYM and crop residue resulted in a considerable build up of soil fertility particularly in crop residue treatment because it is a long term manurial trial. Increase in Organic carbon, available N, P, K and S in plough layer, due to treatment T6 over control.
- Addition of organics and RDF has helped to build up soil fertility but lower doses of N and P as compared to RDF has depleted to RDF has depleted the soil fertility in terms of organic carbon, N, P, K and S.
- The perusal of the data revealed that O.C. balance was found negative in the treatment T1, T2 and T3. The highest buildup of OC was obtained in T6- FYM 6t ha^{-1} +T2 followed by T8-FYM 6t ha^{-1}, T7- residues 5t ha^{-1} +T2, T9- residues 5t ha^{-1}, T5- $N_{60}P_{35}$ and T4-$N_{40}P_{26}$.
- In case of nitrogen there was a negative balance in T1 (control) and T2 treatments rest of the treatments have positive balance.
- The P and K balance was found positive in all the treatments except T1 control, where it was found negative. S balance was found negative balance in all the treatments.
- The highest microbial count was recorded in T6-FYM 6t ha^{-1} + T2 and lowest in T1 (control).
- The soil quality assessment study on the basis of the criteria given by Pierce and Larson (1993) and Larson and Pierce (1994) conclude that there was a great increase in soil quality in the treatments T6, T7, T8 and T9 due to addition of organics, while this increase was moderate in the treatments T3, T4 and T5. The increase in soil quality in case of inorganic fertilization with 50% of RDF was slight.

- The highest nutrient content in soybean seed and stover at harvest was recorded in T6: FYM 6t ha^{-1} + T2 as compared to any level of application of fertilizer source. Lowest uptake of all the nutrients was recorded in the T1control.
- Treatment T6: FYM 6t ha^{-1} + T2 recorded higher uptake of N, P, K and S as compared to any level of application of fertilizer source. Lowest uptake of all the nutrients was recorded in the T1control.

6.3 Suggestions

- Long term results of the experiments should be evaluated in terms of soil and crop quality including detailed soil physical, chemical and biological properties to compare the organics and inorganics system of cultivation.
- Detailed soil microbiological studies should be carried out.
- On farm evaluation of organics and inorganics system of cultivation is required in farmers' participatory mode.

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Appendices

Meteorological parameters recorded at Indore (M.P.) during crop season 2015-2016

SMW	Date	Rainfall (mm)	Temperature Max (^oC)	Temperature Min (^oC)	No. of rainy days	Relative Humidity (%)
24	11-17 June, 2015	65.3	34.6	25.7	4	83
25	18-24 June, 2015	166.6	33.9	24.4	3	83
26	25 -01 July, 2015	5.6	33.1	23.6	1	91
27	02 -08 July, 2015	0.0	33.3	24.1	0	86
28	09 -15 July, 2015	0.0	32.9	29.6	0	83
29	16 -22 July, 2015	397.8	30.0	25.9	4	87
30	23 -29 July, 2015	152.0	25.6	22.1	6	92
31	30 -05 Aug, 2015	246.0	27.7	20.9	3	84
32	06 -12 Aug, 2015	68.5	27.7	22.4	3	92
33	13 -19 Aug, 201	9.5	27.4	23.1	3	90

	5					
34	20 -26 Aug, 201 5	0.0	30.4	22.9	0	92
35	27 -02 Sept, 2015	1.4	30.9	23.1	0	91
36	03 -09 Sept, 2015	0.0	32.3	22.6	0	87
37	10 -16 Sept, 2015	28.1	33.6	24.0	2	88
38	17 -23 Sept, 2015	33.3	29.6	22.4	2	89
39	24 -30 Sept, 2015	0.0	32.0	21.1	0	89
40	01- 07 Oct,2015	0.0	35.1	20.4	0	79
		1174.1			31	

Source: Observatory, All India Co-ordinated Research Project for Dryland Agriculture; College of Agriculture, Indore (M.P.)

Effect of various treatments on seed yield of soybean (kg $plot^{-1}$)

Symbol	Treatment	Yield kg $plot^{-1}$
T1	N_0P_0	2.23
T2	$N_{20}P_{13}$	3.72
T3	$N_{30}P_{20}$	3.17
T4	$N_{40}P_{26}$	5.20
T5	$N_{60}P_{35}$	3.62
T6	FYM6t+T2	7.88
T7	Residues 5t+T2	5.99
T8	FYM6t	3.96
T9	Residues 5t	4.51
SE(m)±		0.19
CD at 5 %		0.54

Vita

The author of this thesis ***Ms. Jyoti Bangre*** *D/O Shri N.K. Bangre was born 19th Sep. 1991 in Jabalpur (M.P.). She completed her schooling from Indore, securing (73%) in M.P. Board of Secondary Examinations and her higher schooling from M.P. Board of secondary examinations, securing (69%).Gradually; she joined Agricultural College, Indore in the year 2010 and successfully completed her B.Sc. (Ag.) degree in the year 2013-2014 with an OGPA of 7.86 out of 10.00 scales. Subsequent to the graduation she joined the soil science and agricultural chemistry section at College of Agriculture, Indore of RVSKVV, Gwalior, for master degree in the year 2014-2015. For partial fulfillment of master's degree she was allotted a topic "Effect of Organics and Inorganics Application on Productivity and Chemical Composition of Soybean Grown in Semi-arid Vertisols'' which has successfully completed by her and presented in the form of this thesis. She has completed her M.Sc. (Ag.) course with an OGPA OF 8.18 out of 10.00 scale.*

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