RESPONSE OF SOYBEAN (*Glycine max* L. Merill) TO ORGANIC SOURCES OF NUTRIENT

Thesis

Submitted to

NAGALAND UNIVERSITY

In partial fulfilment of requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

AGRICULTURAL CHEMISTRY AND SOIL SCIENCE

By

ROVIZELHOU KUOTSU

Admin. No. Ph-158/14; Regn. No. 763/2017

Department of Agricultural Chemistry and Soil Science

School of Agricultural Sciences and Rural Development

NAGALAND UNIVERSITY

Medziphema Campus

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2018

Dedicated to my Parents,

Vicha Kuotsu & Bano Kuotsu,

and my siblings

Kevizhalhou,

Vimeno,

&

Riizeno

STUDENT'S DECLARATION

I, Mr. Rovizelhou Kuotsu, hereby declare that the subject matter of this Thesis is the record of work done by me, that the contents of this Thesis did not form the basis of the award of any previous Degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree to any other University/ Institute.

This is submitted to SASRD, Nagaland University for the Degree of Doctor of Philosophy in Agricultural Chemistry and Soil Science.

…………………………

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Supervisor

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Date: 05/02/2018

Place: NEDZIPHEMA

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MEDZIPHEMA: NAGALAND

CERTIFICATE - I

This is to certify that the Thesis entitled "Response of soybean (*Glycine max* L. Merill) to organic sources of nutrient" submitted to Nagaland University in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY in the discipline of Agricultural Chemistry and Soil Science, is a record of research work carried out by Mr. Rovizelhou Kuotsu, Registration No. 763/2017, under my personal supervision and guidance.

All help received by him/her have been duly acknowledged.

Dated: 05/02/18

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CERTIFICATE - II

This is to certify that the Thesis entitled "Response of soybean (*Glycine max* L. Merill) to organic sources of nutrient" submitted by Mr. Rovizelhou Kuotsu, Admission No. Ph-158/14, Registration No.763/2017, to Nagaland University in partial fulfilment of the requirements for the DOCTOR OF PHILOSOPHY (AGRICULTURE) in the discipline of Agricultural Chemistry and Soil Science has been examined and approved by the student Advisory Committee and the External Examiner, after viva voce.

	Signature
1. Dr. A. K. Singh Supervisor	……………… 21/5/18
2. Prof. B. K. Medhi External Examiner	……………… 21/5/18
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Members of the Advisory Committee:	**Signature**
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ABSTRACT

A field experiment was conducted during *Kharif* season of 2016 and 2017 at the Experimental research farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, Nagaland with the purpose of studying the effect of different nutrient combinations on growth, yield and quality of soybean. An experiment was carried out in soybean variety JS 97-52, with the application of FYM, Forest litter, Pig manure, Poultry manure and Vermicompost at varying doses and combinations using randomized block design. Application of Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} produced maximum number of leaves, highest plant height and highest number of seed, stover and biological yield, protein and oil content. Incorporation of Poultry manure @ 3 t ha^{-1} along with Forest litter @ 0.25 t ha^{-1} registered maximum nutrient content and uptake by seed and stover and available nutrient in soil after crop harvest. Balance sheet of nitrogen showed that actual difference of initial and final was positive only under treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} and Poultry manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} and remaining were negative. Balance sheet of phosphorus showed positive balance in all the treatments and recorded maximum with application of Poultry manure @ 3 t ha^{-1} + Forest Litter @ 0.25 t ha^{-1} except control which was negative. Balance sheet of potassium was recorded highest in the treatment Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}. Negative balance were recorded in the control, Forest litter @ 0.5 t ha^{-1}, FYM @ 1 and 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, Pig manure @ 1 and 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} and Vermicompost @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}. The present study revealed that Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} was the best nutrient management practice which improved plant growth, yield and yield attributes, nutrient uptake and available nutrient status of the soil after harvest of soybean.

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LIST OF ABBREVIATIONS

@	-	at a rate of
BCR	-	Benefit Cost Ratio
cm	-	Centimetre
cm^2	-	Centimetre square
CD	-	Critical Difference
DAS	-	Days after Sowing
°C	-	Degree Celsius
CEC	-	Cation exchange capacity
eg	-	Example
et al.	-	*et allia* (and others/co-workers)
Fig.	-	Figure
FYM	-	Farmyard manure
g	-	Gram
ha	-	Hectare
ICAR	-	Indian Council of Agricultural Research
i.e.	-	Id est (that is)
K	-	Potassium
kg	-	Kilogram
m	-	Metre
m^2	-	Metre square
mm	-	Millimetre
msl	-	Mean sea level
MT	-	Metric Tonnes
N	-	Nitrogen
NU	-	Nagaland University
No.	-	Number
P	-	Phosphorus
$^{-1}$ or /	-	Per
%	-	Per cent
q	-	Quintal
RBD	-	Randomised Block Design

RDF	-	Recommended Dose of Fertilizers
S	-	Sulphur
SASRD	-	School of Agricultural Sciences and Rural Development
Sl. No.	-	Serial number
SEm±	-	Standard error of mean
var.	-	Variety
viz.	-	Videlicet (Namely)

Chapter-1

INTRODUCTION

INTRODUCTION

Soybean (*Glycine max* L. Merill) a leguminous crop has been cultivated since 2800 BC in China. However, it acquired global importance only in the later half of the 18^{th} century. Globally, soybean ranked first among various oilseed crops, contributing approximately 25% of the world's total edible oil and fat production. Globally soybean is grown in 103 million ha with an annual production of 261 million tons and average productivity of 2533 kg ha^{-1} (FAOSTAT, 2013). In India, area under soybean cultivation is 12.03 million hectares with a production of 11.95 million tones and average productivity of 993 kg ha^{-1} (AICRP Soybean, Annual report, 2013). In India the important states producing soybean are Madhya Pradesh, Uttar Pradesh, Rajasthan and Maharasthra. In North- Eastern Region, it is grown in slopes, jhumland, terraces and plains. It is primarily grown as a pulse intercropped with maize, ragi, arhar etc. (Kichu and Singh, 2013). In Nagaland, it is one of the most popular food items of majority of the people and utilized as a fermented product as well as a pulse crop. Inspite of its popularity in the state, the farmers give very little priority for its cultivation in large scale as a sole crop because the productivity is lesser as compared to other adjoining states.

Soybean contains 18-20 % oil and 40-42% protein (Longkumer *et al.*, 2013). It contains 5% lysine, which is deficient in most cereal crops and also contains a good amount of minerals, salts and vitamins (thiamine and riboflavin). Approximately 85% of soybean is used for oil extraction, other 10% for seed and only 5% for food purpose. In addition to all these, soybean also helps in preventing cancer, heart disease etc (Kumar, 2007). Soybean being the richest source of quality proteins and fats has multiple uses in food and industrial products and also called the wonder plant.

Soybean can be grown successfully on wide range of soils but it grows well on fertile, well-drained loamy soils. Soil with a normal pH of 7 and a fair degree of water retention capacity are better for its cultivation. Like other leguminous crops, requirement of N substantially fulfilled with symbiotic N fixation through *rhizobium* and it simultaneously builds up the soil fertility by fixing large amounts of atmospheric N through the root nodules, and also add N through leaf fall on the ground at maturity. It requires an optimum temperature of 26^0C to 30^0C. Soybean fails to grow below 10^0C and above 40^0C since it effects the growth, flowering and seed formation.

Soybean suits nicely in Indian climate and cropping patterns. The seeds of soybean are borne in hairy pods, which grow in clusters of three to five; each pod contains two or three seeds, which resemble peas. Soybean is a *kharif* crop in India and is sown in June-July and harvested in the late September-October. The average rainfall of 75-125 cm yearly helps in the cultivation of soybean without irrigation. It contains less starch thus it is good for diabetic patients and its oil is used for human food, various pharmaceuticals, disinfectant, printing ink and soaps. Due to these promising findings, the All India Co-ordinated Research Project on Soybean was started in 1967 to develop soybean as an oilseed as well as rich protein source.

In North Eastern states of India application of fertilizer is meager in general and Nagaland particular. Farmers of Nagaland are using only organic manures to maintain the crop yields as well as soil fertility. The crop yield is low because it is grown on marginal land with minimum inputs. Response of soybean to organic manures needs careful attention. Chandel *et al.* in 1989 reported that requirement of nitrogen is substantially fulfilled from symbiotic nitrogen fixation through *rhizobium* (125-150 kg N ha^{-1}). Soybean fixes 30-40 kg N ha^{-1} which is build up and used by succeeding crop (Saxena and Chandel., 1992).

Organic fertilizers ensure that the farmers remain fertile for hundreds of years. Land located at the site of ancient civilizations, such as India and China, are still fertile, even though agriculture has been practiced there for thousands of years. The fertility is maintained because organic fertilizers were always used in the past. However, with the increased use of chemical fertilizers today, land is rapidly becoming infertile, forcing many farmers to further increase their use of chemical fertilizers or even leave the farming industry entirely. Organic fertilizers are easily bio-degradable and do not cause environmental pollution. On the other hand, chemical fertilizers contaminate both the land and water, which is a major cause of disease for human beings and is the force behind the extinction of a number of plant, animal and insect species.

Organic manures viz. forest litter, poultry manure, pig manure, FYM and vermicompost helps in the improvement of soil structure, aeration and water holding capacity of soil. Further, it stimulates the activities of micro organisms that makes the plant to get the macro and micro nutrients through enhance biological processes, increased nutrient solubility, alter soil salinity, sodicity and pH (Alabadan *et al*., 2009). Though, they content relatively low concentrations of nutrients and handling them in labour intensive, there has been largely increased in their use over inorganic fertilizers as a nutrient source (Kannan *et al* ., 2005). The long term manurial studies conducted at many places have revealed the superiority of integrated nutrient supply system in sustaining crop productivity in comparison to chemical fertilizers alone (Gaur, 1991).

Even though soybean is the cheapest high quality vegetable protein, we are yet to exploit its full potential. The excess use of chemical fertilizers spoils the structure of the soil. Therefore, use of chemical fertilizer alone may not keep pace with time in maintenance of soil health for sustaining the crop productivity. Farmyard manure (FYM) and vermicompost are the most important and widely used bulky organic manures, supply plant nutrients including micronutrients, improve soil physical properties and increase availability of nutrients. Crop rotation, cover cropping, green manuring, use of livestock manure and composting contribute much more to the whole agro ecosystem than may be readily apparent. By adding organic manures and stimulating biological activity in the soil, these practices make mineral nutrients more available to plants, generate the microbial production of plant-beneficial chemicals (eg. Streptomycin) and improve the soil's tilth. Spreading livestock manure, in particular, cycle's essential macro and micro nutrients back into the fields. Farms producing livestock and farms that are in proximity to confinement operations have the advantage of access to animal wastes, which contains major nutrients and organic matter. Composting is a means of stabilizing and enhancing livestock wastes for storage, in order to avoid certain problems inherent in applying fresh manure. Composts, though lower in nitrogen, are a more balanced fertilizer and are more useful in building soil fertility over time.

Keeping the above facts in view, the present investigation entitled "Response of Soybean (*Glycine max* L. Merill) to Organic Sources of Nutrient" is being undertaken at the instructional-cum-research farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema with the following objectives.

1. To study the effect of organic sources of nutrient on nodulation, growth, yield attributes and yield of soybean.
2. To study the effect of organic sources of nutrient on nutrient uptake (N, P, K and S), protein and oil content of soybean.
3. To study the effect of organic sources of nutrient on soil fertility status after harvest of the crop.

Chapter – 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Organic materials are valuable by-products of farming and allied industries which are derived from plant and animal sources. They influence favorably the plant growth and yield directly as well as indirectly and also sustain the soil quality and fertility (Ramesh *et al.,* 2006). Escalating production costs heavy reliance on non-renewable resources, reduced microbial biodiversity, water contamination, chemical residues in food grains and health risk to the populations which served as a main reason to think for substituting the nutrient requirement of the crop through different organic manures (Singh *et al*., 2008).

In the light of the objectives stated above, the following are some reviews of works, carried out by different scientists in relation to Farm Yard Manure (FYM), Poultry manure, Pig manure, Vermicompost and Forest litter in soybean and related crops.

2.1. Effect on growth attributes

Haider *et al.* (1995) reported that the response of soybean to *rhizobium* inoculation and urea fertilization shows the highest number and weight of nodules per plant and seed yield which were obtained with a combination of *rhizobium* inoculation and application of 20 kg N ha^{-1}.

Jain and Tiwari (1995) reported that the application of FYM @ 5 t ha^{-1} has significantly enhanced the plant height (55.83 cm), number of leaves plant^{-1} (15.00), number branches plant^{-1} (4.33), pods plant^{-1} (39.00), 100 seed weight (15.40 g) and seed yield (1233.83 kg ha^{-1}) over control (52.17 cm, 13.33, 3.33, 32, 9.07 g and 947 kg ha^{-1}, respectively) in soybean.

Dubey (1999) in a field experiment, c.v. JSS 335 were inoculated with *rhizobium* by seed inoculation which resulted in greatest nodule number as well as gave the highest yield.

Chinnamuthu and Venkatakrishnan (2001) in their studies reported that the application of vermicompost @ 2 t ha^{-1} recorded significantly higher plant height (147.80cm) and 100 seed weight (4.14 g) compared to application of FYM @ 5 t ha^{-1} (140.8 cm and 4.06 g respectively) in sunflower.

Ramasamy *et al.* (2001), reported that the application of enriched FYM resulted in a significant increase in plant height, number of pods $plant^{-1}$ in soybean. He also observed that the enriched FYM application recorded highest grain yield of 1259 kg ha^{-1} in summer and 1499 kg ha^{-1} in *kharif*.

Chiezey and Odunze (2003) carried out a study on soybean varieties TGx 1448-2E and TGx 1019-2EB which were grown without and with 1t ha^{-1} of poultry manure and four levels of P (0, 13.2, 26.4 and 39.6 kg P ha^{-1}) in all possible factorial combinations using randomized complete block design with four replicates and reported that application of poultry manure @ 1 t ha^{-1} significantly increased grain yield as well as plant height by 12.8 and 15.4 % as compared with plots without P when averaged over both years in 2003 and 2005.

Paradkar and Deshmukh (2004), also reported that the recommended rate of NPK fertilizer in combination with 10 t FYM ha^{-1} resulted in the tallest plant (60cm), highest number of pods $plant^{-1}$ (32) and 100 seed weight (14.9 gm) in soybean.

Roy *et al.* (2004), also found out that application of 10 t ha^{-1} vermicompost in maly barley significantly increased plant height, number of tillers and dry matter production m^{-2} row higher compared to control. All the growth parameters attained higher value with the application of 10 t ha^{-1} vermicompost.

Govindan and Thirumurugan (2005) observed that the application of vermicompost (75%) had significantly recorded higher plant height (84.70 cm), leaf area index (3.40) over press mud (100% N) (78.20 cm and 2.70 respectively).

Das *et al*. (2007) evaluated the effect of organic manure and NPK on productivity of black gram and concluded that rabbit manure along with NPK treatment and pig manure along with NPK treatment plots produced higher growth, yield attributes and seed yield. They also inferred that all organic manures applied alone produced superior pod and seed yields compared to control.

An investigation was carried out by Mathur *et al.* (2009) during winter season of 2006-07 and 2007-08 at Jodhpur, to evaluate the effect of VC, *Rhizobium* and DAP on mothbean. The experimental soil was sandy loam in texture with pH 7.4 and poor in organic carbon content. It was noticed that VC applied @ 2 t ha^{-1} significantly increased yield attributes *viz.* number of pods $plant^{-1}$ (52.21) and total seed weight $plant^{-1}$ (15.02g). *Rhizobium* inoculation also significantly increased number of pods $plant^{-1}$ (50.94) and total seed weight $plant^{-1}$ (14.73 g) over no inoculation because of the fact that *Rhizobium* inoculation enhanced the supply of N and its translocation and favourably influenced the development of photosynthetic organs and accumulation of photosynthates.

Ogbonna and Umarshaba (2009), conducted a two year study on the research farm of department of Crop Science, University of Nigeria to test the effects of accession of poultry manure (0, 5 and 10 t ha^{-1}) and four accessions of sesame. The results showed that the application of poultry manure significantly promoted sesame growth and yield. Seed yield kg ha^{-1} was increased by 24 and 78 % as manure rate increased from 0 to 5 and 10 t ha^{-1} respectively in 2009 season. In 2010, it was increased by 96 and 155 % with the same increase in the rate of poultry manure.

Paliwal *et al.* (2011) conducted a field experiment to evaluate the response of soybean – wheat cropping system to vermicompost and NPK fertility levels. A conjunctive use of vermicompost @ 5t ha^{-1} along with 15:45:15 kg ha^{-1} NPK in soybean followed by an application of 90:45:30 kg ha^{-1} NPK in succeeding wheat crop recorded significantly higher plant population, dry matter accumulation and root nodulation thereby found to be more profitable and productive over RDF and control.

Vairavan (2011) at National Pulse Research Centre, Vamban, Pudukkotai District (Tamil Nadu) carried out a study on the response of black gram to integrated nutrient management, where he observed that application of recommended dose of fertilizer in combination with FYM@ 5 t ha^{-1} recorded maximum plant height of 36.5 cm and 36 cm in 1^{st} and 2^{nd} year, respectively. Also there was a significant increase in grain yield giving 888 kg ha^{-1} for the 1^{st} and 2^{nd} year, respectively.

2.2. Effect on yield and yield attributes

Nimje and Seth (1987) reported that the application of FYM @ 5 t ha^{-1} recorded significantly higher number of branches $plant^{-1}$ (13.90), dry weight $plant^{-1}$ (75.80 g), pods $plant^{-1}$ (217), 100 seed weight (7.78 g) and seed yield (25.55 q ha^{-1}) compared to control (11.10, 60.90 g, 185, 7.10 g and 21.72 q ha^{-1}, respectively) in soybean.

Gupta (1995) conducted a field experiment on effect of different organic manures in India on rice and reported that application of pig manure (10 t ha^{-1}) produced the highest yield (4.5 t ha^{-1}) followed by poultry manure and FYM which produced yield of 4.1 and 3.9 t ha^{-1} respectively. The increased in yield with organic manure was 34-35 % higher over the control and 5-22 % higher over NPK.

Rajput *et al.* (1995) studied the profitability of conventional and mixed organic farming on soybean crop and showed that soybean yield increased by 53% under mixed organic farming and the cost benefit ratio of Soybean was just doubled in the mixed organic farming area than conventional farming.

Ramamurthy and Shivashankar (1996) reported that the application of FYM 10 t ha^{-1} recorded significantly higher seed yield (2694 kg ha^{-1}) of soybean as compared to the application of FYM @ 5 t ha^{-1} (2300 kg ha^{-1}) and control (2070 kg ha^{-1}).

Bobde *et al*. (1998) studied nutrition management of soybean and soybean based cropping system. Application of 7.5 tonnes FYM ha^{-1} along with reduced dose of fertilizers to 50% gave significantly more grain yield of soybean as well as more monetary returns than the absolute control and recommended dose of fertilizers only.

Aruna and Reddy (1999) reported that the application of vermicompost @ 15 t ha^{-1} to soybean recorded significantly higher number of pods $plant^{-1}$ (59), 100 seed weight (15.80 g), seed yield (1143 kg ha^{-1}), seed protein content (41.80 %) and seed oil content (24.30 %) over the application of FYM @ 5 t ha^{-1} + 50 kg N ha^{-1} (29.70, 139, 782 kg ha^{-1}, 38.70 % and 23 % respectively).

Appavu *et al.* (1999), reported that the application of all the organic treatments i.e., FYM, poultry manure and compost coir pith to soybean improved the yield as compared to control, but the plots which received FYM addition significantly recorded higher yield than other treatments. Also, the application of poultry manure @ 5 t ha^{-1} significantly recorded highest seed yield (1039 kg ha^{-1}) followed by the application of FYM @ 12.5 t ha^{-1} (899 kg ha^{-1}) over control (638 kg ha^{-1}) in soybean.

Mandel *et al.* (2000) also conducted a field experiment to study the effect of combination of NPK and FYM on growth, yield and agronomic efficiency in soybean and he also reported that application of 100% recommended NPK + 10 t ha^{-1} FYM gave significantly superior seed yield.

Navale *et al.* (2000) also noted the significant response of soybean and showed that FYM treatment resulted in higher soil nutrient content, N, P, K uptake and increase in seed yield by 24 %.

Rajkhowa *et al.* (2000), also reported that the application of 75 % N as urea along with vermicompost @ 5 t ha^{-1} recorded significantly higher seed yield

(8.30 g plot) and it was at par with the application of N as vermicompost (7.70 g plot) over control (3 g ha^{-1}) in green gram.

Channabasvana *et al.* (2001) conducted an experiment to study the effect of organics in seed yield, quality and storability of soybean, where he observed that application of poultry manure @ 2 t ha^{-1} recorded significantly higher seed yield (4883 kg ha^{-1}), and press mud @ 2 t ha^{-1}, (4595 kg ha^{-1}) over control (4124 kg ha^{-1}). The application of poultry manure and FYM increased the seed yield (2.65 t ha^{-1}) compared to N, P and K alone (91.45 t ha^{-1}).

Singh *et al.* (2001) found out that FYM biogas slurry @ 5 t ha^{-1} gave the same yield of soybean and net profit as in 20 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1} and 20 kg K_2O ha^{-1} of inorganic fertilizer. He then suggested that use of biogas slurry @ 5 t ha^{-1} can be better substitute to chemical fertilizer in soybean production.

Kumari and Kumara (2002) reported that enriched vermicompost showed its superiority over other treatments for yield and uptake of major nutrients like N, P, K, Ca and Mg.

Aeswar *et al.* (2003) also observed in his study that application of vermicompost @ 2 t ha^{-1} was promising for achieving a higher productivity of chick pea.

Vyas *et al.* (2003) conducted a long-term field experiment on clay loam soil to study the effect of application of micronutrients (Zn, Mo and B) individually and in combination with FYM and recorded significant increase in the seed yield, N, P and K content and its uptake by soybean.

Ghosh *et al.* (2004) reported that application of poultry manure @ 1.5 t ha^{-1} and 75 % NPK resulted in higher nodule mass (22%) as compared to NPK alone. Also, there was significant improvement in dry matter production and seed yield of soybean.

Siag and Yadav (2004), also recorded significantly increase in seed yield with application of vermicompost upto 2 t ha^{-1} owing to increased secondary branches $plant^{-1}$, pods $plant^{-1}$ and seed index in gram.

Jat *et al*. (2005), conducted an experiment on effect of organic manures on productivity and economics of summer mungbean (*Vigna radiata var.* Radiata), where he observed similar results with significant increase in all yield attributes like plant height (46.20 cm), dry weight $plant^{-1}$ (13.73 g), branches $plant^{-1}$ (5), pods $plant^{-1}$ (16), seeds pod^{-1} (11), seed weight $plant^{-1}$ (5.90 g) and test weight (41.92 g) with vermicompost. Also the highest grain yield of 1325 kg ha^{-1} was achieved in vermicompost followed by FYM (1252 kg ha^{-1}).

Gina *et al*. (2006) reported that soybean grain yield showed greater in the treated manured plots than the control or urea fertilized block and composted swine manure application before growing maize resulted in detectable, positive residual effect on soybean growth and yield.

Das *et al*. (2007) reported that organic manures (rabbit manure, pig manure and FYM) and NPK fertilizers produced higher growth, yield attributes and seed yield as compared to control. Among the different treatments, rabbit manure along with NPK fertilizers performed the best which produced an equivalent result to that of NPK fertilizers incorporated along with FYM or pig manure. All organic manures applied alone produced superior pod and seed yields as compared to the control.

Yadav (2007) conducted an experiment to study the effect of FYM on growth and yield of *Vigna radiata*, where it was observed that application of FYM specially cattle dung significantly improved its growth, yield and pod quality, where as less vegetative and reproductive growth of *Vigna radiata* was found with artificial fertilizer (DAS sulphate) in comparison to FYM.

Kanan and Singaram (2009) conducted an experiment in the Agricultural College, Nagpur to study the influence of foliar sprays of cowdung and vermiwash, it revealed that 200 ppm vermiwash significantly increased leaf chlorophyll and Nitrogen content, seed protein and oil content and yield contributing parameters viz., number of leaves and dry weight of plant, 100 seed weight and seed yield.

Kadam *et al*. (2010) reported that application of 100% N through poultry manure along with pulvic acid sprays @ 100 ppm at 30 and 60 DAS recorded higher grain (25.7 q ha^{-1}) and straw (38.6 q ha^{-1}) yield as compared to application of 100 % N through vermicompost + fulvic acid sprays which yielded (24.5 and 36.7 q ha^{-1} of grain and straw yield respectively).

Tagoe *et al*. (2010) conducted an experiment on effects of carbonized poultry manure on the growth, nodulation, yield, Nitrogen and Phosphorus content in soybean where it was observed that poultry manure application significantly increased the number and weight of root nodules and seed yield of soybean by 27 %.

Chesti and Alui (2012), conducted an experiment to study the rhizosphere micro flora, nutrient availability and yield of green gram as influenced by organic matter, phosphate solubilizers and phosphorus levels in Alfisols, where results revealed among the organic matters, application of FYM@ 10 t ha^{-1} proved significantly superior in increasing the grain straw yield in gram.

2.3. Effect on quality attributes

Sardana (1990) reported that organic manure increased protein content and oil yield of toria and gobhi sarson over unmanured.

Jain *et al*. (1995) reported that nutrient content and yield of grain and straw in soybean were increased with application of FYM.

Bachham and Sable (1996) conducted an experiment of soybean cv "Macs 124' to study the quality of seed yield, its protein content and oil content with 50 kg N ha^{-1} or urea, FYM, Compost, Vermicompost and observed that highest seed yield, seed protein content were obtained with 50% each of urea and FYM.

Ramamurthy and Shivashankar (1996) reported that the application of FYM @ 10 t ha^{-1} recorded significantly higher protein content (38.54%), oil content (19.38%), protein yield (103.60 ka ha^{-1}) and oil yield (522.70 kg ha^{-1}) compared to control (37.25 %, 18.84%, 857.38 kg ha and 433.23 kg ha^{-1} respectively) in soybean.

Patil and Bhilare (2000) in their study reported that the application of FYM @ 5 t ha^{-1} recorded higher protein content (12.10%) compared to control (10.16%) in wheat.

An experiment was conducted by Singh and Rai (2004) to study the yield attributes, yield and quality of soybean (*Glycine max* L.) as influenced by integrated nutrient management at IARI, New Delhi and reported that application of RDF + FYM @ 5 t ha^{-1} + biofertilizers recorded highest oil content (20.07%) and protein content (38.09%).

Gunjal *et al.* (2011) conducted field experiment to study the response of potassium levels alone and combination with farm yard manure on soybean (*Glycine max* L.) under rainfed conditions at M.P.K.V, Rahuri (MS) and reported that application of 50 kg N ha^{-1} + 75 kg P_2O_5 ha^{-1} + 50 kg K_2O ha^{-1} + FYM @ 5 t ha^{-1} recorded significantly higher oil content (19.97%) and protein content (40.33%).

Virkar and Tumbare (2011) conducted an experiment at M.P.K.V, Rahuri (MS) to study the effect of integrated nutrient management on growth and yield of soybean and reported that application of FYM @ 5 t ha^{-1} + 50 kg N ha^{-1} + 75 kg P_2O_5 ha^{-1} + biofertilizers recorded highest oil and protein content (18.53 and 41.43 %, respectively).

Waghmare *et al.* (2012) conducted an experiment to study the effect of integrated nutrient management on yield, yield attributes and quality of soybean (*Glycine max* L.) at Department of Agronomy, College of Agriculture, Latur

(MS) and reported that application of 75 % RDF + *Rhizobium* + *PSB* + FYM @ 5 t ha^{-1} recorded highest oil content (21.02%) and protein (40.05 %) content.

A study on the influence of inorganic and organic manures on yield of soybean (*Glycine max* L.) at College of Agriculture, CAU, Imphal (Manipur) was conducted by Devi *et al.* (2013) where he reported that application of 75% RDF + V.C. @ 1 t ha^{-1} + *PSB* recorded highest oil content (18.61%) and protein content (36.71%).

Khaim *et al.* (2013) conducted field experiment to study the effect of organic and inorganic fertilization on the yield and quality of soybean at Genetics and Plant Breeding farm, 25 Bangladesh Agricultural University, Mymensingh (Bangladesh) and observed that the application of RDF 75% + PM @ 1 t ha^{-1} recorded the highest oil content (20.98%) and protein content (45 %).

Rana and Badiyala (2014) conducted an experiment to study the effect of integrated nutrient management on seed yield, quality and nutrient uptake of soybean (*Glycine max* L.) under mid hill conditions at CSK Himachal Pradesh Krishi Vishvavidyalya, Palampur (HP) and reported that use of FYM @ 2.5 t ha^{-1} + V.C. @ 1.25 t ha^{-1} recorded the significantly higher oil content (18.9 %) and protein content (39.4 %).

2.4. Effect on nutrient uptake

Navale *et al.* (2000) recorded that the significant response on application of FYM in increasing the yield of soybean and showed that FYM treatment resulted in higher soil nutrient content, seed yield and N, P, K uptake and increase in seed yield by 24%.

Adeli *et al.* (2005) evaluated the effect of broiler litter and commercial fertilizer application on soybean yield. Soybean grain and N and P uptake were quadratically increased with increasing broiler and commercial fertilizer application rates. Soybean grain yield and N uptake from broiler litter applications were significantly greater than those from commercial fertilizers.

Laxminarayan *et al.* (2004) conducted an experiment in Mizoram, India during the *kharif* season, to study the effect of integrated use of organics (FYM, Poultry manure and pig manure) and inorganic manures on the yield attributes and uptake of groundnut. The result showed that the conjunctive use of organic manures and optimum rates of NPK produced the highest and most sustainable crop yields and improved the fertility status of the soil.

Kumar *et al.* (2006) conducted an experiment on nutrient uptake and availability and seed yield of soybean under rainfed condition in Karnataka where he reported that application of 50 % N through green leaf manure, poultry manure and crop residue compost resulted in higher nutrient uptake (122, 37 and 110 kg of NPK ha^{-1} respectively) and higher seed yield (1793 kg ha^{-1}) as compared with absolute control (823 kg ha^{-1}).

Laxminarayan *et al.* (2006) again conducted another experiment in Mizoram to study the integrated effect of inorganic, biological and organic manures on yield and nutrient uptake of groundnut and their effects on the residual fertility status of the soil. Where similar results were observed, in which recommended dose of NPK with 15 t FYM ha^{-1} recorded the highest pod and haulm yield, followed by NPK + 5 t ha^{-1} pig manure.

Jat *et al.* (2012) observed that application of 5 t ha^{-1} FYM significantly increased N and P uptake in seed and straw of green gram to no manure.

Patra and Sinha (2012) conducted a field experiment to evaluate the uptake pattern of NPK by green gram at Pundibari (West Bengal) and recorded significantly highest value of N (41.31 and 40.67 kg ha^{-1}), P (10.54 and 10.50 kg ha^{-1}) and K (14.53 and 16.22 kg ha^{-1}) uptake with the application of neem cake @ 3 t ha followed by treatments receiving NC @ 1.5 t ha^{-1} + PM @ 1.5 t ha^{-1}, VC @ 1.5 t ha^{-1} + NC @ 1.5 t ha^{-1} and 100 % RDF. The significant improvement in N, P and K uptake by green gram to the extent of 6.49, 7.62 and 7.67 %, respectively was noted due to the inclusion of organics over 100 % RDF.

Rana and Badiyala (2014) conducted a field experiment to study the effect of integrated nutrient management on seed yield, quality and nutrient uptake of soybean (*Glycine max* L.) under mid hill conditions at CSK Himachal Pradesh Krishi Vishvavidyalya, Palampur (HP) and reported that use of FYM @ 2.5 t ha^{-1} + V.C. @ 1.25 t ha^{-1} recorded the significantly highest available nutrients 359.6, 23.0, 261.3 N, P and K kg ha^{-1}, respectively, at harvest.

2.5. Effect on soil fertility

Maheshwarappa *et al.* (1999) reported that organic manures like, FYM and vermicompost application alone and FYM + NPK application decreased the bulk density, improved soil porosity and water holding capacity to a greater extent. Organic carbon of the soil was increased to a greater extent under FYM and vermicompost treated plots compared to composted coir pith. Whereas, no change was observed in the physico-chemcial properties of the soil under NPK alone and under control.

Nehra and Grewal (2001) reported that the application of vermicompost @ 15 t ha^{-1} increased OC, available N, P and K in soil significantly. However, soil pH and EC did not change under the influence of organic manures as well as fertilizer levels.

Singh and Rai (2004) conducted field experiment to study the yield attributes, yield and quality of soybean (*Glycine max* L.) as influenced by integrated nutrient management at IARI, New Delhi and reported that application of RDF + FYM @ 5 t ha^{-1} + biofertilizers recorded highest soil available nutrient OC 0.375% and 182.62:14.60: 200 N, P and K kg ha^{-1}, respectively.

Chaturvedi and Chandel (2005) conducted field experiment to study the influence of organic and inorganic fertilization on productivity of soybean (*Glycine max* L.) at Department of Agronomy, College of Agriculture, Pantnagar (UT) and reported that the application of RDF + FYM @ 10 t ha^{-1} recorded the highest soil available nutrient 215.8, 22.9, 203.4 N, P and K kg ha^{-1}, respectively.

Deshmukh *et al.* (2005) conducted an experiment on INM in soybean-chickpea cropping system and found out that all the INM treatments were significantly superior to the farmers' practice with respect to growth, yield attributes, yield and economics from soybean and chickpea in increasing the soil fertility status. Among the INM treatments, 100% RDF for + 2.5 tonnes farmyard (FYM) ha^{-1} + drainage in soybean and soil mulch in chickpea proved the best in all these parameters. The total productivity from the soybean-chickpea sequence was 32.09 q ha^{-1} with the net return up to 26273 ha^{-1} and BC ratio up to 2.91. This INM treatment also improved the organic carbon, available N, P and K status of the sol over their initial values.

Kumawat and Jat (2005) conducted a field experiment on loamy sandy soil at Jobner during 2000-01 and 2001-02 and observed significant improvement in organic carbon, available N, P and K with the application of FYM @10 t ha^{-1} over the control, vermicompost @ 4.5 t ha^{-1} and 60 kg N ha^{-1}.

Chesti and Ali (2012) have also reported that application of organic manures significantly increased the available N, P and K in soil after harvest of green gram.

Jat *et al.* (2012) reported that the application of FYM (5 t ha^{-1}) significantly increased the available N, P and K content of the soil after the harvest of green gram.

Devi *et al.* (2013) conducted field experiment to study the influence of inorganic and organic manures on yield of soybean (*Glycine max* L.) at College of Agriculture, CAU, Imphal (Manipur) and reported that application of 75% RDF + V.C. @ 1 t ha^{-1} + *PSB* recorded highest soil available nutrients 14.56, 194.41 N, P and K kg ha^{-1}, respectively after harvest.

Laharia *et al.* (2013) conducted the field experiment to study the effect of organic sources on soil fertility, nutrient uptake and yield of soybean (*Glycine max* L.) soybean at Experimental Farm, PDKV, Akola (MS) and reported that application of 100% RDN through V.C. + jeevamrut recorded highest soil available nutrients 226.2, 21.68, 346.1 N, P and K kg ha^{-1}, respectively after harvest.

Chapter-3

MATERIALS AND METHODS

MATERIALS AND METHODS

3.1. Site of experiment

The present investigation entitled **"Response of soybean (*Glycine max* L. Merill) to organic sources of nutrient"** was carried out in the experimental research farm of School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, situated at 25°45′ 45″ N latitude and 93° 53′ 04″ E longitude at an elevation of 310 m above mean sea level.

3.2. Climatic condition

The experimental farm lies in the humid sub-tropical zone with an average rainfall ranging from 2000 to 2500 mm per annum. The mean temperature ranges from 21˚C to 32˚C during summer and goes down to about 11˚C in winter season.

3.3. Soil condition

The soil of the experimental field was found to be well drained and sandy loam in texture. The texture and fertility status of the soil were ascertained by taking soil samples from a depth of 15-20 cm from different locations of the experimental plots with the help of soil auger, which were processed and analysed by methods of mechanical and chemical analysis. The soil of the experimental plot was sandy loam in texture, acidic in reaction (pH 5.5) with 0.87 % organic carbon, 215.3 kg ha^{-1} available nitrogen, 16.7 kg ha^{-1} available phosphorus, 126.2 kg ha^{-1} available potassium and 14.2 kg ha^{-1} available sulphur (table 1).

3.4. DETAILS OF THE EXPERIMENT

3.4.1. Experimental layout

The present experimental field trial was laid out in Randomised Block Design (RBD) with three replications along with fourteen nutritional schedules on soybean variety JS 97-52. The experiment was conducted for two consecutive years (2016 and 2017). Thus, there were a total of 14 treatments which were

Table 1. Initial physico chemical properties of the soil

Soil Parameters	Values
pH	5.50
Organic Carbon (%)	0.87
Sand (%)	62. 00
Silt (%)	27. 00
Clay (%)	10. 00
Water Holding Capacity (%)	14.70
Infiltration (mm hr^{-1})	21.30
Bulk Density (g cm^{-3})	1.29
Particle Density (g cm^{-3})	2.01
Available N (kg ha^{-1})	215.30
Available P_2O_5 (kg ha^{-1})	16.70
Available K_2O (kg ha^{-1})	126.20

replicated thrice. The seed of soybean variety JS 97-52 was treated with *Rhizobium* culture for the entire nutritional schedule, except for absolute control plot. The whole experimental field was divided into three equal blocks and each block was again divided into fourteen equal sized plots measuring 2 m x 2.25 m in order to accommodate the treatments. All together there were 42 plots. The details of the plan and layout of the experimental field are given in figure 1. The treatments were randomly allocated within the plots of a block.

3.4.2. Layout plan of the experimental field

a. **Crop :** Soybean (*Glycine max* L. Merill)

b. **Variety:** JS 97-52

c. **Initial soil sample analysis (one composite sample)**

1. pH
2. Organic Carbon
3. Available N
4. Available P
5. Available K
6. Available S
7. Water holding capacity
8. Infiltration
9. Sand, Silt and clay
10. Bulk density
11. Particle density
12. Porosity

d. **Experimental design :** Randomised Block Design (RBD)

The experimental field was equally divided into 14 equal plots per replication and three replications were carried out.

e. **Treatments details:**

1. T_1 Control
2. T_2 Forest litter @ 0.5 t ha^{-1}

3. T_3 Farm Yard Manure @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}

4. T_4 Farm Yard Manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}

5. T_5 Farm Yard Manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}

6. T_6 Pig manure @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}

7. T_7 Pig manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}

8. T_8 Pig manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}

9. T_9 Poultry manure @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}

10. T_{10} Poultry manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}

11. T_{11} Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}

12. T_{12} Vermicompost @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}

13. T_{13} Vermicompost @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}

14. T_{14} Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}

f. Plot size: 42m x 10.75 m (length x breadth)

g. Spacing

Plant to plant = 10 cm

Row to row = 45 cm

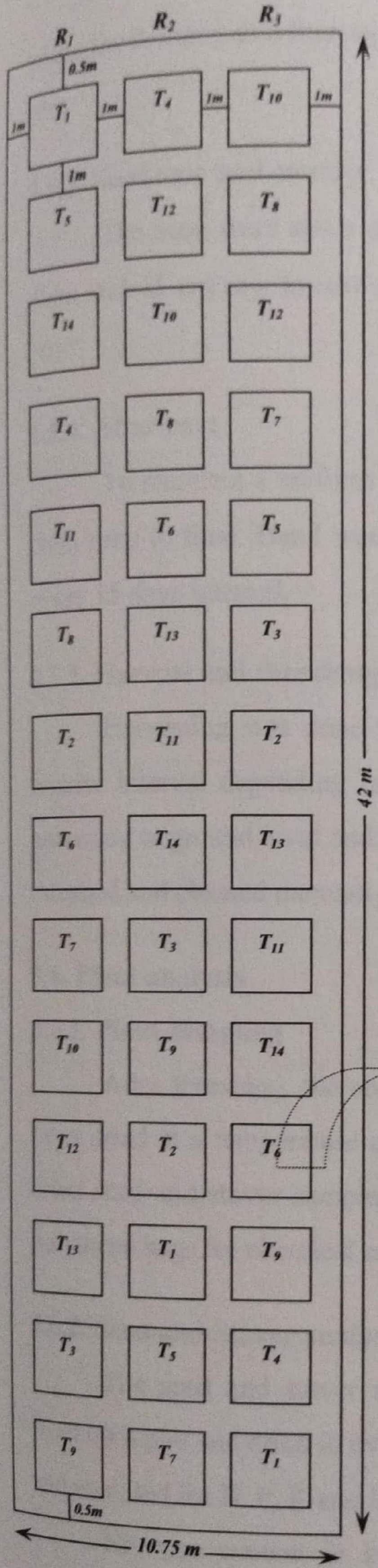
3.5. Cultivation details

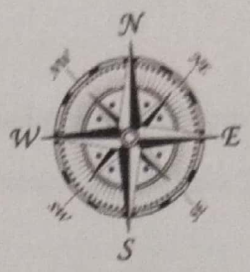
3.5.1. Selection and preparation of field

A rectangular plot having uniform fertility and even topography was selected for conducting the experimental field trail. The experimental plot was ploughed in the first week of May 2016 and again on the last week of May 2016. The field was then harrowed and levelled properly. All the stubbles were removed and then the field was laid out according to the layout plan.

3.5.2. Manure and fertilizer application

Organic manures were applied to each plot according to the pre-planned doses made specifically for each plot. Organic manures were applied one month before sowing so that well decomposition of the organic manures would take





Treatments details:

T_1: *Control*

T_2: *Forest litter @ 0.5 t ha*$^{-1}$

T_3: *Farm Yard Manure @ 1 t ha*$^{-1}$ *+ Forest litter @ 0.25 t ha*$^{-1}$

T_4: *Farm Yard Manure @ 2 t ha*$^{-1}$ *+ Forest litter @ 0.25 t ha*$^{-1}$

T_5: *Farm Yard Manure @ 3 t ha*$^{-1}$ *+ Forest litter @ 0.25 t ha*$^{-1}$

T_6: *Pig manure @ 1 t ha*$^{-1}$ *+ Forest litter @ 0.25 t ha*$^{-1}$

T_7: *Pig manure @ 2 t ha*$^{-1}$ *+ Forest litter @ 0.25 t ha*$^{-1}$

T_8: *Pig manure @ 3 t ha*$^{-1}$ *+ Forest litter @ 0.25 t ha*$^{-1}$

T_9: *Poultry manure @ 1 t ha*$^{-1}$ *+ Forest litter @ 0.25 t ha*$^{-1}$

T_{10}: *Poultry manure @ 2 t ha*$^{-1}$ *+ Forest litter @ 0.25 t ha*$^{-1}$

T_{11}: *Poultry mamure @ 3 t ha*$^{-1}$ *+ Forest litter @ 0.25 t ha*$^{-1}$

T_{12}: *Vermicompost @ 1 t ha*$^{-1}$ *+ Forest litter @ 0.25 t ha*$^{-1}$

T_{13}: *Vermicompost @ 2 t ha*$^{-1}$ *+ Forest litter @ 0.25 t ha*$^{-1}$

T_{14}: *Vermicompost @ 3 t ha*$^{-1}$ *+ Forest litter @ 0.25 t ha*$^{-1}$

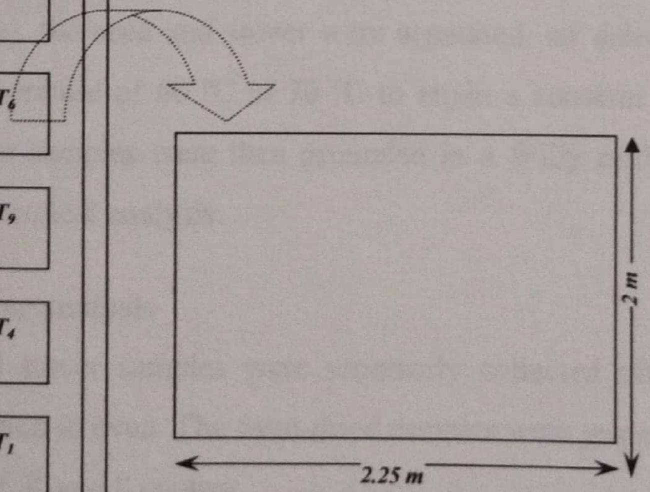


Fig1*: Experimental Field Layout*

place for the crop and thoroughly incorporated into the soil except for the control plot.

3.5.3. Seed rate and sowing

The seed were sown directly to the plots by maintaining 10 cm plant to plant and 45 cm row to row spacing. The seeds were sown on 1st July 2016 and 2017.

3.5.4. After care

To maintain a uniform plant population, thinning and gap filling was done from time to time. Hand weeding was done firstly at 20 DAS and then later at every 15 days interval.

3.5.5. Harvest and threshing

Harvesting was done in the month of October and subsequent days on regular interval depending on the maturity level of the pods. The crops were harvested at ground level and plot wise bundle of harvested crops were sun dried, threshed and cleaned manually.

3.6. Plant analysis

3.6.1. Plant sampling

After threshing, the seed and stover were separated, air dried and finally oven dried at a temperature of 60 °C to 70 °C to attain a constant weight. The dried seed and stover samples were then grounded in a Willy mill and kept in polythene bags for chemical analysis.

3.6.2. Seed and Stover analysis

The seed and stover samples were separately collected after threshing from each plot and dried in oven. The oven-dried samples were ground to powder and analysed for N, P, K and S content.

Nitrogen content in both seed and stover was estimated by modified kjeldhal method as described by Black (1965). Phosphorus was determined by vanado-molybdate yellow colour method as outlined by Jackson (1973).

Potassium was determined by flame photometry as described by Chapman and Pratt (1961) and sulphur content was determined by turbidimetric method as described for soil sulphur by Chesnin and Yien (1951).

3.7. Soil analysis

3.7.1. Soil sampling

Surface soil sample (0-20 cm) was collected from the experimental field after harvest of crop. The samples were air dried, finely grounded and sieved through 2 mm sieve and then kept in polythene bags with proper labeling for analysis.

3.7.2. Determination of soil sample for nutrient status of the soil

The nutrient status of the soil samples were analyzed for pH, organic carbon, available nitrogen, phosphorus, and potassium and sulphur contents.

3.7.3. Soil pH: Soil pH was determined by glass electrode pH meter (Richards, 1954)

3.7.4. Soil Texture: It was determined by International Pipette method using 1N sodium hydroxide (NaOH) (Piper, 1966)

3.7.5. Soil Organic Carbon: Rapid titration method advocated by Walkley and Black method and expressed in percentage as described by Jackson (1973).

3.7.6. Available nitrogen

Available nitrogen was estimated by alkaline potassium permanganate method given by Subbiah and Asija (1956).

3.7.7. Available phosphorus

Available phosphorus was extracted with 0.03 NH_4F in 0.025 HCl solutions. The procedure is primary meant for soils which are moderate to strongly acidic pH around 5.5 or less (Brays and Kurtz, 1945). The phosphorus content of the soil extract was then determined by calorimetric method of estimation.

3.7.8. Available potassium

The available potassium was determined flame photometrically after extracting the soil with neutral normal ammonium acetate (pH 7.0) (Jackson, 1973).

3.7.9. Available sulphur

The available sulphur was determined by turbidimetric method using 1:5 soil and extractant 0.15 % $CaCl_2$ solution and the intensity of turbidity formed was measured using UV spectrophotometer at a wave length of 440 nm (Chesnin and Yien, 1951).

3.7.10. Infiltration: The infiltration rate was determined by the method Double Ring Infiltrometer as described by Bouwer (1986).

3.7.11. Water holding capacity

For determination of water holding capacity the soil samples were packed in Keen Raczkowski boxes with uniform tapping and saturated overnight. After saturation the samples were weighed and kept in oven for 48 hours at equilibrium temperature of 105^{0}C. The samples were then cooled and weighed. The water holding capacity was calculated by the weight difference (Piper, 1996).

3.7.12. Bulk density: The bulk density of soil was determined by core method as described by Baruah and Barthakur (1997).

3.7.13. Particle density: Particle density was determined by pycnometer method as described by Baruah and Barthakur (1997).

3.7.14. Porosity: The porosity of soil was obtained by using the formula:

$$\text{Porosity (\%)} = \left(1 - \frac{\text{Bulk Density}}{\text{Particle Density}}\right) \times 100$$

3.8. Plant sampling for growth attributes

3.8.1. Plant height (cm)

Three plants in each plot were selected and tagged for recording the plant height. The plant height was measured in cm from the ground level to the top of plants at 30 DAS, 60 DAS and 90 DAS. The average plant height was calculated for each treatment.

3.8.2. Number of leaves plant^{-1}

The number of leaves plant^{-1} was counted from three selected plants from each plot or treatment at 30 DAS, 60 DAS, and 90 DAS and the average number of leaves plant^{-1} was calculated for each treatment.

3.8.3. Nodule count

The nodule count was obtained by carefully removing sample plants from each plot, then separating the soil and plant roots, nodule and soil mixture and carefully picking up the nodule for counting. This was done at 30 DAS and 60 DAS and average number of nodules plant^{-1} was calculated for each treatment.

3.8.4. Nodule fresh weight

After obtaining the nodules, they are weighed and their average was obtained to get the final nodule fresh weight. This was done at 30 DAS and 60 DAS and average number of nodules fresh weight plant^{-1} was calculated for each treatment.

3.8.5. Nodule dry weight

After the nodule fresh weight is obtained, the nodules are dried to remove the moisture content in the nodule. The nodules are then weighed to obtain the nodule dry weight. This was done at 30 DAS and 60 DAS and average nodule dry weight plant^{-1} was calculated for each treatment.

3.8.6. Plant dry weight

The dry weight of the plants were taken from all the plots at 30 DAS and 60 DAS, then the same samples were sun dried and later dried in hot air oven for about 24 hours at 60°C and then taken for recording.

3.9. Yield attributes

3.9.1. Number of pods plant^{-1}

Total Number of pods plant^{-1} within 2 m^2 of each plot was counted and average was taken for each treatment.

3.9.2. Number of filled pods plant^{-1}

The Number of filled pods plant^{-1} was counted from three randomly selected pods and average was taken for each treatment for record.

3.9.3. Number of seeds pod^{-1}

Selected three plants were taken and the number of seeds pod^{-1} was counted and the average was taken for each treatment and then recorded.

3.10. Yield

3.10.1. Seed index (100 grain weight)

From the threshed grains, 100 grains were counted and their weight was recorded on plot-wise basis.

3.10.2. Harvest index

The harvest index was calculated by using the formula as described by Sharma and Gangaiah (2009). Where,

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.10.3. Seed yield (kg ha^{-1})

The seed yield of all the plots were collected on treatment basis and the plot yield of each treatment were converted into kg ha^{-1}.

3.10.4. Stover yield (kg ha^{-1})

After harvest, the straw were left in each respective plots for a week for sun drying, weight of all the straw were taken and recorded accordingly in plot-wise. The plot yield was converted into kg ha^{-1}.

3.11. Quality attributes

3.11.1. Seed protein content %

The protein content in seed was estimated by the formula:

Protein % = 6.25 x N% in seed

3.11.2. Oil content (%)

Seed samples of 5g each from all the treatments were taken for extraction of oil. The crushed samples were placed in a thimble and extracted with light petroleum ether for 6 hours in a soxhlet extraction unit as per method described by AOAC (1960). The extract was transferred to weight flask, the solvent distilled of and the last traces of solvent and moisture being removed by treating the flask at 100-150^{0}C. Then, the flask was cooled and reweighed; the formula used for calculation of per cent oil in seed was as follows:

$$\text{Per cent oil} = \frac{(W2 - W1) \times 100}{X}$$

Where,

W_2= weight of the empty flask (g)

W_1= weight of empty flask + weight of oil (g)

X = weight of sample taken for extraction (g)

3.12. Analysis of data

The data related to each character were analyzed statistically by applying the techniques of analysis of variance and the significant of different source of variations was tested by '*F*' test (Gomez and Gomez, 1984).

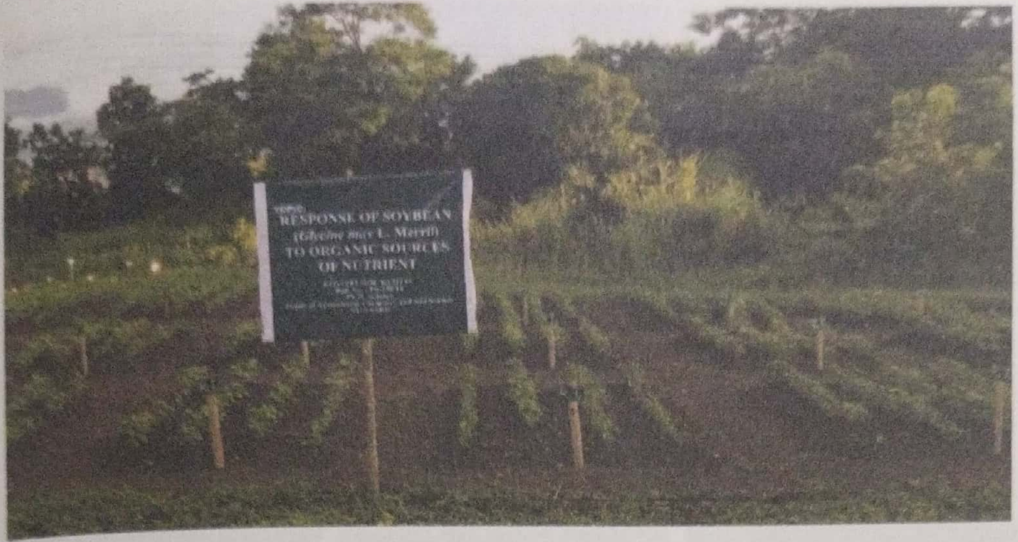


Plate 1. General view of the experimental plot at 30 DAS

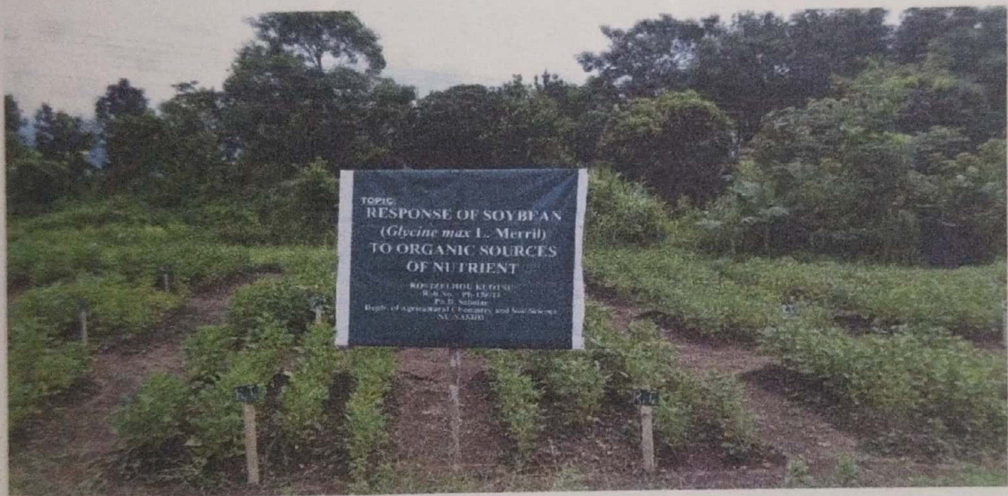


Plate 2. General view of the experimental plot at 60 DAS

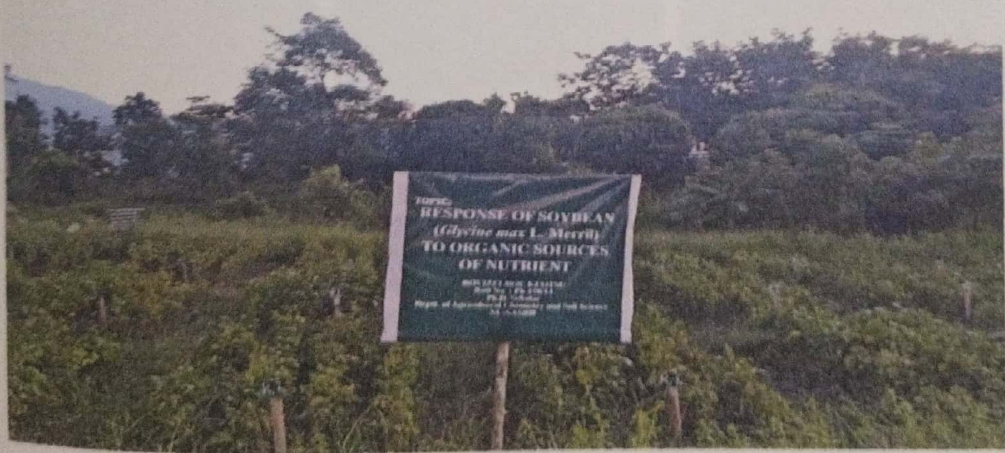
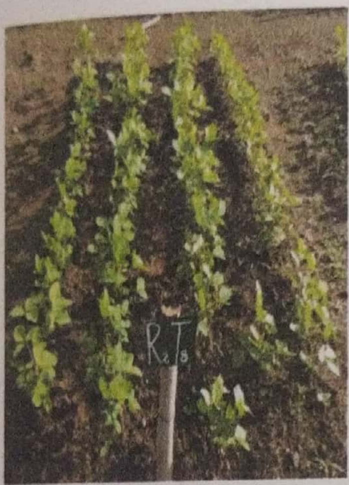


Plate 3. General view of the experimental plot at 90 DAS

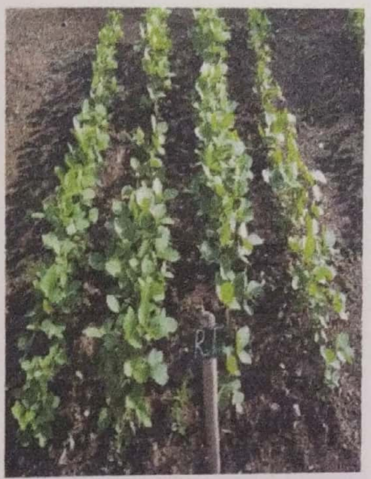
R_1T_1

R_1T_5

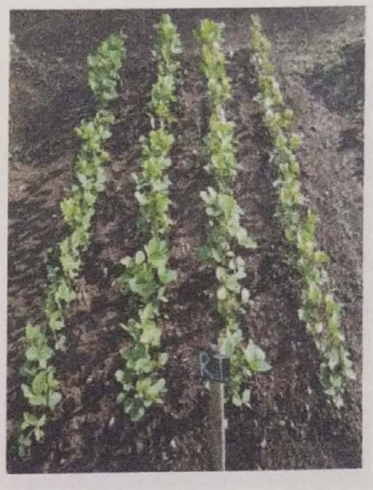
R_1T_{10}



R_2T_8



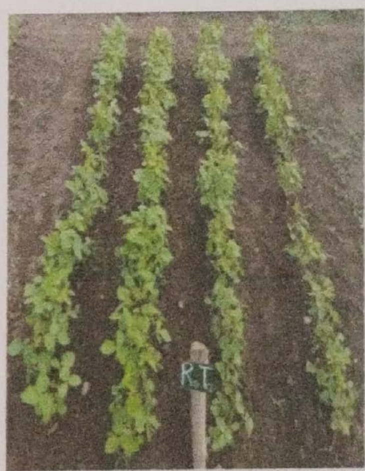
R_2T_{11}



R_2T_{14}

R_3T_3

R_3T_4



R_3T_{13}

Plate 4. Effect of organic sources of nutrient on growth of soybean at 30 DAS

R_1T_2

R_1T_4

R_1T_{11}

R_2T_2

R_2T_{10}

R_2T_{12}

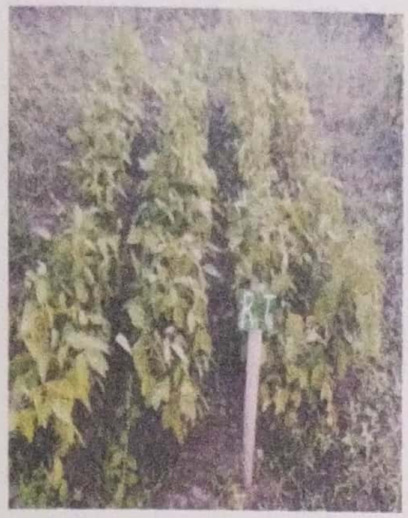
R_3T_3

R_3T_{10}

R_3T_{13}

Plate 5. Effect of organic sources of nutrient on plant height at 60 DAS

R_1T_3

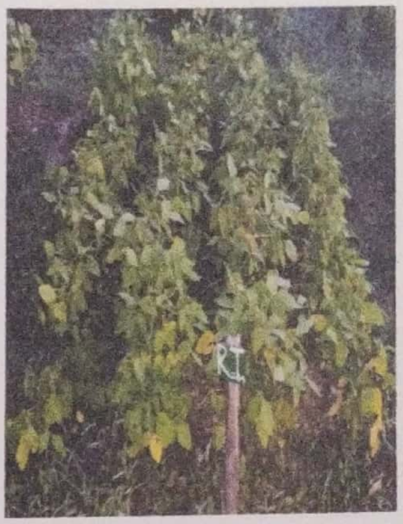


R_1T_8

R_1T_{12}

R_2T_1

R_2T_9



R_2T_{14}

R_3T_2

R_3T_7

R_3T_9

Plate 6. Effect of organic sources of nutrient on plant height at 90 DAS

Chapter – 4

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Organic farming at conceptual level, aims at achieving the regeneration and continuance of natural processes of plant growth in a given ecosystem by making the ecosystem as a self sustainable system. The organic production aims at making crop husbandry self-supporting and self sustainable system activity in a given ecosystem rather than its dependence on outside inputs. Nutrient availability, which is an important factor for crop development is achieved with the use of organic nutrients. Besides, the binding and aggregation properties of organic sources also improves the moisture holding capacity and other physical and chemical properties of the soil leading to enhanced crop growth and productivity in a sustained manner. With this objective, the present investigation entitled "Response of soybean (*Glycine max* L. Merill) to organic sources of nutrient" was carried out. Here in this chapter, an attempt has been made to explain the cause and effect relationships which may be responsible for some of the important observations recorded during the course of investigations. The salient research findings obtained from this study are discussed in details.

4.1. Effect of organic sources of nutrient on growth attributes

4.1.1. Plant height

The results obtained on the plant height in different treatments have been presented in table 2. There was an appreciable increase with the advancement of days in the height of the plant and significant difference among various treatments. As was apparent from the data, the maximum plant height was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 32.33 and 33 cm, 65.33 and 66 cm, 71 and 71.67cm at 30, 60 and 90 DAS, respectively during 2016 and 2017 while pooled data was 32.67, 65.67 and 71.33 cm. At 30 DAS, pooled data showed the highest plant height in Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which was at par with Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} while it was significantly higher than all the other treatments during the whole duration of crop growth.

Table 2. Effect of organic sources of nutrient on plant height (cm) at different growth stages

Treatments		30 DAS			60 DAS			90 DAS		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	Control	19.33	19.43	19.73	41.00	42.00	41.50	46.33	47.33	46.83
T_2	Forest litter @ 0.5t ha^{-1}	20.33	21.00	20.67	43.00	44.00	43.50	51.33	52.33	51.83
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	22.00	23.00	22.50	43.33	44.00	43.67	52.00	53.00	52.50
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	24.00	24.67	24.33	46.67	47.67	47.17	53.33	54.33	53.83
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	25.67	26.33	26.00	54.67	55.00	54.83	61.67	62.00	61.83
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	21.33	22.33	21.83	43.33	44.00	43.67	52.67	52.00	52.33
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	21.67	22.67	22.17	45.33	46.33	45.83	52.67	53.00	52.83
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	24.33	25.00	24.67	52.33	52.67	52.50	61.00	61.33	61.17
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	23.33	24.00	23.67	49.00	50.00	49.50	58.33	58.67	58.50
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	28.33	28.67	28.50	55.00	55.67	55.33	65.00	66.33	65.67
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	32.33	33.00	32.67	65.33	66.00	65.67	71.00	71.67	71.33
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	23.00	23.67	23.33	47.00	47.33	47.17	56.00	57.00	56.50
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	27.00	27.67	27.33	57.00	57.67	57.33	63.33	64.33	63.83
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	30.33	31.00	30.67	58.00	59.00	58.50	67.00	68.00	67.50
SEm±		1.07	1.53	0.93	2.37	1.82	1.50	2.69	2.91	1.98
CD ($P = 0.05$)		3.12	4.45	2.65	6.90	5.29	4.24	7.82	8.46	5.62

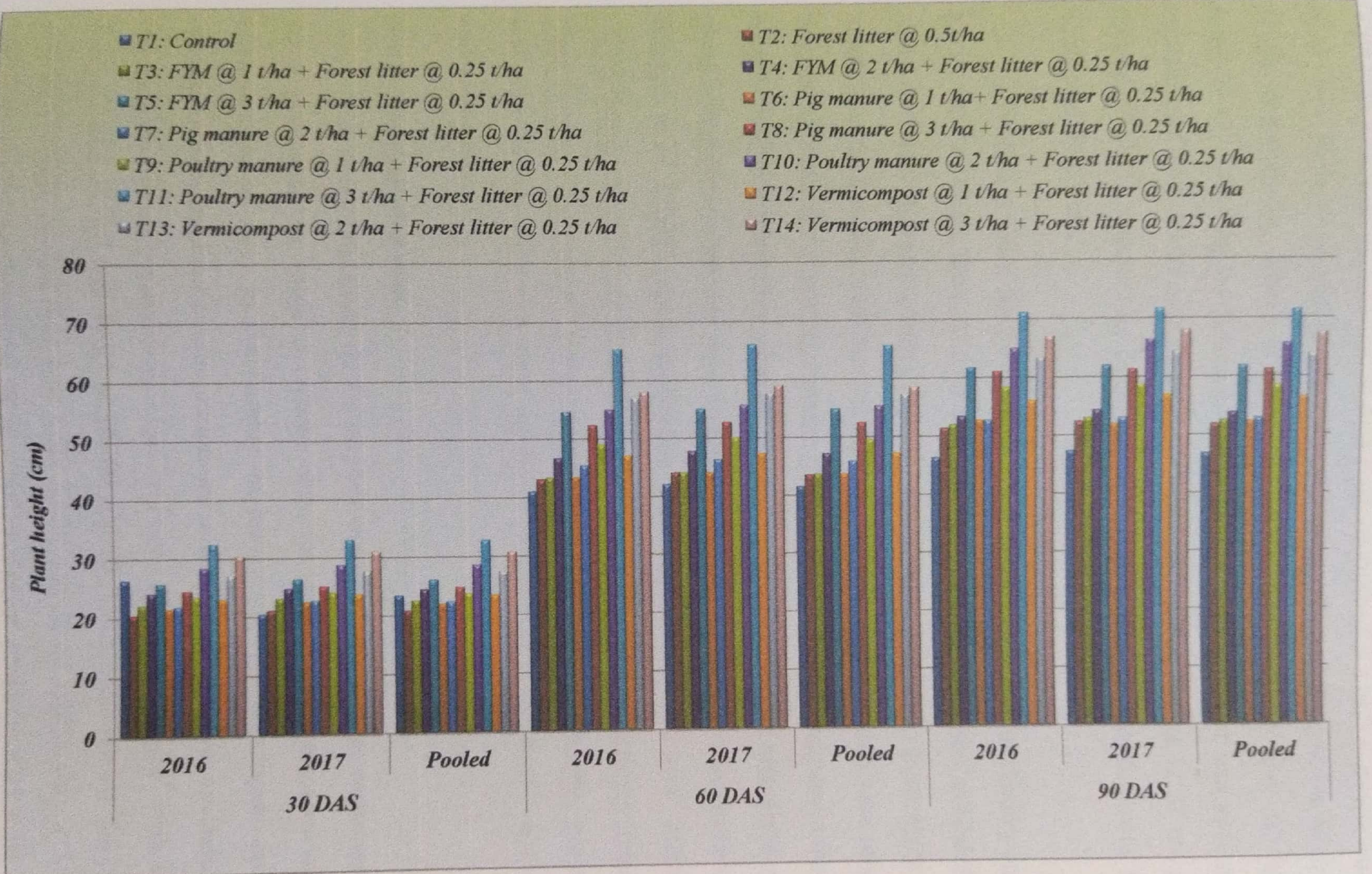


Fig 2. Effect of organic sources of nutrient on plant height at different growth stages

This was followed by application of Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 30.33 and 31 cm, 58 and 59 cm, 67 and 68 cm at 30, 60 and 90 DAS, respectively where pooled data was 30.67, 58.50 and 67.50 cm respectively. Among the treatments, the minimum plant height was recorded in control plot with 19.33 and 19.43 cm, 41 and 42 cm, 46.33 and 47.33 cm at 30, 60 and 90 DAS, respectively during 2016 and 2017 while pooled data was 19.73, 41.50 and 46.83 cm.

The tallest plant height was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which may be due to the availability of more nutrients through poultry manure as compared to other treatments. This result is in conformity with the findings of Suppadit *et al.* in 2006 who observed that the application of poultry manure @ 5 t ha^{-1} significantly increased the plant height (96.84 cm) and also other growth parameters (number of primary branches plant^{-1}, leaf area index and root nodules). Similar results were also observed by Ramesh *et al.* (2006) where application of poultry manure @ 1 t ha^{-1} along with 100% recommended dose of fertilizers (NPK) resulted in a significant increase in plant height, other growth parameters (number of primary branches plant^{-1} and leaf area index), yield and yield attributes (number of pods plant^{-1}, test weight and seed yield).

4.1.2. Number of leaves

The results obtained on the number of leaves in different treatments have been presented in table 3. There was an appreciable increase with the advancement of days in the number of leaves showing significant difference among various treatments. The maximum number of leaves was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 8.33 and 8.67, 37 and 38, 39 and 40.33 at 30, 60 and 90 DAS, respectively during 2016 and 2017 while pooled data was 8.50, 37.50 and 39.67 which was followed by application of Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded 7.33 and 7.67, 35.67 and 36, 37.67 and 38 at 30, 60 and 90 DAS

Table 3. Effect of organic sources of nutrient on number of leaves at different growth stages

	Treatments	30 DAS			60 DAS			90 DAS		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	Control	3.33	3.67	3.50	13.67	15.00	14.33	15.67	17.00	16.33
T_2	Forest litter @ 0.5t ha^{-1}	4.00	4.33	4.17	16.33	17.00	16.67	18.33	19.00	18.67
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	4.33	4.67	4.50	19.00	19.67	19.33	20.33	21.67	21.00
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	4.67	5.00	4.83	23.67	24.33	24.00	25.67	26.33	26.00
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	5.00	5.33	5.17	33.33	34.67	34.00	35.33	36.67	36.00
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	4.33	4.67	4.50	17.67	18.67	18.17	18.67	20.67	19.67
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	4.67	5.00	4.83	22.00	23.00	22.50	20.67	22.33	21.50
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.00	5.33	5.17	32.33	32.67	32.50	34.00	34.67	34.33
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.33	5.67	5.50	29.00	29.33	29.17	31.00	31.00	31.00
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	7.00	7.33	7.17	34.00	34.33	34.17	36.00	36.33	36.17
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	8.33	8.67	8.50	37.00	38.00	37.50	39.00	40.33	39.67
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	4.67	5.00	4.83	26.00	26.67	26.33	28.00	28.67	28.33
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	6.00	6.33	6.17	31.67	32.00	31.83	33.67	33.67	33.67
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	7.33	7.67	7.50	35.67	36.00	35.83	37.67	38.00	37.83
SEm±		0.44	0.47	0.32	1.43	1.32	0.97	0.90	0.85	0.62
CD ($P = 0.05$)		1.29	1.36	0.91	4.15	3.85	2.76	15.67	17.00	16.33

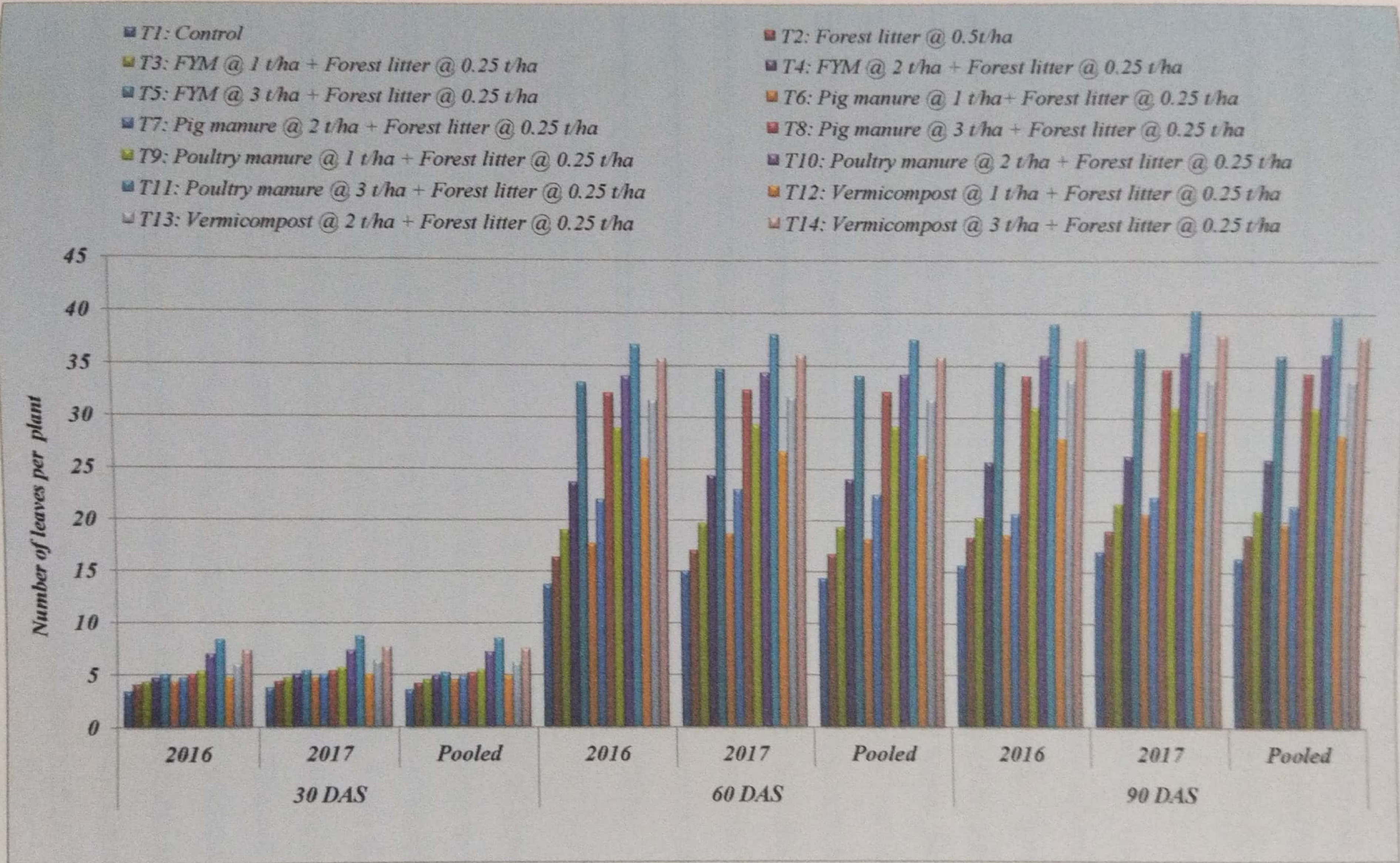


Fig 3. Effect of organic sources of nutrient on number of leaves at different growth stages

respectively. Whereas, the minimum number of leaves was recorded under Control plot with 3.33 and 3.67, 13.67 and 15, 15.67 and 17 at 30, 60 and 90 DAS, respectively while pooled data was 3.50, 14.33 and 16.33. In both the years during the cropping period, the number of leaves was found significantly higher in Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}.

The number of leaves during all the stages of crop growth was found highest in plots where poultry manure was applied which can be attributed to the higher supply of nutrients particularly NPK and their subsequent increase in uptake. Also Ghosh *et al.* (2004) reported that application of poultry manure @ 1.5 t ha^{-1} + 75 % NPK significantly increased the number of leaves and other growth parameters (dry matter production, number and weight of root nodules $plant^{-1}$) and also the yield and yield components of the plant. Similarly, Eliakira *et al.* (2014) reported that application of poultry manure @ 8 t ha^{-1} along with NPK (20: 40: 60) resulted in highest number of leaves (70) in tomato. Higher plant height (28 cm) and number of leaves (14.7) was also observed in carrot by the application of poultry manure @ 10 Mg ha^{-1} by Taiwo *et al.* (2014).

4.1.3. Number of nodules

There was an appreciable increase with the advancement of days in the number of nodules and showed significant difference among various treatments (table 4). As was apparent from the data, the maximum number of nodules was recorded under the treatment FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 24.63 and 24.90, 52.27 and 52.73 at 30 and 60 DAS, respectively during 2016 and 2017 while pooled data was 24.77 and 52.50 which was followed by the treatment Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 22.17 and 21.93, 49.10 and 49.87 at 30 and 60 DAS, respectively with pooled data of 22.05 and 49.84. The minimum number of nodules was recorded under the Control plot with 9.10 and 9.47, 31.23 and 31.80 while pooled data were 9.28 and 31.52.

In general, the number of nodules during all the stages of crop growth was found higher in plots where organic matter was applied in higher amounts which

Table 4. Effect of organic sources of nutrient on number of nodule plant^{-1} at 30 and 60 DAS

Treatments		Number of nodule plant $^{-1}$					
		30 DAS			60 DAS		
		2016	2017	Pooled	2016	2017	Pooled
T_1	Control	9.10	9.47	9.28	31.23	31.80	31.52
T_2	Forest litter @ 0.5t ha^{-1}	11.17	11.77	11.47	36.37	36.50	36.43
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	16.87	16.87	16.87	47.30	47.93	47.62
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	21.50	22.57	22.03	49.10	49.60	49.35
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	24.63	24.90	24.77	52.27	52.73	52.50
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	14.40	14.73	14.57	37.97	38.77	38.37
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	17.23	17.47	17.35	40.27	40.53	40.40
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	19.57	19.87	19.72	41.63	42.23	41.93
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	15.33	15.90	15.62	36.70	37.60	37.15
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	16.73	17.03	16.88	38.87	40.10	39.48
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	20.20	20.57	20.38	39.83	40.83	40.33
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	17.93	18.33	18.13	41.87	41.30	41.58
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	19.30	19.73	19.52	43.90	44.23	44.07
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	22.17	21.93	22.05	49.10	49.87	49.48
SEm±		0.51	1.59	0.84	1.67	1.69	1.19
CD ($P = 0.05$)		1.47	4.63	2.37	4.85	4.90	3.37

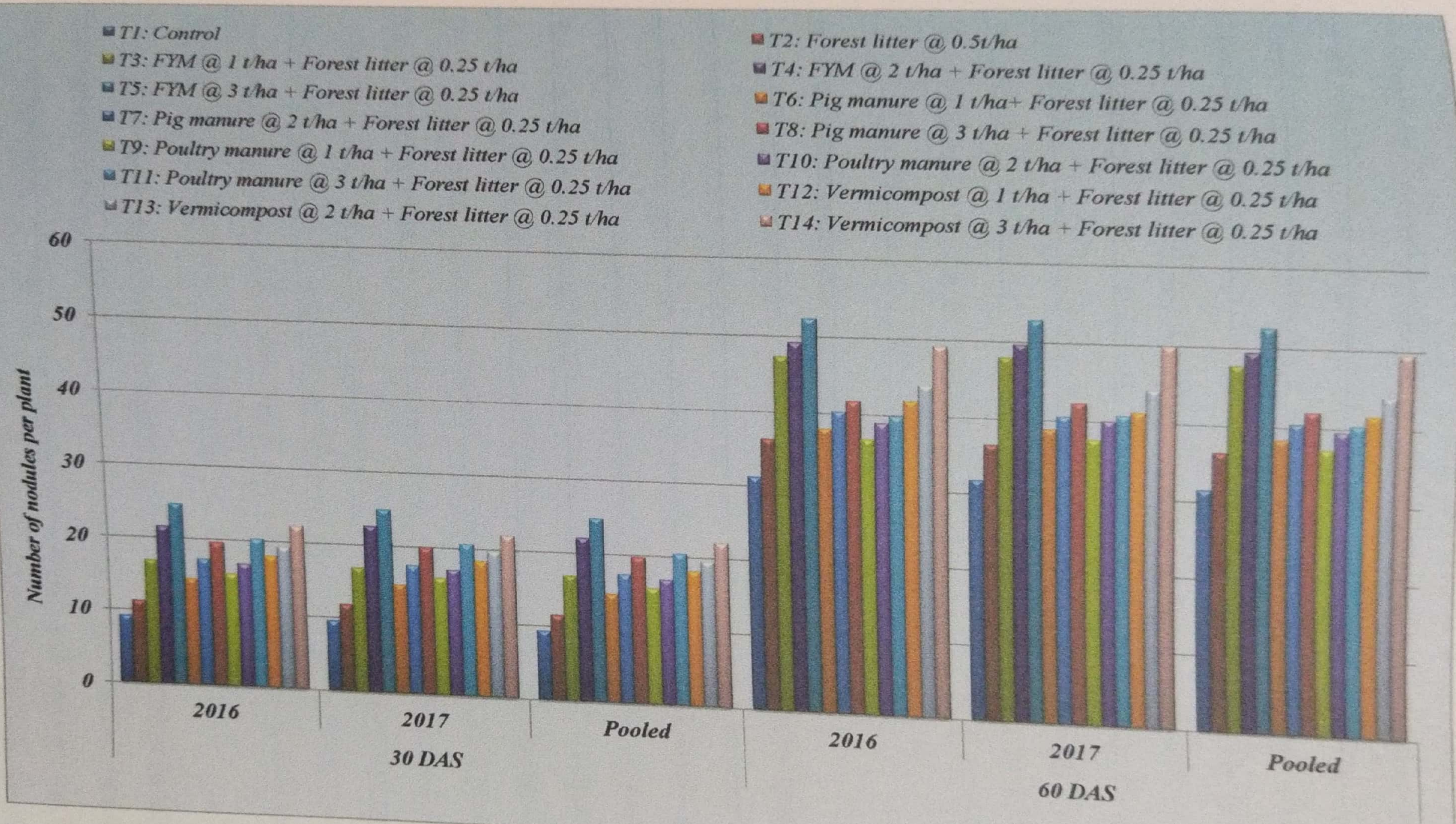


Fig 4. Effect of organic sources of nutrient on number of nodule per plant at 30 and 60 DAS

can be attributed to the higher supply of nutrients particularly NPK and their subsequent increase in uptake. As compared to the other treatments, those that were applied FYM seemed to have better nodulation. This might be a result of more availability of nutrients due to combined application, which exerted beneficial effects. The application of FYM in general, seemed to have a positive effect on the nodulation which could be due to better soil health provided by the application of FYM which also enhanced more microbial activity in the soil. Yeptho *et al.*, (2012) reported that application of FYM increased the microbial activity in soil. Higher number of nodules plant^{-1} was also reported by Singh *et al.* (2006) by the application of FYM @ 10 t ha (33.3) over NPK 50 % (30), NPK 100 % (25) and VC @ 2.5 t ha + VW @ 10 % (32).

4.1.4. Nodules fresh and dry weight

The results obtained on the nodule fresh weight in different treatments as presented in table 5 showed that there was an appreciable increase with the advancement of days in the number of nodules and showed significant difference among various treatments. As was apparent from the data, the highest nodule fresh weight was recorded under the treatment FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 0.36 and 0.36 g, 0.89 and 0.89 g, respectively during 2016 and 2017 at 30 and 60 DAS, respectively while pooled data was 0.36 and 0.89 g which was followed by Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 0.33 and 0.33 g, 0.84 and 0.84 g at 30 and 60 DAS, respectively while pooled data were 0.33 and 0.84 g. Whereas, the significantly least number of nodules was recorded under the Control plot with 0.14 and 0.14 g, 0.53 and 0.54 g, while pooled data were 0.14 and 0.54g.

The results which were obtained on the nodule dry weight in different treatments have been presented in table 6. There was an appreciable increase with the advancement of days in the number of nodules and showed significant difference among various treatments. As was apparent from the data, the highest nodule dry weight was recorded under the treatment FYM @ 3 t ha^{-1} + Forest

Table 5. Effect of organic sources of nutrient on nodule fresh weight (g) plant^{-1} at 30 and 60 DAS

Treatments		Nodule fresh weight (g) plant^{-1}					
		30 DAS			60 DAS		
		2016	2017	Pooled	2016	2017	Pooled
T_1	Control	0.14	0.14	0.14	0.53	0.54	0.54
T_2	Forest litter @ 0.5t ha^{-1}	0.16	0.18	0.17	0.62	0.62	0.62
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	0.25	0.25	0.25	0.80	0.81	0.81
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.32	0.34	0.33	0.83	0.84	0.83
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	0.36	0.36	0.36	0.89	0.89	0.89
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.22	0.22	0.22	0.64	0.66	0.65
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.26	0.26	0.26	0.69	0.69	0.69
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.32	0.30	0.31	0.71	0.72	0.71
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.23	0.24	0.24	0.63	0.64	0.63
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.25	0.26	0.26	0.66	0.68	0.67
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.32	0.31	0.31	0.68	0.70	0.69
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.28	0.28	0.28	0.71	0.70	0.71
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.31	0.30	0.30	0.75	0.75	0.75
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.33	0.33	0.33	0.84	0.84	0.84
SEm±		0.006	0.008	0.005	0.008	0.006	0.005
CD (P = 0.05)		0.019	0.022	0.014	0.024	0.016	0.014

Fig 5. Effect of organic sources of nutrient on nodule fresh weight (g) per plant at 30 and 60 DAS

Table 6. Effect of organic sources of nutrient on nodule dry weight (g) plant^{-1} at 30 and 60 DAS

Treatments		Nodule dry weight (g) plant^{-1}					
		30 DAS			60 DAS		
		2016	2017	Pooled	2016	2017	Pooled
T_1	Control	0.030	0.028	0.029	0.12	0.16	0.14
T_2	Forest litter @ 0.5t ha^{-1}	0.034	0.035	0.035	0.15	0.15	0.15
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	0.051	0.051	0.051	0.19	0.19	0.19
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.064	0.068	0.066	0.20	0.20	0.20
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	0.074	0.075	0.074	0.21	0.21	0.21
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.043	0.044	0.044	0.15	0.16	0.15
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.052	0.053	0.052	0.16	0.16	0.16
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.060	0.060	0.060	0.17	0.17	0.17
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.046	0.048	0.047	0.15	0.15	0.15
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.051	0.051	0.051	0.15	0.16	0.16
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.061	0.062	0.061	0.16	0.16	0.16
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.054	0.055	0.054	0.17	0.17	0.17
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.058	0.059	0.059	0.18	0.18	0.18
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	0.067	0.066	0.066	0.20	0.20	0.20
SEm±		0.0016	0.0015	0.0011	0.015	0.0100	0.0092
CD (P = 0.05)		0.0046	0.0045	0.0031	0.0446	0.0291	0.0260

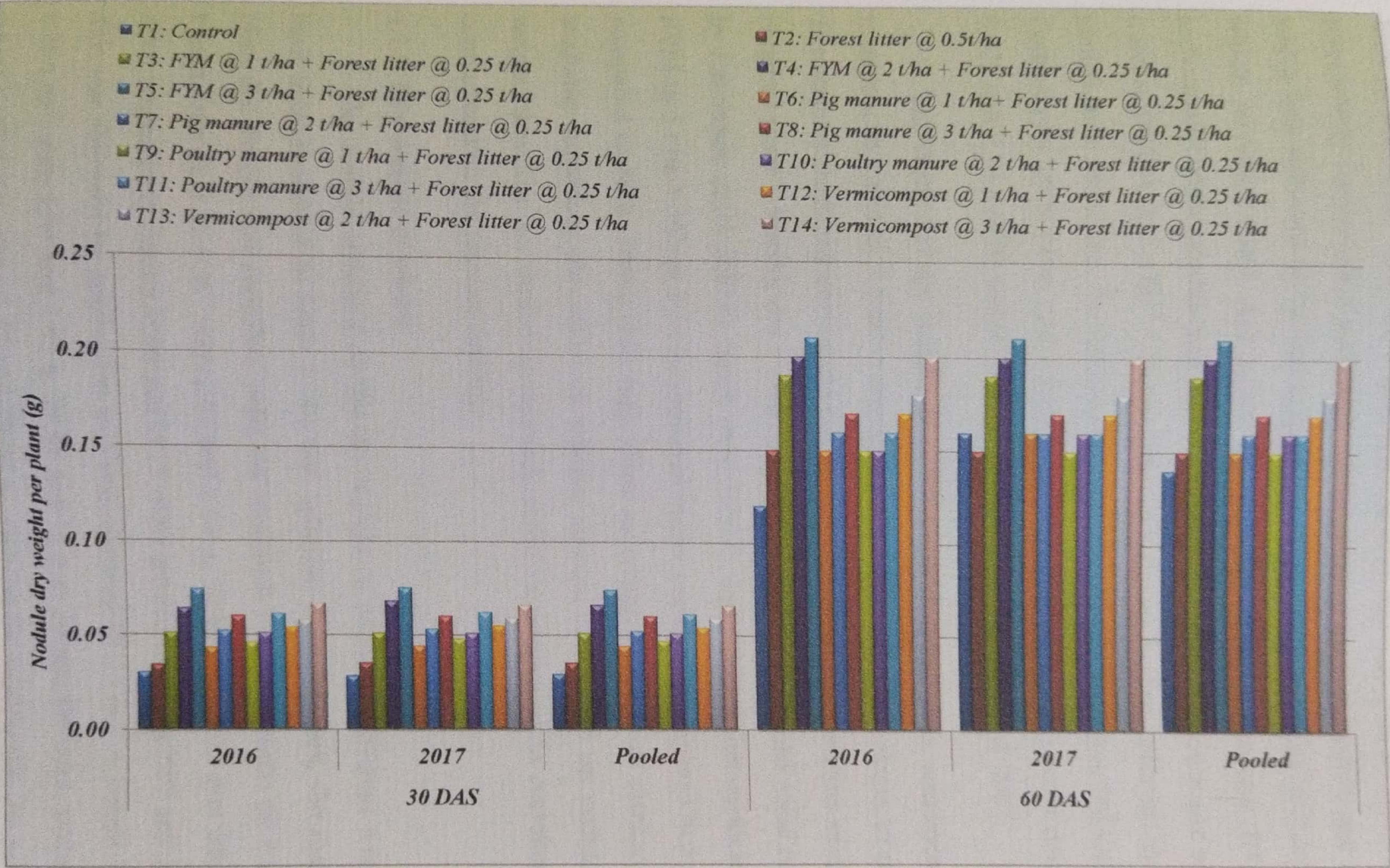


Fig 6. Effect of organic sources of nutrient on nodule dry weight (g) per plant at 30 and 60 DAS

litter @ 0.25 t ha^{-1} with 0.074 and 0.075 g, 0.21 and 0.21 g at 30 and 60 DAS, respectively during 2016 and 2017 while pooled data were 0.074 and 0.21 g which was followed by Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded 0.067 and 0.066 g, 0.20 and 0.20g at 30 and 60 DAS, respectively while pooled data were 0.066 and 0.20 g which was at par with the treatment FYM @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded the same pooled data. Whereas, the minimum nodule dry weight was recorded under the Control plot with 0.030 and 0.028 g, 0.12 and 0.16 g, while pooled data were 0.029 and 0.14 g at 30 and 60 DAS respectively, during 2016 and 2017.

The fresh and dry weight of nodules was observed to be maximum with treatment of FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} at all stages of growth. The nodules fresh and dry weight $plant^{-1}$ corresponds with the number of nodules obtained $plant^{-1}$. Similar dry weight of nodules at 45 and 60 DAS were reported by Lakshman *et al.* (2015). Singh *et al.* (2006) also reported that application of FYM @ 5 t ha + VC @ 2.5 t ha produced higher nodule dry weight (370.5 mg) as compared to NPK 100% (182 mg). Since no proper literature or citations were available regarding the effect of organic sources of nutrient on nodule fresh weight, therefore no further comparison could be conducted to corroborate or contradict with the present findings.

4.1.5. Dry weight of plants

The results obtained on the dry weight of plants in different treatments have been presented in table 7. As was apparent from the data, the maximum plant dry weight was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 2.07 and 2.08 g, 32.40 and 32.53 g at 30 and 60 DAS, respectively during 2016 and 2017 while pooled data was 2.07 and 32.47 g. This was followed by application of Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 1.94 and 1.95 g, 29.80 and 30 g at 30 and 60 DAS, respectively where pooled data were 1.95 and 29.90 g. Among the treatments, the minimum plant dry weight was recorded in control plot with 1.17 and 1.21 g, 17.43 and

Table 7. Effect of organic sources of nutrient on dry weight (g) of plants at 30 and 60 DAS

Treatments		Dry weight (g) plant $^{-1}$					
		30 DAS			60 DAS		
		2016	2017	Pooled	2016	2017	Pooled
T_1	Control	1.17	1.21	1.19	17.43	17.57	17.50
T_2	Forest litter @ 0.5t ha^{-1}	1.32	1.32	1.32	19.73	19.83	19.78
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	1.49	1.52	1.51	24.90	21.67	23.28
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.58	1.60	1.59	26.83	26.93	26.88
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	1.85	1.86	1.86	27.33	27.53	27.43
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.47	1.50	1.48	23.90	24.20	24.05
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.52	1.54	1.53	24.37	24.53	24.45
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.81	1.83	1.82	26.73	26.83	26.78
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.75	1.76	1.75	25.93	26.17	26.05
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.93	1.95	1.94	28.63	29.00	28.82
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	2.07	2.08	2.07	32.40	32.53	32.47
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.67	1.69	1.68	25.23	25.47	25.35
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.89	1.90	1.89	27.97	28.20	28.08
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.94	1.95	1.95	29.80	30.00	29.90
SEm±		0.15	0.15	0.11	1.48	1.80	1.17
CD (P = 0.05)		0.44	0.45	0.31	4.30	5.24	3.31

Fig 7. Effect of organic sources of nutrient on dry weight (g) of plants at 30 and 60 DAS

17.57 g at 30 and 60 DAS, respectively during 2016 and 2017 while pooled data were 1.19 and 17.50 g.

All fertilizer management treatments recorded significantly higher dry matter production plant^{-1} as compare to absolute control. In association with soil microorganisms, organic manures are known to help in synthesis of cetain phytohormones and vitamins which promote the growth and development of the crop. The slow release of nutrients associated with poultry manure and vermicompost might have resulted in higher dry matter production plant^{-1} of the crop (Rana and Badiyala. 2014). Due to this, the influence of organic nutrient sources on the plant dry weight was found to be highest in the plot treated with poultry manure and vermicompost. This may be also due to better growth characteristics owing to more availability of nutrients. These findings are in accordance with the findings of Pookpadi (2003) who observed that, substitution of chemical fertilizers by 70% poultry manure significantly increased the dry matter accumulation. Also in 2008, Singh *et al.,* found that application of poultry manure @ 5 t ha^{-1} along with recommended dose of fertilizer resulted in the highest dry matter production and significantly increased other growth attributes and yield.

4.2. Effect of organic sources of nutrient on yield attributes

Table 8 revealed that, the various organic nutrient sources had significant effect on the yield attributes such as, pods plant^{-1} and filled pods plant^{-1}. The number of seeds pod^{-1} was however not significantly affected by the various treatments. Both pods plant^{-1} and filled pods plant^{-1} was recorded maximum under treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 48.03 and 48.63, 44.27 and 44.73, respectively in the year 2016 and 2017 while pooled data were 48.33 and 44.50 which was followed by Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded 46.80 and 47.13, 42.67 and 42.83, respectively with the pooled data of 46.97 and 42.75. The minimum pods plant^{-1} and filled pods plant^{-1} was recorded in the Control plot with 35.23 and 36.50,

Table 8. Effect of organic sources of nutrient on yield attributes

Treatments		Pods plant^{-1}			Filled pods plant^{-1}			Seeds pod^{-1}		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	Control	35.23	36.50	35.87	32.93	33.07	33.00	2.19	2.20	2.19
T_2	Forest litter @ 0.5t ha^{-1}	37.67	38.47	38.07	34.63	35.43	35.03	2.23	2.24	2.24
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	40.37	40.90	40.63	35.37	35.77	35.57	2.38	2.39	2.38
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	40.73	41.33	41.03	37.23	36.70	36.97	2.42	2.43	2.42
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	42.67	43.00	42.83	40.67	41.40	41.03	2.42	2.44	2.43
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	41.30	42.00	41.65	36.27	36.70	36.48	2.42	2.42	2.42
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	42.87	43.27	43.07	39.00	39.23	39.12	2.37	2.38	2.38
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	45.07	45.73	45.40	40.23	40.70	40.47	2.38	2.39	2.39
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	40.80	41.43	41.12	39.23	39.57	39.40	2.32	2.33	2.33
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	45.63	46.00	45.82	40.70	41.23	40.97	2.46	2.46	2.46
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	48.03	48.63	48.33	44.27	44.73	44.50	2.62	2.63	2.62
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	43.57	43.97	43.77	39.87	40.70	40.28	2.36	2.37	2.37
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	44.93	45.03	44.98	40.57	40.93	40.75	2.43	2.44	2.44
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	46.80	47.13	46.97	42.67	42.83	42.75	2.61	2.62	2.61
SEm±		1.32	1.56	1.02	1.45	1.55	1.06	0.17	0.17	0.12
CD (P = 0.05)		3.845	4.525	2.898	4.21	4.49	3.00	NS	NS	NS

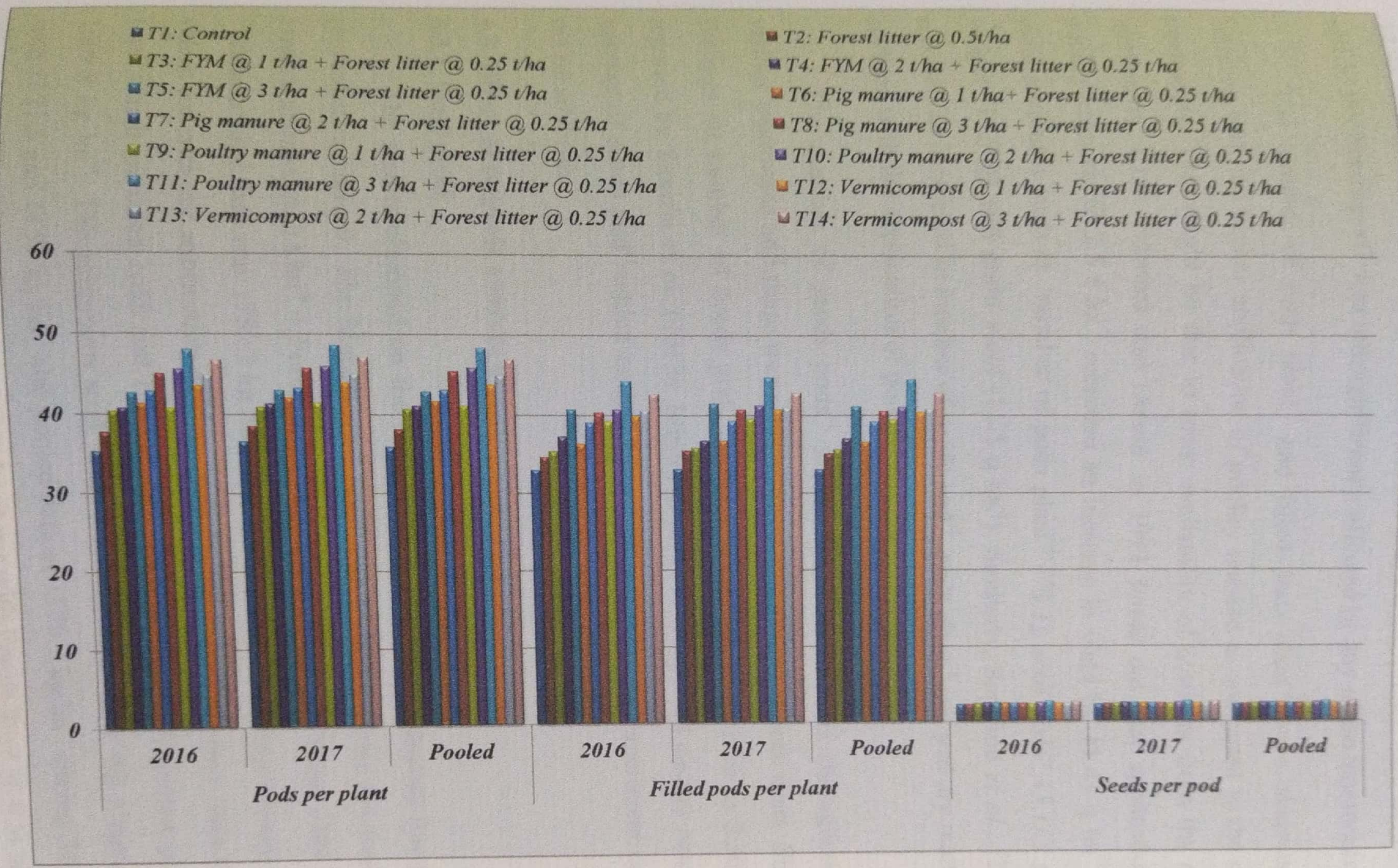


Fig 8. Effect of organic sources of nutrient on yield attributes

32.93 and 33.07, respectively during both the years while pooled data were 35.87 and 33.00. Seeds pod^{-1} was not significantly affected by any of the treatments.

The number of pods plant^{-1} and filled pods plant^{-1} were observed to increase with the higher application of poultry manure as compared to the other treatments. This might be due to more availability of nutrients from the other treatments. Also, Edward and Daniel in 1992 found out that application of poultry manure @ 2.5 t ha^{-1} recorded an increase in yield by 11.43 q ha^{-1} and yield attributes such as number of pods plant^{-1} (73.3), seed pods^{-1} (3.12), grain weight (14.9 g) and grain yield (11.5 q ha^{-1}). Similarly, Suppadit *et al.*, (2006) reported an increased in number of seeds pod^{-1}, pods plant^{-1} and pod dry matter in soybean with the application of poultry manure.

The number of seeds pods^{-1} varied from 2.10 to 2.62 throughout the various treatments and there was no significant difference between them. Similar findings on number of seeds pod^{-1} in soybean ranging from 2.10 to 2.30 was reported by Saxena *et al.* (2013). Mishra *et al.* (1999) reported similar result on number of seeds pod^{-1} which ranged from 2.18 to 2.90 in an experiment carried out on soybean.

4.3. Effect of organic sources of nutrient on yield

4.3.1. Seed yield

The results obtained on the seed yield in different treatments have been presented in table 9. The highest seed yield was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 1777 and 1784 kg ha^{-1} while pooled data was 1780.7 kg ha^{-1} during 2016 and 2017, respectively which was at par with the application of Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded 1658 and 1681 kg ha^{-1}, respectively while pooled data was 1669.8 kg ha^{-1}. The minimum seed yield was recorded under the Control plot with 1121.3 and 1152 kg ha^{-1} and pooled data of 1136.7 kg ha^{-1} during 2016 and 2017, respectively which was found to be at par with Forest litter @ 0.5t ha^{-1} and FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1} for both the years.

Seed yield was significantly affected by the different nutritional schedules where the maximum seed yield was found under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}. This increase in seed yield may be due to the increase in yield parameters *viz.* number of pods $plant^{-1}$, number of seeds pod^{-1} and number of filled pods $plant^{-1}$. Similar result was found by Channabasavana *et al.*, in 2001 where he studied the effectiveness of three organic manures (FYM, poultry manure and vermicompost at varying rate) and biofertilizers (Azotobacter + Phosphate Solubilizing Bacteria) on productivity, grain yield, soil fertility and profitability of wheat soybean cropping system and found out that application of poultry manure @ 2 t ha^{-1} recorded significantly higher seed yield (4882 kg ha^{-1}) over control. This finding was also in accordance with the findings of Ramesh *et al.*, (2006) who recorded 17.5 % higher yield than chemical fertilizers (1243 kg ha^{-1}) with the application of poultry manure @ 7 t ha^{-1}. Similarly, Kumar et al. (2006) also reported that application of 50 % N through green leaf manure, poultry manure and crop residue compost resulted in higher nutrient uptake (122, 37 and 110 kg of NPK ha^{-1} respectively) and higher seed yield (1793 kg ha^{-1}) as compared with absolute control (823 kg ha^{-1}).

4.3.2. Stover yield

Table 9 revealed the results of the stover yield. There was an appreciable increase in the stover yield which showed significant difference among various treatments. The highest stover yield was recorded by the application of Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 2277 and 2288.7 kg ha^{-1}, respectively while pooled data was 2176.8 kg ha^{-1} during 2016 and 2017. It was followed by the application of Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} and Poultry manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded 2158.3 and 2195.3 kg ha^{-1}, 2056 and 2068.7 kg ha^{-1}, respectively while pooled data were 2176.8 and 2062.3 kg ha^{-1}. Whereas, the minimum stover yield was recorded under the Control plot with 1621.3 and 1644.7 kg ha^{-1} while pooled data was 1633 kg ha^{-1} during 2016 and 2017, respectively.

Stover yield was observed to increase with the higher application of organic sources of nutrient due to higher uptake and metabolism leading to more and easy availability of nutrients. The vegetative growth was observed to be enhanced where nutrients were applied in higher amounts. The highest stover yield was reported by the application of Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which may be due to the increase in growth parameters and yield attributes. Similar results were observed by Paradkar and Deshmukh (2004) and Channabasavana *et al.*, (2001). These findings is also in accordance to the findings of Kadam *et al.*, (2010) who reported that application of 100% N through poultry manure along with pulvic acid sprays @ 100 ppm at 30 and 60 DAS recorded higher grain (25.7 q ha^{-1}) and straw yield (38.6 q ha^{-1}) as compared to application of 100 % N through vermicompost + fulvic acid sprays which yielded (24.5 and 36.7 q ha^{-1} of grain and straw yield respectively).

4.3.3. Biological yield

The results obtained on the biological yield in different treatments have been presented in table 9. There was an appreciable increase in the biological yield and had shown significant difference among various treatments. As was apparent from the data, the highest biological yield was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 4054 and 4073 kg ha^{-1} while pooled data was 4063.5 kg ha^{-1} during 2016 and 2017, respectively. It was followed by the application of Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} and Poultry manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded 3816.7 and 3876.7 kg ha^{-1}, 3612 and 3656.3 kg ha^{-1}, respectively while pooled data were 3846.7 and 3634.2 kg ha^{-1}. Whereas, the minimum seed yield was recorded under the control plot with 2742.7 and 2793 kg ha^{-1} while pooled data was 2767.8 kg ha^{-1} during 2016 and 2017, respectively.

Biological yield which combine of both seed yield and stover yield was recorded the maximum under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} this is due to the increase in seed yield and stover yield. Gupta

Table 9. Effect of organic sources of nutrient on yield (kg ha^{-1})

Treatments		Seed yield			Stover yield			Biological yield		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	Control	1121.3	1152.0	1136.7	1621.3	1644.7	1633.0	2742.7	2793.0	2767.8
T_2	Forest litter @ 0.5t ha^{-1}	1194.0	1205.0	1199.5	1791.0	1791.0	1791.0	2885.0	2905.0	2895.0
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	1220.7	1244.3	1232.5	1763.7	1783.7	1773.7	2984.3	3028.0	3006.2
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1351.7	1364.3	1358.0	1851.0	1877.7	1864.3	3186.0	3242.0	3214.0
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	1505.7	1425.7	1465.7	2007.0	2030.7	2018.8	3512.7	3456.3	3484.5
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1246.7	1258.3	1252.5	1794.0	1814.3	1804.2	3040.7	3072.7	3056.7
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1324.3	1350.0	1337.2	1885.7	1904.7	1895.2	3210.0	3254.7	3232.3
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1424.3	1450.7	1437.5	1962.3	1976.0	1969.2	3386.7	3426.7	3406.7
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1206.3	1227.0	1216.7	1729.0	1758.0	1743.5	2935.3	2985.0	2960.2
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1556.0	1567.7	1561.8	2056.0	2068.7	2062.3	3612.0	3656.3	3634.2
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1777.0	1784.3	1780.7	2277.0	2288.7	2282.8	4054.0	4073.0	4063.5
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1215.3	1235.0	1225.2	1748.0	1774.3	1761.2	2963.3	3009.3	2986.3
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1535.0	1557.3	1546.2	2023.7	2052.7	2038.2	3558.7	3562.0	3560.3
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1658.3	1681.3	1669.8	2158.3	2195.3	2176.8	3816.7	3876.7	3846.7
SEm±		49.36	49.36	40.86	32.04	61.8	39.4	71.92	87.44	92.07
CD (P = 0.05)		143.49	143.49	118.78	90.92	179.7	111.8	209.07	254.18	267.64

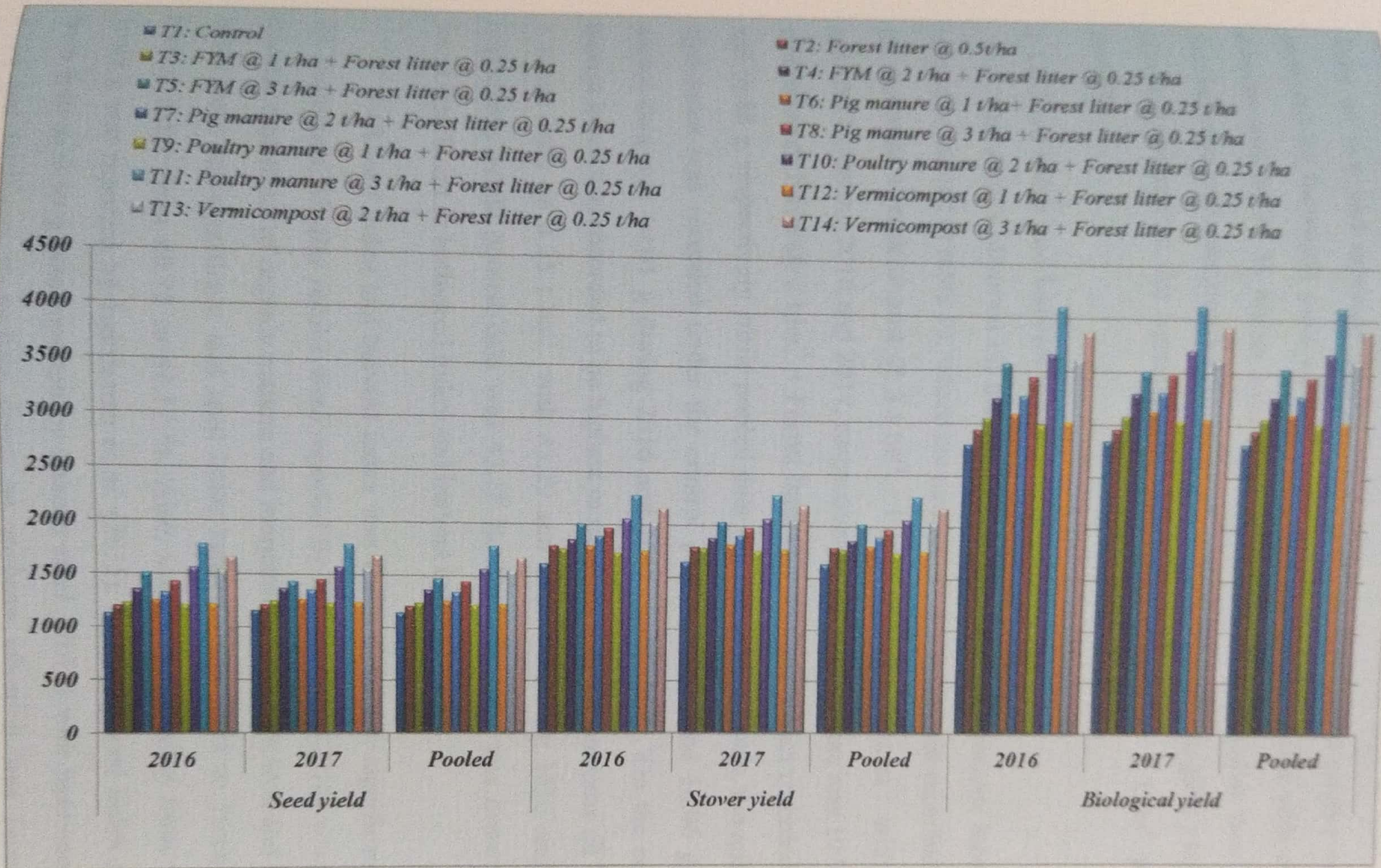


Fig 9. Effect of organic sources of nutrient on yield (kg per ha)

in 1995 conducted a field experiment on effect of different organic manures in India on rice and reported similar case where application of poultry manure produced an increased yield of 4.1 t ha^{-1}. The increased in yield with organic manure was 34-35 % higher over the control and 5-22 % higher over NPK. Similar case was reported by Singh *et al.*, (2008) where biological yield was observed highest in the treatment 15-13.1 16.6 N kg ha^{-1} + 5 t ha^{-1} poultry manure.

4.3.4. Seed index and harvest index

The results obtained on the seed index in different treatments have been perusal presented in table 10, where the maximum seed index was recorded under the treatment Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 10.94 and 10.97 g during 2016 and 2017, respectively while pooled data was 10.95 g. It was followed FYM @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded 10.86 and 10.88 g, respectively while pooled data was 10.87 g. Whereas, the minimum seed index was recorded under the control plot with 9.96 and 10.06 g while pooled data was 10.01 g during 2016 and 2017, respectively. On the contrary harvest index was recorded to be highest in the case of Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 43.29 and 43.27 % during 2016 and 2017, respectively while pooled data was 43.28 %. The difference was however not found significant in both seed index and harvest index.

Both seed index and harvest index was found to be non significant in all the treatments. Similar results were reported by Meena *et al.* (2010) where they reported that effect of organic manure and inorganic fertilizer on seed and harvest index were non-significant and seed index ranged from 10.57 to 10.66 g and harvest index from 40.75 to 41.17 %. Also, seed index ranging from 9.54 to 10.49 g was reported by Lakshman *et al.* (2015). Similarly seed index ranging from 8.40 to 9.30 g was reported by Saxena *et al.* (2013) with treatment using FYM and fertilizers at various doses on soybean where it was found non-significant by the various treatments.

Table 10. Effect of organic sources of nutrient on harvest index (%) and seed index (g)

Treatments		Harvest index			Seed index		
		2016	2017	Pooled	2016	2017	Pooled
T_1	Control	40.16	40.38	40.27	9.96	10.06	10.01
T_2	Forest litter @ 0.5t ha^{-1}	40.68	40.41	40.54	10.76	10.16	10.46
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	39.90	40.08	39.99	10.56	10.57	10.56
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	41.77	41.45	41.61	10.86	10.88	10.87
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	42.26	40.61	41.44	10.20	10.23	10.21
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	40.33	40.29	40.31	10.29	10.31	10.30
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	40.62	40.84	40.73	10.39	10.41	10.40
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	41.44	41.72	41.58	10.37	10.39	10.38
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	40.41	40.43	40.42	10.48	10.50	10.49
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	42.48	42.30	42.39	10.59	10.61	10.60
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	43.29	43.27	43.28	10.68	10.70	10.69
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	40.33	40.36	40.35	10.57	10.58	10.58
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	42.53	43.11	42.82	10.77	10.79	10.78
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	42.88	42.81	42.85	10.94	10.97	10.95
SEm±		1.58	1.60	1.12	0.478	0.316	0.287
CD (P = 0.05)		NS	NS	NS	NS	NS	NS

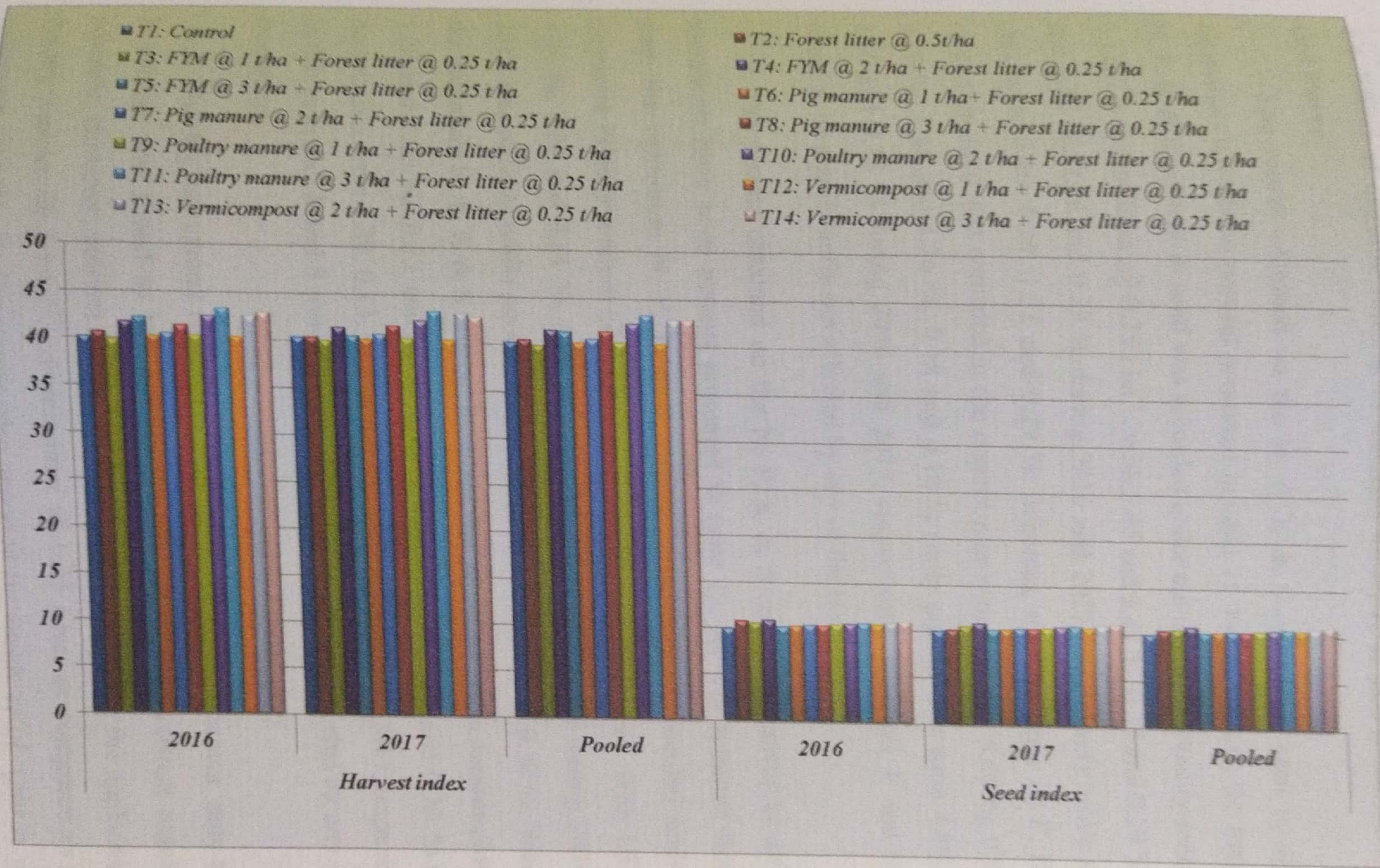


Fig 10. Effect of organic sources of nutrient on harvest index and seed index

4.4. Effect of organic sources of nutrient on N, P, K and S content in seed and stover

The results obtained on the N, P, K & S content in seed in different treatments have been perusal presented in table 11. From the data, the maximum N, P, K & S content in seed was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 5.46 and 5.47 %, 0.39 and 0.39 %, 1.51 and 1.52 %, 0.29 and 0.29 % during 2016 and 2017, respectively while pooled data were 5.46, 0.39, 1.51 and 0.29 %. Whereas, the minimum N, P, K & S content in seed was recorded in the control plot with 4.72 and 5.07 %, 0.30 and 0.26 %, 1.26 and 1.26 %, 0.18 and 0.18 % while pooled data were 4.89, 0.28, 1.26 and 0.18 % during 2016 and 2017, respectively. Whereas, P and S were found to be significantly not affected by any of the treatments.

The results obtained on the N, P, K & S content in stover in different treatments have been perusal presented in table 12. As was apparent from the data, the maximum N, P, K & S content in stover was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 1.38 and 1.38 %, 0.20 and 0.21 %, 2.08 and 2.10 %, 0.32 and 0.32 % during 2016 and 2017, respectively while pooled data were 1.38, 0.21, 2.09 and 0.32 %. Whereas, the minimum N, P, K & S content in stover was recorded in the control plot with 1.20 and 1.20 %, 0.13 and 0.13 %, 1.77 and 1.78 %, 0.23 and 0.23 % while pooled data were 1.20, 0.13, 1.77 and 0.23 % during 2016 and 2017, respectively. In this case also P and S were found to be significantly not affected by any of the treatments.

Among the nutrient content (N, P, K and S) in seed and stover, only N and K content was found to be significantly affected by the various nutritional schedule. However, nutrient content was found to be higher by the application of Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} as compared to other treatments. Similar findings were also reported by Singh *et al.* (2013) where application of 15-13.1-16.6 NPK kg ha^{-1} + Poultry manure @ 5 t ha^{-1} recorded

Table 11. Effect of organic sources of nutrient on N, P, K and S content in seed (%)

Treatments		N content			P content			K content			S content		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	Control	4.72	5.07	4.89	0.30	0.26	0.28	1.26	1.26	1.26	0.18	0.18	0.18
T_2	Forest litter @ 0.5t ha^{-1}	5.16	5.18	5.17	0.30	0.30	0.30	1.30	1.31	1.31	0.21	0.21	0.21
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	5.19	5.20	5.19	0.31	0.32	0.31	1.37	1.37	1.37	0.23	0.24	0.24
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.24	5.25	5.24	0.33	0.34	0.34	1.39	1.40	1.40	0.24	0.25	0.25
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	5.29	5.29	5.29	0.33	0.34	0.34	1.45	1.45	1.45	0.26	0.26	0.26
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.22	5.23	5.23	0.29	0.30	0.30	1.37	1.38	1.37	0.23	0.24	0.24
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.27	5.28	5.28	0.29	0.29	0.29	1.39	1.40	1.39	0.25	0.25	0.25
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.37	5.38	5.38	0.31	0.31	0.31	1.41	1.42	1.41	0.27	0.27	0.27
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.20	5.21	5.20	0.33	0.33	0.33	1.39	1.40	1.39	0.24	0.24	0.24
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.25	5.26	5.26	0.36	0.37	0.37	1.43	1.43	1.43	0.24	0.24	0.24
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.46	5.47	5.46	0.39	0.39	0.39	1.51	1.52	1.51	0.29	0.29	0.29
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.25	5.26	5.25	0.30	0.31	0.31	1.40	1.41	1.41	0.24	0.24	0.24
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.27	5.25	5.26	0.33	0.34	0.34	1.45	1.46	1.45	0.26	0.26	0.26
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.39	5.39	5.39	0.37	0.38	0.37	1.49	1.50	1.50	0.27	0.27	0.27
SEm±		0.088	0.008	0.044	0.032	0.032	0.023	0.039	0.034	0.026	0.023	0.022	0.016
CD (P = 0.05)		0.256	0.024	0.126	NS	NS	NS	0.113	0.100	0.074	NS	NS	NS

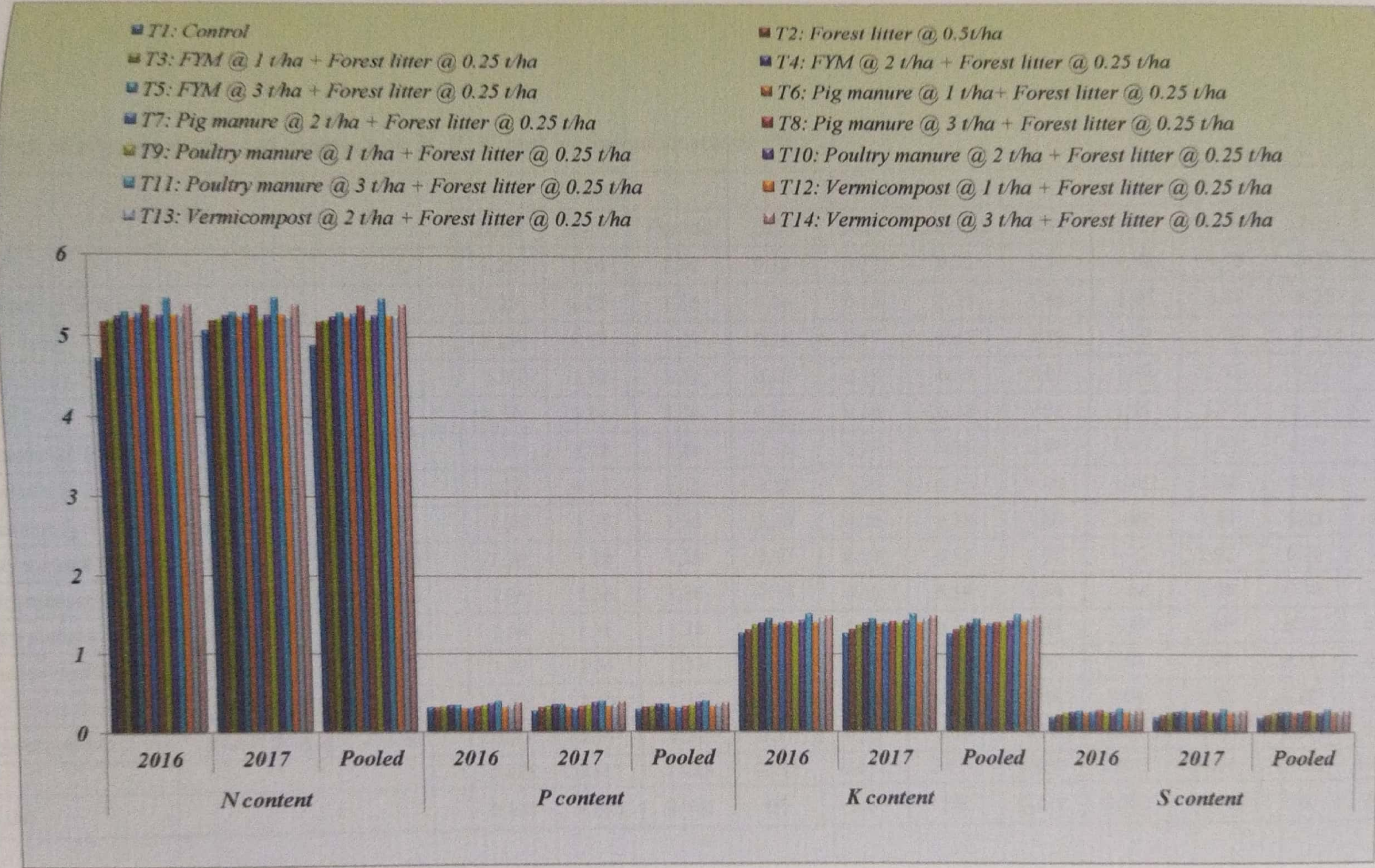


Fig 11. Effect of organic sources of nutrient on N, P, K and S content in seed (%)

Table 12. Effect of organic sources of nutrient on N, P, K and S content in stover (%)

Treatments		N content			P content			K content			S content		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	Control	1.20	1.20	1.20	0.13	0.13	0.13	1.77	1.78	1.77	0.23	0.23	0.23
T_2	Forest litter @ 0.5t ha^{-1}	1.25	1.25	1.25	0.15	0.15	0.15	1.86	1.87	1.87	0.25	0.25	0.25
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	1.29	1.29	1.29	0.16	0.17	0.17	1.89	1.91	1.90	0.25	0.26	0.26
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.32	1.32	1.32	0.17	0.18	0.17	1.91	1.94	1.92	0.26	0.26	0.26
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	1.34	1.34	1.34	0.18	0.18	0.18	1.91	1.93	1.92	0.26	0.27	0.27
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.28	1.28	1.28	0.16	0.17	0.16	1.87	1.87	1.87	0.27	0.27	0.27
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.32	1.32	1.32	0.18	0.19	0.18	1.90	1.91	1.90	0.28	0.28	0.28
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.35	1.35	1.35	0.19	0.20	0.19	1.89	1.89	1.89	0.25	0.25	0.25
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.28	1.28	1.28	0.17	0.17	0.17	1.91	1.92	1.92	0.28	0.28	0.28
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.36	1.36	1.36	0.18	0.18	0.18	1.94	1.94	1.94	0.30	0.30	0.30
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.38	1.38	1.38	0.20	0.21	0.21	2.08	2.10	2.09	0.32	0.32	0.32
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.33	1.33	1.33	0.18	0.18	0.18	1.90	1.91	1.91	0.26	0.27	0.27
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.35	1.35	1.35	0.18	0.18	0.18	1.93	1.94	1.93	0.28	0.28	0.28
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	1.37	1.37	1.37	0.19	0.19	0.19	1.99	2.04	2.01	0.30	0.30	0.30
SEm±		0.035	0.035	0.025	0.015	0.017	0.011	0.040	0.035	0.026	0.032	0.031	0.022
CD (P = 0.05)		0.101	0.102	0.070	NS	NS	NS	0.115	0.102	0.075	NS	NS	NS

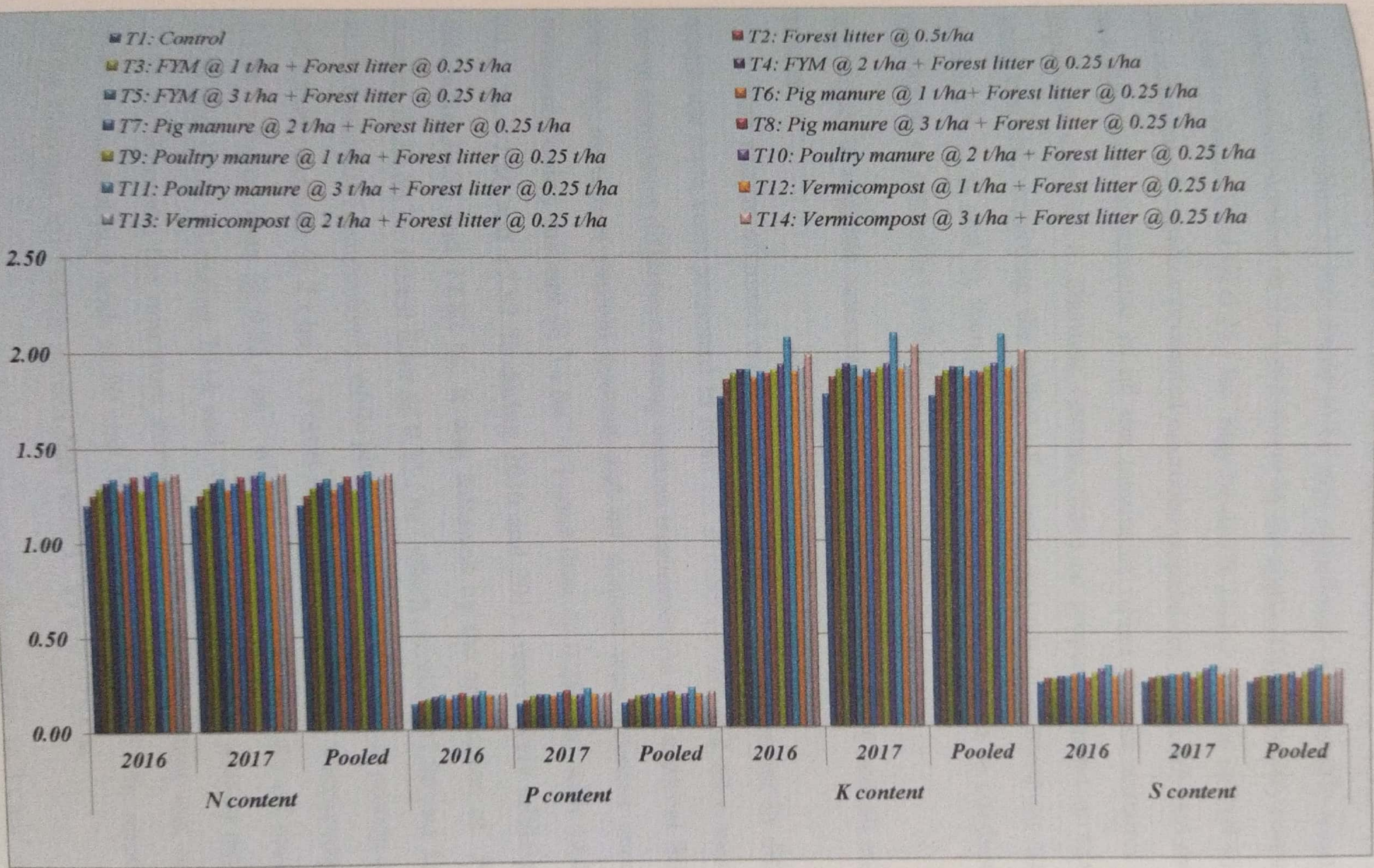


Fig 12. Effect of organic sources of nutrient on N, P, K and S content in stover (%)

higher N (6.27 % in seed and 2.47 % in stover) content over 50 % RDF (6.26 % and 2.46 %) where P was found to be non significant. The possible reason for higher nutrient content in seed and stover by the application of Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} may be due to higher organic carbon content and inclusion of organics promoted microbial population. The result also showed that there was an increase in all the treatments where organic manures were applied as compare to absolute control. Since no proper literature or citations were available regarding the effect of organic sources of nutrient on nutrient content (N, P, K and S), therefore no further comparison could be conducted to corroborate or contradict with the present findings.

4.5. Effect of organic sources of nutrient on protein content and oil content in seed

The results obtained on the protein content and oil content in different treatments have been presented in table 13. Protein content and oil content had shown significant difference among various treatments. As was apparent from the data, the maximum protein content and oil content was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 39.47 and 39.57 %, 17.80 and 17.83 % during 2016 and 2017, respectively while pooled data were 39.52 and 17.82 %. It was followed by the application of Poultry manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded 37.80 and 38.87 % in 2016 and 2017, respectively while pooled data were 38.33 % in protein content and Poultry manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} and Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded the same for oil content i.e 17.40 and 17.43 % during 2016 and 2017 repectively, while pooled data were 17.43 %. Whereas, the minimum protein content and oil content was recorded under the control plot with 35.80 and 35.90 %, 15.83 and 15.87 %, respectively during 2016 and 2017 while pooled data were 35.85 and 15.85 %.

Higher protein content in the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} might be due to the fact that greater amount of nitrogen is

Table 13. Effect of organic sources of nutrient on protein and oil content in seed

Treatments		Protein content (%)			Oil content (%)		
		2016	2017	Pooled	2016	2017	Pooled
T_1	Control	35.80	35.90	35.85	15.83	15.87	15.85
T_2	Forest litter @ 0.5t ha^{-1}	36.63	36.70	36.67	16.00	16.07	16.03
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	37.57	37.63	37.60	16.70	16.73	16.72
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	37.77	37.80	37.78	16.73	16.77	16.75
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	37.83	37.83	37.83	17.00	17.03	17.02
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	36.83	36.70	36.77	16.57	16.63	16.60
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	37.70	37.70	37.70	16.53	16.57	16.55
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	37.53	37.53	37.53	16.73	16.77	16.75
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	36.80	37.17	36.98	16.50	16.57	16.53
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	37.80	38.87	38.33	17.40	17.47	17.43
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	39.47	39.57	39.52	17.80	17.83	17.82
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	37.73	37.73	37.73	16.63	16.67	16.65
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	36.33	38.03	37.18	17.23	17.30	17.27
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	37.77	38.83	38.30	17.40	17.47	17.43
SEm±		0.58	0.26	0.32	0.366	0.360	0.257
CD (P = 0.05)		1.69	0.76	0.90	1.06	1.05	0.73

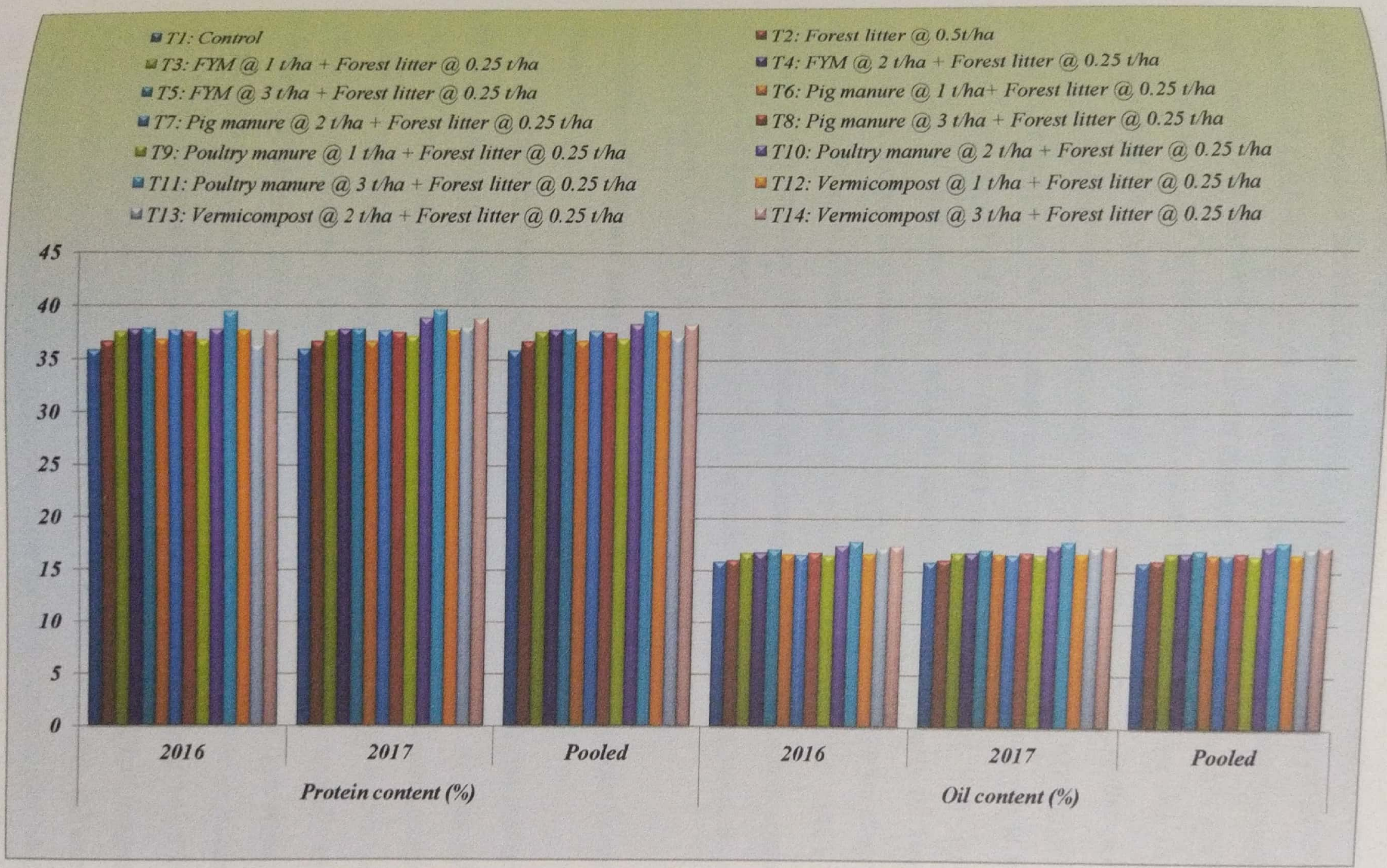


Fig 13. Effect of organic sources of nutrient on protein and oil content in seed

supplied by poultry manure and since nitrogen is the constituent of amino acids which is known to be building blocks of protein (Bommesha *et al.* 2012). Also, Deepa *et al.* (2014) in her study found out that application of poultry manure @ 2 t ha^{-1} resulted in increase in protein content (21.57 %) over control (20.12 %). The increase in the protein and oil content in the seed may be due to higher uptake of nutrients by the application of more organic manures. In the case of oil content the highest was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}. Increase in oil content might be attributed to balance nutrition and supply of organic nutrients seems to be involved in an increased conversion of primary fatty acids metabolites to end products of fatty acid resulting in higher oil content in seeds (Singh and Rai. 2004). Similar observation was also reported by Khaim *et al.* (2013) by the application of RDF 75% + PM @ 1 t ha^{-1} which recorded the highest oil content (20.98%) and protein content (45 %). Also Sardana (1990) reported that organic manure increased protein content and oil yield of toria and gobhi sarson over unmanured.

4.6. Effect of organic sources of nutrient on N, P, K and S uptake in seed and stover

The results obtained on the N, P, K & S uptake in seed and stover under different treatments have been perusal presented in table 14. As was apparent from the data, the maximum N, P, K & S uptake in seed and stover was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 145.9 and 146.2 kg ha^{-1}, 16.57 and 16.67 kg ha^{-1}, 50.4 and 50.6 kg ha^{-1}, 15.8 and 15.8 kg ha^{-1} during 2016 and 2017, respectively while pooled data were 146.1, 16.62, 50.5 and 15.8 kg ha^{-1}. It was followed by the application of Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded 142.7 and 143.0 kg ha^{-1}, 15.70 and 15.65 kg ha^{-1}, 49.5 and 49.6 kg ha^{-1}, 14.9 and 15.0 kg ha^{-1}, respectively while pooled data were 142.9, 15.65, 49.6 and 15 kg ha^{-1}. Whereas, the minimum N, P, K & S uptake in seed and stover was recorded in the control plot with 123.3 and 124.3 kg ha^{-1}, 12.34 and 12.40 kg ha^{-1}, 40.7 and 40.9 kg ha^{-1}, 10.2 and 10.4 kg ha^{-1} while pooled data were 123.8, 12.37, 40.8, 10.3 kg ha^{-1}, respectively during 2016 and 2017. Whereas, P and S were found to be significantly not affected by any of the treatments.

The result pertaining on the influence of different organic nutrient sources on the nutrient uptake by the plant showed significant result for N and K. The highest N, P, K and S uptake was however observed with the application of Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}. The increase in availability of nutrients in soil due to the application of poultry manure expectedly led to increase uptake of N, P, and K (Agbede *et al.* 2008). The increase in N uptake by the plant (seed and Stover) may be due to the increased availability of N in the soil owing to the application of poultry manure and forest litter. This result was in accordance with the findings of Madhumita *et al.*, (1991) where it was reported that application of poultry manure was superior to application of FYM in improving N, P, K and S uptake in plants particularly in acid soils with low organic carbon content. The increase in N uptake might be attributed to the increase in size and number of nodules and thereby increasing the fixation of N by the plant and also due to the utilization of carbohydrates for protein synthesis as reported by Najar *et al.*, in 2011. Also, Shepherd and Withers in 1999 reported similar result in which N and P uptake in plants was increased since, 74 % of total P and 40 % of total N in poultry manure was in available form. Kumar *et al.*, (2006) also reported that application of 50 % N + 100 % N supplied through green leaf manure, poultry manure and crop residue compost significantly resulted in higher N uptake (122 kg ha^{-1}) in soybean as compared to that of control plot (823 kg ha^{-1}). P and S uptake in seed and stover was found to be non significant in all the cases. Similar result was also reported by Kumar *et al.*, (2006) on his experiment on nutrient uptake and availability and seed yield of soybean under rainfed condition in Karnataka where he reported that application of 50 % N through green leaf manure, poultry manure and crop residue compost resulted in higher nutrient uptake (122, 37 and 110 kg of NPK ha^{-1}, respectively) and higher seed yield (1793 kg ha^{-1}) as compared with absolute control (823 kg

Table 14. Effect of organic sources of nutrient on N, P, K and S uptake (seed and stover)

Treatments		N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})			S uptake (kg ha^{-1})		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	Control	123.3	124.3	123.8	12.34	12.40	12.37	40.7	40.9	40.8	10.2	10.4	10.3
T_2	Forest litter @ 0.5t ha^{-1}	126.4	126.7	126.6	12.75	12.83	12.79	43.2	43.3	43.3	10.8	11.0	10.9
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	134.7	135.0	134.9	13.30	13.27	13.28	44.2	44.3	44.3	12.3	12.5	12.4
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	137.8	138.1	138.0	14.00	14.07	14.03	46.5	46.6	46.5	12.7	12.8	12.8
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	138.9	139.2	139.1	14.43	14.50	14.47	47.5	47.6	47.5	13.6	13.7	13.7
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	132.7	133.1	132.9	13.43	13.57	13.50	46.0	46.2	46.1	11.4	11.6	11.5
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	137.1	137.4	137.3	13.80	13.87	13.83	45.2	45.5	45.3	13.5	13.7	13.6
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	138.7	139.4	139.0	14.10	14.27	14.18	46.5	46.8	46.6	14.7	14.8	14.7
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	131.1	134.1	132.6	13.30	13.43	13.37	45.5	45.6	45.6	12.5	12.6	12.5
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	140.8	141.1	140.9	14.60	14.70	14.65	48.1	48.3	48.2	13.7	13.8	13.8
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	145.9	146.2	146.1	16.57	16.67	16.62	50.4	50.6	50.5	15.8	15.8	15.8
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	133.9	135.9	134.9	14.40	14.53	14.47	46.2	46.3	46.3	13.3	13.5	13.4
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	139.3	140.0	139.7	14.60	14.67	14.63	47.4	47.5	47.4	13.6	13.8	13.7
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	142.7	143.0	142.9	15.70	15.60	15.65	49.5	49.6	49.6	14.9	15.0	15.0
SEm±		4.17	3.84	2.83	1.19	0.78	0.71	1.61	1.63	1.14	1.18	1.33	0.89
CD (P = 0.05)		12.12	11.17	8.04	NS	NS	NS	4.67	4.74	3.25	NS	NS	NS

Fig 14. Effect of organic sources of nutrient on N, P, K and S uptake (seed and stover)

ha^{-1}). Similarly, increased uptake of N, P, K, Ca and Mg in tomato plant by the application of poultry manure was also observed by Ewulo *et al.*, (2008).

4.7. Effect of organic sources of nutrient on available N, P, K and S after harvest.

The results obtained on the available N, P, K & S in the soil after harvest in different treatments have been perusal presented in table 15. As was apparent from the data, the maximum available N, P & S in the soil after harvest was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 220 and 220.7 kg ha^{-1}, 22.57 and 22.77 kg ha^{-1}, 19.30 and 19.37 kg ha^{-1} during 2016 and 2017, respectively while pooled data were 220.3, 22.67 and 19.33 kg ha^{-1}. It was followed by the application of Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded 217.7 and 218 kg ha^{-1}, 22.20 and 22.30 kg ha^{-1}, 18.93 and 19 kg ha^{-1}, respectively while pooled data were 217.8, 22.25 and 18.97 kg ha^{-1}. Whereas, the minimum available N, P, K & S in soil after harvest was recorded in the control plot with 191.3 and 192 kg ha^{-1}, 15.05 and 15.17 kg ha^{-1}, 118 and 131.7 kg ha^{-1}, 15.57 and 15.60 kg ha^{-1} while pooled data were 191.7, 15.11, 124.8 and 15.58 kg ha^{-1}, respectively during 2016 and 2017. Whereas the maximum available K in soil after harvest of the crop was found in the treatment Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded 134 and 134.3 kg ha^{-1}, respectively during 2016 and 2017 while pooled data was 134.2 kg ha^{-1} which was followed by the application of Vermicompost @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 131 and 131.7 kg ha^{-1}, respectively with pooled data of 131.3 kg ha^{-1}. However, available P and S was recorded non-significant by the various treatments.

The application of organic manures might have led to the increase of soil microbes thus creating favourable soil conditions for higher fixation and hence the higher balance after of the nutrients after harvest. Soybean being a legume crop and better nodulation in the above stated treatment might have led to more nutrients remaining in the soil after harvest of the crop. Treatment of the seed

Table 15. Effect of organic sources of nutrient on available N, P, K and S of soil after harvest (kg ha^{-1})

Treatments		Available N			Available P			Available K			Available S		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	Control	191.3	192.0	191.7	15.05	15.17	15.11	118.0	131.7	124.8	15.57	15.60	15.58
T_2	Forest litter @ 0.5t ha^{-1}	195.0	195.7	195.3	16.90	16.93	16.92	120.0	120.7	120.3	16.80	16.87	16.83
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	199.0	199.3	199.2	17.40	17.47	17.43	124.7	126.3	125.5	17.73	17.80	17.77
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	203.3	204.0	203.7	18.27	18.30	18.28	125.7	126.0	125.8	17.90	17.97	17.93
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	209.0	209.7	209.3	19.90	19.93	19.92	128.3	129.0	128.7	18.10	18.17	18.13
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	199.0	199.7	199.3	18.87	18.93	18.90	123.0	123.7	123.3	17.33	17.40	17.37
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	205.0	205.7	205.3	20.40	20.47	20.43	124.3	125.0	124.7	17.67	17.73	17.70
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	207.3	208.0	207.7	21.60	21.67	21.63	127.0	127.7	127.3	17.80	17.87	17.83
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	203.3	204.3	203.8	20.00	20.07	20.03	126.3	127.0	126.7	17.50	17.57	17.53
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	216.0	216.7	216.3	21.83	21.90	21.87	129.0	129.7	129.3	18.30	18.37	18.33
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	220.0	220.7	220.3	22.57	22.77	22.67	130.7	124.3	127.5	19.30	19.37	19.33
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	204.0	205.0	204.5	20.00	20.07	20.03	122.0	122.3	122.2	17.90	17.93	17.92
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	214.3	215.7	215.0	20.40	20.47	20.43	131.0	131.7	131.3	18.40	18.47	18.43
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	217.7	218.0	217.8	22.20	22.30	22.25	134.0	134.3	134.2	18.93	19.00	18.97
SEm±		4.35	4.92	3.28	1.95	1.93	1.37	3.03	3.10	2.17	0.77	0.77	0.54
CD (P = 0.05)		12.63	14.30	9.31	NS	NS	NS	8.80	9.01	6.15	NS	NS	NS

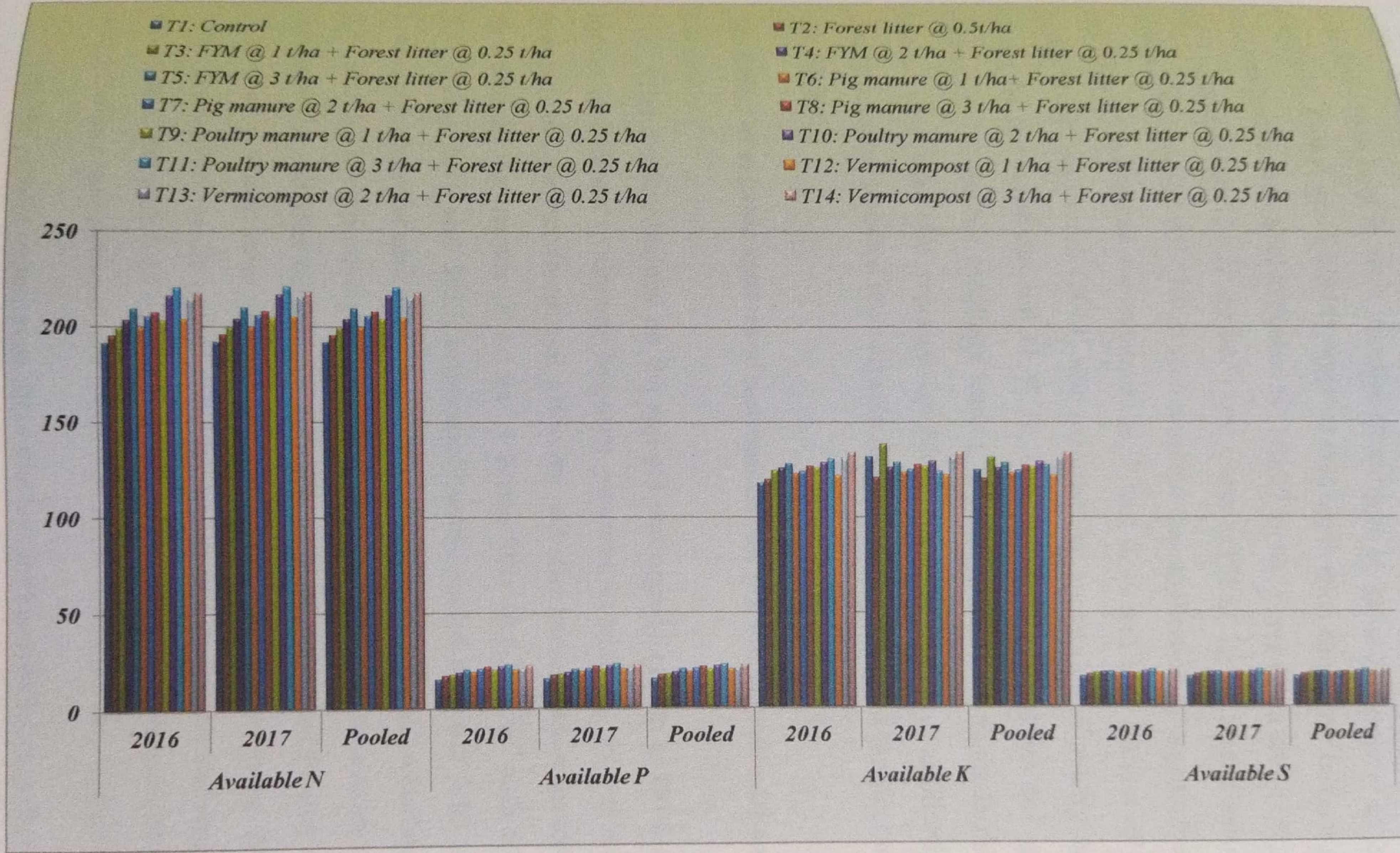


Fig 15. Effect of organic sources of nutrient on available N, P, K and S of soil after harvest (kg per ha)

with *rhizobium* before sowing also resulted in showing more number of root nodules which help in more fixation of nitrogen in the soil (Kumar *et al.* 2006). Similarly, Deepa *et al.* (2014) reported that application of poultry manure @ 2 t ha^{-1} resulted in increased available N (140.27 kg ha^{-1}) over neem cake (131.16 kg ha^{-1}), castor cake (131.32 kg ha^{-1}) and control (121.82 kg ha^{-1}) after harvest of cowpea. Chesti and Ali (2012) also reported that application of organic manures significantly increased the available N, P and K in soil after harvest of green gram. Moyin-jesu *et al.* (2014) also reported that application of poultry manure @ 6 t ha increased the soil N, P, K, Ca and Mg concentrations and growth parameters of coconut seedlings leading to more available nutrients in the soil. Similar case was also reported by Moyin-jesu (2012) where application of poultry manure increased the available soil OM, N, P, K, Ca and Mg after harvest of cabbage.

4.8. Effect of organic sources of nutrient on soil pH and organic carbon after harvest

The results obtained on the soil pH and organic carbon in the soil after harvest in different treatments has been presented in table 16. As was apparent from the data, the maximum soil pH in the soil after harvest was recorded under the treatment Pig manure @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 5.83 and 5.87 during 2016 and 2017, respectively while pooled data was 5.85 and the lowest was recorded under the treatment Forest litter @ 0.5 t ha^{-1} which recorded 5.47 and 5.53, respectively with pooled data of 5.50. The maximum organic carbon in the soil after harvest was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 1.14 and 1.20 % during 2016 and 2017, respectively while pooled data was 1.17 % and the lowest was recorded in the control plot with 0.88 and 0.85 % , respectively with pooled data of 0.87 %. The difference was however, not found significant in soil pH and organic carbon.

In the present experiment, there was no significant effect on soil pH by the various treatments. After the harvest of soybean, slight increase in soil pH could

Table 16. Effect of organic sources of nutrient on soil pH and organic carbon after harvest

Treatments		pH			Organic carbon (%)		
		2016	2017	Pooled	2016	2017	Pooled
T_1	Control	5.57	5.63	5.60	0.88	0.85	0.87
T_2	Forest litter @ 0.5t ha^{-1}	5.47	5.53	5.50	0.90	0.91	0.91
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	5.53	5.60	5.57	0.97	0.98	0.98
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.57	5.63	5.60	1.01	1.02	1.02
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	5.73	5.80	5.77	1.03	1.10	1.06
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.83	5.87	5.85	0.99	0.99	0.99
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.67	5.73	5.70	1.02	1.03	1.03
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.57	5.63	5.60	1.08	1.12	1.10
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.57	5.63	5.60	0.92	0.93	0.92
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.70	5.77	5.73	0.96	0.97	0.97
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.77	5.83	5.80	1.14	1.20	1.17
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.67	5.73	5.70	0.97	0.98	0.98
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.77	5.83	5.80	0.99	1.00	0.99
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	5.80	5.83	5.82	1.09	1.13	1.11
SEm±		0.15	0.15	0.11	0.065	0.072	0.049
CD (P = 0.05)		NS	NS	NS	NS	NS	NS

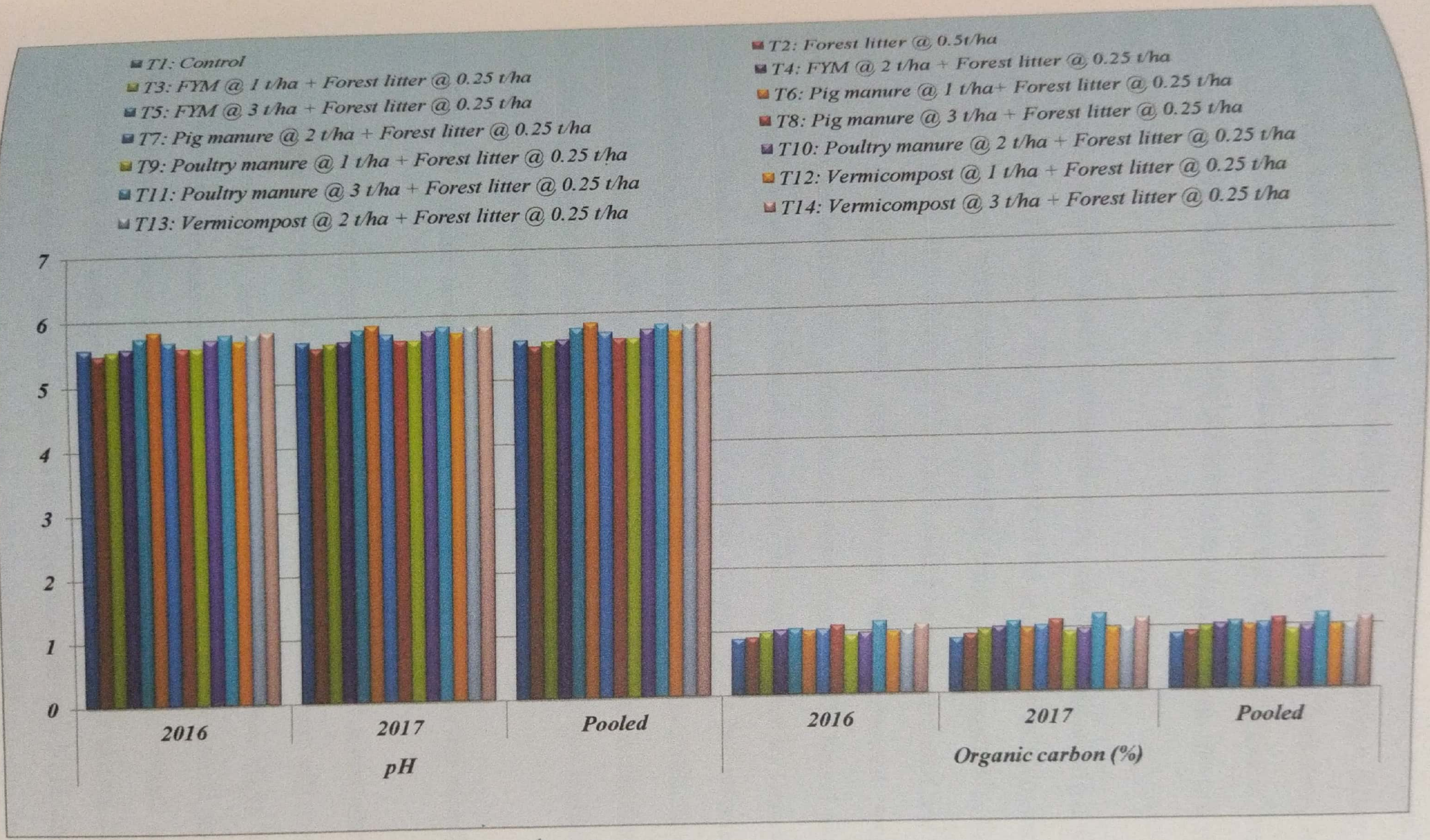


Fig 16. Effect of organic sources of nutrient on soil pH and organic carbon after harvest

be seen which may be because of the fact that leguminous crops acquire their grater part of nitrogen requirement from the air as diatomic nitrogen rather from the soil as NO_3 and their net effect lowers the soil pH (Ali and Venkatesh, 2009). Dikinya and Mufwanzala (2010) also observed that the application of manure irrespective of the application rate showed non significant on the pH of the amended soil.

As in the case of organic carbon also there was no significant effect by the various treatments. However, after the harvest of the crop, the maximum increase in the organic carbon was recorded in the plots which was treated with Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, which may be attributed due to the bulk posting of organic manure rich in nitrogen which enhanced microbial activity in the soil and thereby greater conversion of organically bound nitrogen to inorganic form by the activities of microbes. This was reported by Deepa *et al.* (2014) in her study where application of poultry manure @ 2 t ha^{-1} recorded the highest (0.69 %) as compare to FYM (0.59 %), vermicompost (0.62 %), neem cake (0.56 %), castor cake (0.58 %) and RDF (0.52 %). Similar results were also observed by Roy *et al.* (2014) where organic carbon content was highest after application of poultry manure as compare to cow dung.

4.9. Effect of organic sources of nutrient on physical properties of soil after harvest

The results obtained on physical properties of soil after harvest of the crop are highlighted in table 17. Though there was no significant effect on soil physical properties by the various treatments after harvest, some slight increase were observed. The maximum water holding capacity was observed under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which recorded 24.50 and 24.70 %, with pooled data of 24.60 %, respectively during 2016 and 2017. Whereas the lowest was recorded in the control plot with 14.60 and 14.87 % while pooled data was 14.83 % during 2016 and 2017 respectively. In case of infiltration rate the highest was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 25.57 and 25.60 mm hr^{-1}, respectively during 2016 and 2017 with pooled data of 25.60 mm hr^{-1} and lowest was observed under the treatment FYM @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 20.70 and 20.83 mm hr^{-1} with pooled data of 20.77 mm hr^{-1} during both the years. Both bulk density and particle density were observed maximum with the application of FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 1.34 and 1.34 g cm^{-3}, 2.17 and 2.13 g cm^{-3}, respectively during 2016 and 2017 while pooled data were 1.34 and 2.15 g cm^{-3} whereas the lowest bulk density was recorded under Vermicompost @ 1 and 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 1.25 and 1.26 g cm^{-3}, 1.27 and 1.25 g cm^{-3}, respectively during 2016 and 2017 while pooled data were 1.26 and 1.26 g cm^{-3}. Whereas in case of particle density the lowest was recorded under the treatment Poultry manure @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 1.93 and 1.97 g cm^{-1}, respectively while pooled data was 1.95 g cm^{-1} during both the years. Total porosity however, was recorded highest under the treatment Vermicompost @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 39 and 40 % with pooled data of 39.50 % during 2016 and 2017 and lowest in Poultry manure @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 33 and 34 %, respectively while pooled data was 33.50 % during both the years.

The influence of organic matter on soil biological and physical fertility is well known. The results concerning soil physical properties of soil health such as WHC, infiltration rate, BD, PD and porosity revealed that there were no significant effects of different treatment on these parameters. Such non-significant effect was quite acceptable as physical properties of soil remain unchanged in short course of time. Addition of organic manures can improve the soil physical properties is a well-documented and scientifically proven fact but any significant changes in the soil physical properties can be recorded only on long term application of organic manure. Here, all the treatment received organic sources therefore, non significant result was anticipated. Similar, results were reported by Anonymous (2013). Since, there was no significant effect on the soil physical properties by the various treatments therefore no further comparison

Table 17. Effect of organic sources of nutrient on physical status of soil after harvest

Treatments		Water holding capacity (%)			Infiltration (mm hr^{-1})			Porosity (%)			Bulk density (g cm^{-3})			Particle density (g cm^{-3})		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T_1	Control	14.80	14.87	14.83	21.40	21.47	21.43	33.33	34.67	34.00	1.33	1.32	1.33	2.00	2.03	2.02
T_2	Forest litter @ 0.5t ha^{-1}	16.23	16.17	16.20	21.50	21.60	21.55	37.33	38.33	37.83	1.31	1.30	1.31	2.10	2.13	2.12
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	16.37	16.43	16.40	21.60	21.73	21.67	35.00	36.33	35.67	1.31	1.31	1.31	2.03	2.07	2.05
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	16.57	16.70	16.63	20.70	20.83	20.77	38.33	36.67	37.50	1.34	1.34	1.34	2.17	2.13	2.15
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	20.30	20.63	20.47	23.10	23.20	23.15	33.33	34.33	33.83	1.33	1.33	1.33	2.00	2.03	2.02
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	17.30	17.50	17.40	21.60	21.80	21.70	37.00	35.33	36.17	1.33	1.33	1.33	2.10	2.07	2.08
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	16.30	16.30	16.30	21.70	21.93	21.82	37.33	35.33	36.33	1.31	1.31	1.31	2.10	2.07	2.08
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	19.27	19.77	19.52	22.23	22.37	22.30	34.67	35.33	35.00	1.30	1.31	1.31	2.00	2.03	2.02
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	18.20	18.27	18.23	22.00	22.13	22.07	33.00	34.00	33.50	1.29	1.29	1.29	1.93	1.97	1.95
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	22.27	22.40	22.33	24.47	24.67	24.57	35.67	36.33	36.00	1.28	1.29	1.29	2.00	2.00	2.00
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	24.50	24.70	24.60	25.57	25.63	25.60	37.33	38.33	37.83	1.31	1.30	1.31	2.10	2.13	2.12
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	17.57	17.83	17.70	22.10	22.27	22.18	37.33	37.67	37.50	1.25	1.26	1.26	2.00	2.03	2.02
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	21.10	21.37	21.23	24.03	24.30	24.17	39.00	40.00	39.50	1.27	1.25	1.26	2.10	2.10	2.10
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	22.97	23.20	23.08	24.83	24.90	24.87	38.33	38.00	38.17	1.29	1.30	1.29	2.10	2.10	2.10
SEm±		2.38	2.46	1.71	1.66	1.66	1.17	3.10	3.26	2.25	0.27	0.27	0.19	0.28	0.27	0.19
CD (P = 0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

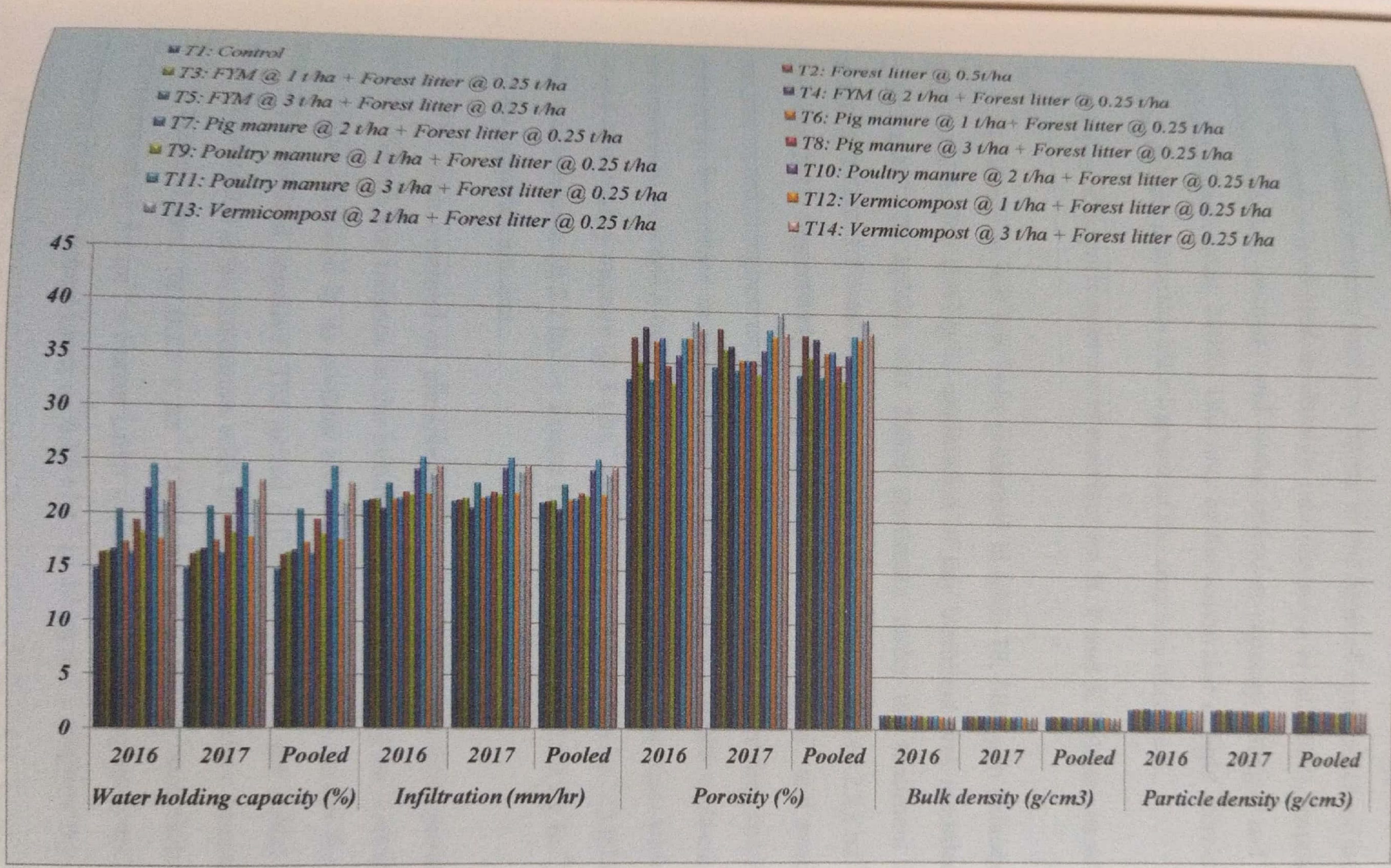


Fig 17. Effect of organic sources of nutrient on physical status of soil after harvest

could be conducted to corroborate or contradict with the present findings. Incorporation of organic manures either in the form of crop mulch or any other organic manures increased infiltration rate (Acharya *et al.* 1988), improve soil shunting, increased porosity and water retention capacity (Bhagat and Verma 1991 and Agbede *et al.* 2008). This may be the reason that a slight increase in all the soil physical properties after harvest of the crop was observed.

4.10. Effect of organic sources of nutrient on N, P and K balance in soil after harvest

N balance in soil has been presented in table 18. Nitrogen balance at the initial stage before sowing or application of any treatment was recorded to be 215.3 kg ha^{-1}. Its uptake was found maximum under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 145.9 and 146.2 kg ha^{-1} during 2016 and 2017, respectively while pooled data was 146 kg ha^{-1} and available N was also recorded highest under the same treatment. Though nutrient balance was expected to be positive in all the plots except control the results showed that all the treatments recorded a loss in the soil nitrogen except for the plots which were treated with Poultry manure @ 3 t ha^{-1} + Forest Litter @ 0.25 t ha^{-1} (5.03 kg ha^{-1}) and Poultry manure @ 2 t ha^{-1} + Forest Litter @ 0.25 t ha^{-1} (1.03 kg ha^{-1}) which recorded a positive amount.

The result obtained on phosphorus balance in soil has been presented in table 19. Phosphorus balance in the initial soil sample (16.7 kg ha^{-1}) showed that there was an increased in its content after harvest of the crop except for control plot which resulted negative. The actual difference between the initial and the final was recorded to be maximum with the application of Poultry manure @ 3 t ha^{-1} + Forest Litter @ 0.25 t ha^{-1} (5.97 kg ha^{-1}) which was followed by Vermicompost @ 3 t ha^{-1} + Forest Litter @ 0.25 t ha^{-1} (5.55 kg ha^{-1}) and Poultry manure @ 2t ha^{-1} + Forest Litter @ 0.25 t ha^{-1} (5.17 kg ha^{-1}), respectively.

Potassium balance in soil after harvest was recorded highest in the treatment Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (7.97 kg ha^{-1}) as can be seen from table 20. It was followed by Vermicompost @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (5.11 kg ha^{-1}) and Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (4.63 kg ha^{-1}). All the treatments showed a positive balance in the actual difference between the initial and the final except for the seven treatments viz .control, Forest litter @ 0.5 t ha^{-1}, FYM @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, FYM @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, Pig manure @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, Pig manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} and Vermicompost @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} which were recorded negative. According to the balance sheet the highest loss of K was recorded in control plot (-8.03 kg ha^{-1}).

Table 18. Effect of organic sources of nutrient on nitrogen balance in soil (kg ha^{-1})

	Treatments	Initial status (A)	Nutrients added (B)	Nutrient Uptake by seed+stover (C)	Expected Nutrient balance (D= (A+B)-C)	Actual Nutrient balance (E)	Apparent gain or loss (F = E-D)	Actual difference of initial and final (G = E-A)
T_1	Control	215.3	0	123.8	91.5	191.67	100.17	-23.63
T_2	Forest litter @ 0.5t ha^{-1}	215.3	10.2	126.57	98.93	195.33	96.4	-19.97
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	215.3	10.4	134.87	90.83	199.17	108.34	-16.13
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	215.3	15.3	137.97	92.63	203.67	111.04	-11.63
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	215.3	20.5	139.07	96.73	209.33	112.6	-5.97
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	215.3	13.3	132.9	95.7	199.33	103.63	-15.97
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	215.3	21.4	137.27	99.43	205.33	105.9	-9.97
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	215.3	29.7	139.03	105.97	207.67	101.7	-7.63
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	215.3	30.4	132.63	113.07	208.83	95.23	-6.47
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	215.3	55.7	149.93	121.47	216.33	94.86	1.03
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	215.3	80.3	146.07	149.53	220.33	70.8	5.03
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	215.3	25.4	134.87	105.83	204.5	98.67	-10.8
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	215.3	45.6	139.67	121.23	215	93.77	-0.3
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	215.3	65.8	142.87	138.23	217.83	79.6	2.53

Table 19. Effect of organic sources of nutrient on phosphorus balance in soil (kg ha^{-1})

	Treatments	Initial status (A)	Nutrients added (B)	Nutrient Uptake by seed+stover (C)	Expected Nutrient balance (D= (A+B)-C)	Actual Nutrient balance (E)	Apparent gain or loss (F = E-D)	Actual difference of initial and final (G = E-A)
T_1	Control	16.7	0	12.37	4.33	15.12	10.79	-1.58
T_2	Forest litter @ 0.5t ha^{-1}	16.7	5.1	12.79	9.01	16.92	7.91	0.22
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	16.7	4.6	13.28	8.02	17.43	9.41	0.73
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	16.7	6.3	14.03	8.97	18.28	9.31	1.58
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	16.7	8.2	14.47	10.43	19.92	9.49	3.22
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	16.7	9.2	13.5	12.4	18.9	6.5	2.22
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	16.7	16.3	13.83	19.17	20.43	1.26	3.73
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	16.7	23.4	14.18	25.92	21.63	-4.29	4.93
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	16.7	19.2	13.37	22.53	20.03	-2.5	3.33
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	16.7	35.4	14.65	37.45	21.87	-15.58	5.17
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	16.7	51.6	16.62	51.68	22.67	-29.01	5.97
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	16.7	12.3	14.47	14.53	20.03	5.5	3.34
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	16.7	22.5	14.63	24.57	20.43	-4.14	3.73
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	16.7	32.1	15.65	33.15	22.25	-10.9	5.55

Table 20. Effect of organic sources of nutrient on potassium balance in soil (kg ha^{-1})

	Treatments	Initial status (A)	Nutrients added (B)	Nutrient Uptake by seed+stover (C)	Expected Nutrient balance (D= (A+B)-C)	Actual Nutrient balance (E)	Apparent gain or loss (F = E-D)	Actual difference of initial and final (G = E-A)
T_1	Control	126.2	0	40.78	85.42	118.17	32.75	-8.03
T_2	Forest litter @ 0.5t ha^{-1}	126.2	10.4	43.27	93.3	120.33	27.03	-5.87
T_3	FYM @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	126.2	10.2	44.25	92.15	124.83	32.68	-1.37
T_4	FYM @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	126.2	15.1	46.53	94.77	125.82	31.05	-0.38
T_5	FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}	126.2	20.4	47.52	99.08	128.67	29.59	2.47
T_6	Pig manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	126.2	10.2	46.12	90.28	123.33	33.05	-2.87
T_7	Pig manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	126.2	15.4	45.33	96.27	124.67	28.4	-1.53
T_8	Pig manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	126.2	20.6	46.63	100.17	127.32	27.15	1.12
T_9	Poultry manure @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	126.2	19.7	45.57	100.43	126.67	26.24	0.47
T_{10}	Poultry manure @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	126.2	33.4	48.22	111.38	129.33	17.95	3.13
T_{11}	Poultry manure @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	126.2	47.2	50.53	122.87	130.83	7.96	4.63
T_{12}	Vermicompost @ 1 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	126.2	20.7	46.25	100.65	122.17	21.52	-4.03
T_{13}	Vermicompost @ 2 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	126.2	35.8	47.43	114.57	131.31	16.74	5.11
T_{14}	Vermicompost @ 3 t ha^{-1}+ Forest litter @ 0.25 t ha^{-1}	126.2	50.6	49.57	127.23	134.17	6.94	7.97

Chapter – 5

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

A field experiment was conducted during the *kharif* season of 2016 and 2017 at the Instructional-cum-research farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema to study the "Response of soybean (*Glycine max* L. Merill) to organic sources of nutrient". The experimental field was set up in Randomized Block Design with three replications. There were fourteen nutritional schedule treatments on one variety of soybean (JS 97-52). The response of soybean to various treatments were evaluated with growth attributes, yield attributes and yield, nutrient content, nutrient uptake by crop, soil physical properties before sowing and after harvest of the crop, protein and oil content in seed and available nutrients before sowing and after harvest of the crop. The salient features of this investigation are enumerated as under:

1. Application of Poultry manure @ 3t ha^{-1} + Forest litter @ 0.25t ha^{-1} showed maximum plant height (32.33 and 33 cm, 65.33 and 66 cm, 71 and 71.67cm) with pooled data as 32.67, 65.67 and 71.33 cm, respectively among the other treatment combinations which was followed by Vermicompost @ 3t ha^{-1} + Forest litter @ 0.25t ha^{-1} (30.33 and 31 cm, 58 and 59 cm, 67 and 68 cm) with pooled data of 30.67, 58.50 and 67.50 cm at 30, 60 and 90 DAS during 2016 and 2017. However, the minimum plant height was recorded in the control plot (19.33 and 19.43 cm, 41 and 42 cm, 46.33 and 47.33 cm) with pooled data as 19.73, 41.50 and 46.83 cm.
2. The number of leaves $plant^{-1}$ was significantly increased with the application of Poultry manure @ 3t ha^{-1} + Forest litter @ 0.25t ha^{-1}. Application of Poultry manure @ 3t ha^{-1} + Forest litter @ 0.25t ha^{-1} produced the maximum number of leaves (8.33 and 8.67, 37 and 38, 39 and 40.33) with pooled data as 8.50, 37.50 and 39.67, respectively at 30, 60 and 90 DAS during 2016 and 2017 among the other nutritional schedules. While a minimum of 3.33 and

3.67, 13.67 and 15, 15.67 and 17 number of leaves with pooled data of 3.50, 14.33 and 16.33 was recorded in the control plot.

3. At 30 and 60 DAS, the number of nodules plant^{-1} were found highest with the application of FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (24.63 and 24.90, 52.27 and 52.73) in 2016 and 2017 while pooled data was 24.77 and 52.50 followed by Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (22.17 and 21.93, 49.10 and 49.87) with pooled data as 22.05 and 49.84 and the least number of nodules plant^{-1} was recorded in control plot (9.10 and 9.47, 31.23 and 31.80) with pooled data of 9.28 and 31.52.

4. The highest nodule fresh weight and nodule dry weight was observed from the application of FYM @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (0.36 and 0.36 g, 0.89 and 0.89 g, 0.074 and 0.075 g, 0.21 and 0.21 g) with pooled data as 0.36 and 0.89 g, 0.074 and 0.21 g at 30 and 60 DAS during 2016 and 2017 as compared to the other nutritional schedule. Significantly least weight was recorded in the control plot.

5. In case of dry matter production at 30 and 60 DAS, application of Poultry manure @ 3t ha^{-1} + Forest litter @ 0.25t ha^{-1} recorded the highest plant biomass (2.07 and 2.08 g, 32.40 and 32.53 g) with pooled data as 2.07 and 32.47 g, respectively during 2016 and 2017 and it was followed by application of Vermicompost @ 3t ha^{-1} + Forest litter @ 0.25t ha^{-1} and FYM @ 2t ha^{-1} + Forest litter @ 0.25t ha^{-1}. The control plot at 30 and 60 DAS (1.17 and 1.21 g, 17.43 and 17.57 g) with pooled data as 1.19 and 17.50 g was found to produce the least plant biomass.

6. In case of yield attributes, the number of seeds pod^{-1} was not significantly affected by any of the treatment applied. Both pods plant^{-1} and filled pods plant^{-1} was recorded maximum under treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (48.03 and 48.63, 44.27 and 44.73) in the year 2016 and 2017 while pooled data were 48.33 and 44.50 which was followed by Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (46.80 and 47.13, 42.67 and 42.83) with the pooled data of 46.97 and 42.75. The minimum pods plant^{-}

^{1} and filled pods plant^{-1} was recorded in the Control plot (35.23 and 36.50, 32.93 and 33.07) during both the years while pooled data were 35.87 and 33.00.

7. Seed yield was recorded significantly the highest under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (1777 and 1784 kg ha^{-1}) while pooled data was 1780.7 kg ha^{-1} during 2016 and 2017. It was followed by the application of Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (1658 and 1681 kg ha^{-1}) and Poultry manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (1556 and 1567.7 kg ha^{-1} while pooled data were 1669.8 and 1561.8 kg ha^{-1}. Whereas, the minimum seed yield was recorded under the Control plot (1121.3 and 1152 kg ha^{-1}) while pooled data was 1136.7 kg ha^{-1} during 2016 and 2017, respectively.
8. Stover yield was recorded significantly highest under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (2277 and 2288.7 kg ha^{-1}) while pooled data was 2176.8 kg ha^{-1} during 2016 and 2017 and followed by the application of Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (2158.3 and 2195.3 kg ha^{-1}) and Poultry manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (2056 and 2068.7 kg ha^{-1}), while pooled data were 2176.8 and 2062.3 kg ha^{-1}. Whereas, the minimum stover yield was recorded under the Control plot (1621.3 and 1644.7 kg ha^{-1}) while pooled data was 1633 kg ha^{-1}, respectively.
9. The highest biological yield (4054 and 4073 kg ha^{-1}) was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with pooled data as 4063.5 kg ha^{-1} during 2016 and 2017, respectively. It was followed by the application of Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (3816.7 and 3876.7 kg ha^{-1}) and Poultry manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (3612 and 3656.3 kg ha^{-1}),while pooled data were 3846.7 and 3634.2 kg ha^{-1}, respectively. Whereas, the minimum biological yield was recorded under the control plot (2742.7 and 2793 kg ha^{-1}) with pooled data as 2767.8 kg ha^{-1} during 2016 and 2017, respectively.

10. Seed index was found to be highest under the treatment Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (10.94 and 10.97 %) during 2016 and 2017, respectively while pooled data was 10.95 %. Whereas, harvest index was found to be highest in the case of Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} with 43.29 and 43.27 % during 2016 and 2017, respectively while pooled data was 43.28 %. However, both in seed index and harvest index the differences were not found significant.

11. N, P, K & S content in seed had shown significant difference among various treatments. However, only N & K content in seed was found out to be significant. Whereas, P and S were found to be significantly not affected by any of the treatments. However, the maximum N, P, K and S content in seed was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (5.46 and 5.47 %, 0.39 and 0.39 %, 1.51 and 1.52 %, 0.29 and 0.29 %) during 2016 and 2017 with pooled data as 5.39, 0.37, 1.50 and 0.27 %, respectively. The minimum N, P, K & S content in seed was recorded in the control plot (4.72 and 5.07 %, 0.30 and 0.26 %, 1.26 and 1.26 %, 0.18 and 0.18 %) with pooled data as 4.89, 0.28, 1.26 and 0.18 % during 2016 and 2017, respectively.

12. In the case of nutrient content in stover, the maximum N, P, K & S content was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (1.38 and 1.38 %, 0.20 and 0.21 %, 2.08 and 2.10 %, 0.32 and 0.32 %) during 2016 and 2017, respectively with pooled data as 1.38, 0.21, 2.09 and 0.32 %. Whereas, the minimum N, P, K & S content in stover was recorded in the control plot (1.20 and 1.20 %, 0.13 and 0.13 %, 1.77 and 1.78 %, 0.23 and 0.23 %) with pooled data as 1.20, 0.13, 1.77 and 0.23 % during 2016 and 2017, respectively. However, P and S were found to be significantly not affected by any of the treatments.

13. Protein and oil content was recorded highest under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (39.47 and 39.57 %, 17.80 and 17.83 %) during 2016 and 2017, while pooled data were 39.52 and 17.82 %,

respectively. It was followed by the application of Poultry manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (37.80 and 38.87 % , 17.40 and 17.47 %) with pooled data as 38.33 and 17.43 %. Whereas, the minimum protein and oil content was recorded under the control plot (35.80 and 35.90 %, 15.83 and 15.87 %), with pooled data as 35.85 and 15.85 %.

14. The maximum N, P, K & S uptake in seed and stover was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (145.9 and 146.2 kg ha^{-1}, 16.57 and 16.67 kg ha^{-1}, 50.4 and 50.6 kg ha^{-1}, 15.8 and 15.8 kg ha^{-1}) during 2016 and 2017, while pooled data were 146.1, 16.62, 50.5 and 15.8 kg ha^{-1}, respectively and was followed by the application of Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (142.7 and 143.0 kg ha^{-1}, 15.70 and 15.65 kg ha^{-1}, 49.5 and 49.6 kg ha^{-1}, 14.9 and 15.0 kg ha^{-1}), respectively while pooled data were 142.9, 15.65, 49.6 and 15 kg ha^{-1}. Whereas, the minimum N, P, K & S uptake in seed and stover was recorded in the control plot (123.3 and 124.3 kg ha^{-1}, 12.34 and 12.40 kg ha^{-1}, 40.7 and 40.9 kg ha^{-1}, 10.2 and 10.4 kg ha^{-1}) with pooled data as 123.8, 12.37, 40.8, 10.3 kg ha^{-1}, respectively during 2016 and 2017. Whereas, in the case of uptake in seed and stover P and S were found to be significantly not affected by any of the treatments.

15. Available soil nutrient status after harvest of the crop was found to be significant in the case of N and K. However, in the case of available P and S, it was found non significant. The maximum available N, P & S in the soil after harvest was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (220 and 220.7 kg ha^{-1}, 22.57 and 22.77 kg ha^{-1}, 19.30 and 19.37 kg ha^{-1}) during 2016 and 2017 while pooled data were 220.3, 22.67 and 19.33 kg ha^{-1}, respectively which was followed by the application of Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (217.7 and 218 kg ha^{-1}, 22.20 and 22.30 kg ha^{-1}, 18.93 and 19 kg ha^{-1}) with pooled data as 217.8, 22.25 and 18.97 kg ha^{-1}, respectively. Whereas, the maximum available K in soil after harvest of the crop was found in the treatment Vermicompost @ 3 t

ha^{-1} + Forest litter @ 0.25 t ha^{-1} (134 and 134.3 kg ha^{-1}), during 2016 and 2017 while pooled data was 134.2 kg ha^{-1}, respectively which was followed by the application of Vermicompost @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}. The minimum available N, P, K & S in soil after harvest was recorded in the control plot (191.3 and 192 kg ha^{-1}, 15.05 and 15.17 kg ha^{-1}, 118 and 131.7 kg ha^{-1}, 15.57 and 15.60 kg ha^{-1}) with pooled data as 191.7, 15.11, 124.8 and 15.58 kg ha^{-1}, respectively during 2016 and 2017.

16. Soil pH after harvest was recorded highest under the treatment Pig manure @ 1 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (5.83 and 5.87) in 2016 and 2017 with pooled data as 5.85 and the lowest was recorded under the treatment Forest litter @ 0.5 t ha^{-1} (5.47 and 5.53) with pooled data of 5.50. Highest organic carbon in the soil after harvest was recorded under the treatment Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (1.14 and 1.20 %) in 2016 and 2017 with pooled data as 1.17 % and the lowest was recorded in the control plot (0.88 and 0.85 %) with pooled data of 0.87 %. The difference was however, not found significant in both soil pH and organic carbon.
17. It was found out that physical status of the soil viz. water holding capacity, infiltration rate, bulk density, particle density and porosity after harvest recorded non significant and was not affected by any of the given treatment.
18. In the case of nitrogen balance in soil, all the other treatments recorded a loss in the soil nitrogen except for the plots which were treated with Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (5.03 kg ha^{-1}) and Poultry manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (1.03 kg ha^{-1}) which recorded a positive amount.
19. Phosphorus balance in soil showed that there was an increased in its content after harvest except for control plot which resulted negative. The actual difference between the initial and the final was recorded to be maximum with the application of Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (5.97 kg ha^{-1}) which was followed by Vermicompost @ 2 t ha^{-1} + Forest litter @

0.25 t ha^{-1} (5.55 kg ha^{-1}) and Poultry manure @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (5.17 kg ha^{-1}), respectively.

20. Potassium balance in soil after harvest was recorded highest in the treatment Vermicompost @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (7.97 kg ha^{-1}). It was followed by Vermicompost @ 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (5.11 kg ha^{-1}) and Poultry manure @ 3 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} (4.63 kg ha^{-1}) and negative balance were recorded in the treatments *viz* .control, forest litter @ 0.5 t ha^{-1}, FYM @ 1 and 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1}, Pig manure @ 1 and 2 t ha^{-1} + Forest litter @ 0.25 t ha^{-1} and Vermicompost @ 1t ha^{-1} + Forest litter @ 0.25 t ha^{-1}. According to the balance sheet the highest loss of K was recorded in control plot (-8.03 kg ha^{-1}).

CONCLUSION

The findings of the present investigation revealed that among the fourteen organic schedules on nutrient management in soybean, application of Poultry manure @ 3t ha^{-1} + Forest litter @ 0.25 t ha^{-1} outperformed the performance of the remaining organic schedules in respect of growth, yield and yield attributes as well as quality attributes without compromising the nutrient status in soil and plant.

Chapter – 6

REFERENCES

REFERENCES

A.O.A.C. 1960. *Association of Official Agricultural Chemist*. Method of Analysis. Washington D. C 9th edition, pp 15-16.

Acharya C L, Kapur O C and Dixit S P. 1988. Moisture conservation for rainfed wheat production with alternative mulches and conservation tillage in the hills of north-west India. *Soil Tillage Research* **46**: 153-163.

Adeli A, Sistani K R, Rowe D E and Tewolde H. 2005. Effect of broiler litter on soybean production and soil nitrogen and phosphorus concentration. *Agronomy Journal* **97**(1):314-321.

Aeswar B V, Bainade S S, Kohire O D and Bainade P S. 2003. Integrated use of vermicompost and inorganic fertilizer in chickpea. *Annals of Plant and Physiology* **17**(2): 205-206.

Agbede T M, Ojeniyi S O and Adeyemo A J. 2008. Effect of poultry manure on soil physical and chemical properties, growth and grain yield of sorghum in Southwest, Nigeria. *American-Eurasian Journal of Sustainable Agriculture* **2**(1): 72-77.

Alabadan B A, Adeoye P A and Folorunso E A. 2009. Effects of different poultry wastes on physical, chemical and biological properties of soil. *Caspain Journal of Environmental Sciences* **7**: 31-35.

Ali M and Venkatesh M S. 2009. Pulses in improving soil health. *Indian Farming*, February 2009: 18-22.

Anonymous (2013). Ninth combined joint AGRESCO report. Natural Research management Subcommittee, NAU, Navsari.

Anup Das Tomar J M S, Patel D P and Munda G C. 2007. Effect of organic manures on the productivity of black gram with and without fertilizers. *Environment and Ecology* **25**(1): 15-18.

Aruna M G and Narsa Reddy V C. 1999. Effect of organic wastes on yield and its component on ground in paddy-groundnut cropping systems. *Environment and Ecology* **22**(4): 770-774.

Appavu K and Saravanan A. 1999. Effect of organic manure and tillage practices on soil physical properties and crop yield under sorghum-soybean cropping sequence. *Madras Agricultural Journal* **86**(10-12): 561-565.

Bachham P R and Sabale R N. 1996. Effect of different sources of N on growth parameters, yield and quality of Soybean. *Journal of Maharashtra Agricultural University.* **21**(2):224-247.

Bandyopadhyay K K, Ghosh P K, Chaudhary R S, Hati K M, Mandal K G and Mirsa A K 2004. Integrated nutrient management practices in Soybean (*Glycine max*) and Sorghum (*Sorghum bicolor*) in sole and intercropping systems in a vertisol. *Indian Journal of Agricultural Sciences* **74**(2): 55-63.

Baruah T C and Barthakur H P. 1997. A textbook of soil analysis. *Vikas Publishing House Pvt. Ltd.*, 576 Masjid Road, Jangpura, New Delhi – 110014.

Bhagat R M and Verma T S. 1991. Impact of rice straw management on soil physical properties and wheat yield. *Journal of Indian Society of Soil Science* **152**: 108-115.

Bobde G N, Deshpande R M, Khandalkar D M and Turankar V L. 1998. Nutrient management of Soybean (*Glycine max*)-based cropping system. *Indian Journal of Agronomy* **43**(3): 390 – 392.

Bommesha B, Naik A I, Mutthuraju G P, Panure A, Imran S and Prashantha P. 2012. Effect of organic manures on biological components of pigeon pea (*Cajanus cajan*). *Current Biotica* **6**: 171-180.

Black C A. 1965. Methods of Soil Analysis. *American Society of Agronomy, Inc, Publisher, Madison, Wisconsin, USA,* pp 171–5.

Bouwer H. 1986. Intake rate: cylinder infiltrometer. In: Klute, A. (ed) *Methods of soil analysis, physical and mineralogical methods*. Agronomy monograph no. 9, 2nd edn. ASA & SSSA, Madison, pp 825-844

Bray R H and Kurtz L T. 1945. Determination of total organic and available forms of phosphorus in soils. *Soil Science* **59**: 39–45.

Chandel A S, Pandey K N and Saxena S. C. 1989. Symbiotic nitrogen benefits by nodulated soybean to interplanted crops in Northern India. *Tropical Agriculture* **66**(10): 73 – 77.

Channabasavana A S, Yelamadi S G and Biradar D P. 2001. Effect of organics on seed yield, quality and storability of soybean (*Glycine max* (L.) Merril). *Indian Journal of Agronomy* **46**(33): 458-461.

Chapman D H and Pratt P F. 1961. Methods of analysis of soils, plants and water. University of California, Riverside, Division of Agriculture Science pp 309.

Chaturvedi S and Chandel A S. 2005. Influence of organic and inorganic fertilization on soil fertility and productivity of soybean (*Glycine max* L.). *Indian Journal of Agronomy* **50**(4): 311-313.

Chesnin L and Yien C H. 1951. Turbimetric determination of available sulphates. *Soil Science Society of America Proceedings* **28**: 149–51.

Chesti M H and Tahir Ali. 2012. Rhizospheric micro-flora, nutrient availability and yield of green gram (*Vigna radiata*) as influenced by organic manures, phosphate solubilizers and phosphorus levels in Alfisols. *Journal of Indian Society of Soil Science* **60**(1): 25-29.

Chiezey U F and Odunze A C. 2005. Soybean response to application of poultry manure and phosphorus fertilizers in the Sub-humid Savanna of Nigeria. *Journal of Ecology and Natural Environment* **1**(2): 23-31.

Chinnamuthu C R and Venkatakrishnan. 2001. Effect of integrationg inorganic fertilizer with vermicompost and vescularbuscular mycorrhizae (VAM) on the productivity of sunflower. *Madras Agricultural Journal* **88**(7-9): 424-427.

Das Anup, Tomar J M S, Patel D P and Munda G C. 2007. Effect of organic manures on the productivity of black gram with and without fertilizer. *Environment and Ecology* **25**(1): 15-18.

Deepa J, Gediya K M, Gupta S and Birari M M. 2014. Effect of organic manures on soil and quality parameters of cow pea (*Vigna unguiculata* (L,) Walp) under middle Gujarat conditions. *Agricultural Science Digest* **36**(3) 2016: 216-219.

Deshmukh, K K, Saraiya A B and Dubey D P. 2005. Effect of integrated nutrient management on productivity trends, economics and soil fertility in soybean-chickpea cropping system. *JNKVV Research Journal* **39**(2): 29–32.

Devi K N, Singh T B, Singh A H, Singh B N and Diana S. 2013. Influence of inorganic, biological and organic manures on nodulation and yield of soybean (*Glycine max* L.) and soil properties. *Australian Journal of Crop Science* 7(9): 1407-1415.

Dikinya O and Mufwanzala N. 2010. Chicken manure-Enhanced soil fertility and productivity: Effects of application rates. *Journal of Soil Science and Environmental Management* **1**: 46-54

Dubey S K. 1999. Comparative effectiveness of different methods of inoculation in soybean (*Glycine max*) in vertisol. *Indian Journal of Agricultural Science* **69**(6):461-464.

Edward D R and Daniel T C. 1992. A review on poultry manure. *Bioresouce and Technology* **41**: 91-102.

Eliakira Kisetu and Peter Heri. 2014. Effect of poultry manure and NPK (23: 10: 5) fertilizer on tomato variety Tanya grown on selected soil of Morogoro Region, Tanzania. *Asian Journal of Crop Science* **6**(2): 165-175.

Ewulo B S, Ojeniyi S O and Akanni D A. 2008. Effect of poultry manure on selected soil physical and chemical properties, growth, yield and nutrient status of tomato. *African Journal of Agricultural Research* **3**(9): 612-616.

FAOSTAT . 2013. htpp :// faostat. fao.org/

Gaur A C. 1991. Bulky organic manures and crop residues. In : Fertilizers, organic matter recyclable wastes and bio-fertilizers H. L. S Tendon, Fertilizer development and consultation organization, New Delhi.

Ghosh P K, Ajay, Bandyopadhyay K K, Manna M C, Mandal K G and Misra A. 2004. Comparative effectiveness of cattle manure, poultry manure, phosphocompost and fertilizer NPK on three cropping systems in vertisols of semi-arid tropics, dry matter, yield, nodulation, chlorophyll content and enzyme activity. *Bioresource technology* **95**(1): 85-93.

Gina M, Andrews M C, Matt Liebman, Cynthia Lambardella A and Tom Richard L. 2006. Residual effect of compost and fresh solid swine manure on soybean growth and yield. *American Society of Agronomy* **45**: 873-882.

Gomez K A and Gomez A A. 1984. Statistical procedures for agricultural research. *Wiley Interscience Publication*, Second edition pp 139–53.

Govindan K and Thirumurugan V. 2005. Synergestic association of *rhizobium* with phosphate-solubilizing bacteria under different sources of nutrient supply on productivity and soil fertility in soybean (*Glycine max*). *Indian Journal of Agronomy* **50**(3): 214-217.

Gunjal B S, Nawale S S, Lambade B M, Ugale N S and Pawar A D. 2011. Response of potassium levels alone and combination with farm yard manure on soybean (*Glycine max* L.) under rainfed conditions. *Journal of Agricultural Research and Technology* **36**(2): 192-195

Gupta S K. 1995. Effect of organic manures on rice yield and moisture retention in Alfisol soil. *Journal of Hill Research* **8**(2): 169-173.

Haider J, Rahman K M, Uddin K S and Hossain T. 1995. Response of Soybean to *Rhizobium* inoculation and urea fertilization in shallow red brown terrace soil. *Legume Research.* **18**(10): 17-24.

Jackson M L. 1973. *Soil Chemical Analysis,* Prentice Hall of India Private Limited, New Delhi.

Jain R C and Tiwari R J. 1995. Influence of farm yard manure and sugar presss mud on yield and nutrient content of soybean (*Glycine max*) in medium black soils of Madhya Pradesh. *Indian Journal of Crop Research* **9**(2): 215-217.

Jat R A, Arvadia M K, Tandel B, Patel T U and Metha R S. 2012. Response of saline water irrigated greengram (*Vigna radiata*) to land configuration, fertilizers and farm yard manure in Tapi command area of south Gujarat. *Indian Journal of Agronomy* **57**: 270-274.

Jat S L, Kedar Prasad ans Parihar C M. 2005. Effect of organic manuring on productivity and economics of summer mungbean (*Vigna radiata*). *Annals of Agricultural Research* **33**(1-2): 17-20.

Kadam S R, Amrutsagar V M and Deshpande A N. 2010. Influence of organic nitrogen sources with fulvic acid spray on yield and nutrient uptake of soybean on inceptisols. *Journal of Soils and Crops* **20**(1): 58-63.

Kanan J and Singaram P. 2009. Impact of compost application on rainfed greengram (*Vigna radiate* L.). *Agricultural Science Digest* **9**(2): 11-14.

Kannan P A, Saravanan S, Krishna K and Natrajan S K. 2005. Biological properties of soil as influenced by different organic manure. *Research Journal of Agricultural and Biological Sciences* **1**: 181-183.

Khaim S, Chowdhury M A H and Saha B K. 2013. Organic and inorganic fertilization on the yield and quality of soybean. *Journal of Bangladesh Agricultural University* **11**(1): 23-28.

Kichu I and Singh A K. 2013. Response of soybean to sulphur and molybdenum fertilization. *LAP LAMBERT Academic Publishing*, Saarbrucken, Germany.

Kumar. 2007. A study of consumer attidudes and acceptability of soy food in Ludhiana. *MBA research project report,* Department of business management, Punjub Agricultural University, Ludhiana, Punjab.

Kumar Y K D, Ananda M R, Vishwanath A P and Vittal Navi. 2006. Nutrient uptake, availability and yield of soybean as influenced by integrated nutrient management. *Environment and Ecology* **24**(4): 1056-1058.

Kumawat P D and Jat N L. 2005. Effect of organic manure and nitrogen fertilization on productivity of barley (*Hordium valgare*). *Indian Journal of Agronomy* **50**: 200-202.

Laharia G S, Patil D U and Damre P R. 2013. Effect of organic sources on soil fertility, nutrient uptake and yield of soybean. *Indian Journal of Agronomy* **45**(1, 2 and 3): 155-159.

Laxminarayan K. 2004. Effect of organic and inorganic on yield and uptake by groundnut (*Arachis hypogeae* L.) in Ultisols of Mizoram. *Journal of Oilseed Research* **21**(2): 280-283.

Laxminarayan K and Patiram. 2006. Influence of inorganic, biological and organic manureson yield and nutrient uptake of groundnut (*Arachis hypogeae* L.) and soil properties. *Indian Journal of Agricultural Sciences* **75**(4): 218-221.

Lakshman K, Vyas A K, Shivakumar B G and Rana D S. 2015. Effect of levels and time of sulphur application on growth, yield and quality of soybean (*Glycine max*). *Indian Journal of Agronomy* **60**(1): 121–5.

Longkumer L T, Singh A K and Gupta R C. 2013. Response of soybean to sulphur and boron nutrition. *LAP LAMBERT Academic Publishing*, Saarbrucken, Germany.

Madhumita Das, Singh B P, Munna R A, Dwivedi B S and Prasad R N. 1991. Influence of organic manures on native plant nutrients availability in acid soils. *Annals of Agricultural Research* **13**(1): 122-127.

Maheswarappa H P, Nanjappa H V and Hedge M R. 1999. Influence of organic manures on yield of arrowroot, soil physico-chemical and biological properties when grown as intercrop in coconut garden. *Annals of Agricultural Research* **20**: 318-323.

Mandel K G, Mishra A K and Hati K M. 2000. Effect of combination of FYM and NPK on growth yield and agronomic efficiency on soybean in vertisols. *Journal of Environment and Ecology* **18**(1): 207-209.

Mathur N, Singh J, Bohra S, Bohra A, Solanki R and Vyas A. (2009). Effect of vermicompost, *rhizobium* and DAP on growth, yield and nutrient uptake by mothbean. *Journal of Arid Legumes* **6**(1): 57-59.

Meena D S, Baldev Ram and Chaman Jadon. 2010. Effect of integrated nutrient management on productivity, profitability, nutrient uptake and soil fertility in soybean (*Glycine max* L. Merrill). *Soybean Research* **14**(1): 21-33 (2016).

Mishra S N, Paikaray R K and Mishra K N. 1999. Effect of lime, organic and inorganic nutrients on wheat (*Triticum aestivum*) – soybean (*Glycine max*) cropping system in acidic red soils. *Indian Journal of Agronomy* **44**(1): 26–9.

Moyin-jesu E I. 2012. Use of different organic fertilizers on soil fertility improvement, growth and yield parameters of cabbage (*Brassica oleraceae* L). *International Journal of Recycling of Organic Waste in Agriculture* (2015) **4**: 291-298.

Moyin-jesu E I and Ogochukwu. 2014. Comparative evaluation of different organic fertilizers effect on soil fertility, leaf chemical composition and growth performance of coconut (*Cocus mucifera*) seedlings. *International Journal of Plant and Soil Science* **3**(6): 737-750.

Najar G R, Singh S R, Akhtar F H and Hakeem S A. 2011. Influence of sulphur levels on yield, uptake and quality of soybean (*Glycine max*) under temperate conditions of Kashmir. *Indian Journal of Agricultural Sciences* **81**(4): 340-343.

Navale K B, Gaikwad C B and Tamboli B D. 2000. Effect of integrated nutrient management on yield, nutrient availability and uptake of nutrients by soybean. *Journal of Maharastra Agricultural University* **25**(1): 63-65, 105-107.

Nehra A S and Grewal K S. 2001. Influence of integrated use of organic manures and inorganic fertilizers on soil properties and yield of wheat. *International*

Conference on Natural Farming and Ecological Balance, CCS HAU, Hissar, India, March 7-10:155.

Nimje P M and Seth Jagdish, 1987. Effect of phosphorous and farmyard manure of soybean and their residual effect on succeeding winter maize. *Indian Journal of Agricultural Sciences,* **57**(6) : 404 – 409.

Ogbonna P E and Umar Shaba Y G. 2009. Effect of accessions and poultry manure rates on the growth and yield of sesame in the derived Savannah zone of South Eastern Nigeria. *African Journal of Agricultural Research* 7(30): 288-289.

Paliwal D K, Khushwaha H S, Thakur H S, Tailo R S and Deshwal A K. 2011. Effect of vermicompost in combination with fertilizers on nodulation, growth and yield of soybean (*Glycine max*) in soybean-wheat cropping system. *Soybean Research* **9**:95-102.

Paradkar V K and Deshmuk M R. 2004. Response of soybean to application of inorganic fertilizers and their integration with FYM in sapture plactane zone of Madhya Pradesh. *Journal of Oil Seed Research* **21**(2): 288-289.

Patil V S and Bhilare R L. 2000. Effect of vermicompost prepared from different organic sources on growth and yield of wheat. *Indian Journal of Agricultural Sciences* **69**: 413-417.

Patra P S and Sinha A C. 2012. Effect of organics on yield, uptake and economics of green gram (*Vigna radiata* L.) production under terai region of West Bengal. *Legume Research* **35**(2): 169-172

Piper C S. 1966. Soil and Plant Analysis, *Hans Publishers* pp 368.

Pookpakdi A. 2003. *Soybean: Valuable crop of Thailand*, 246 pp. Kasetsart University Printing Press, Bangkok, Thailand.

Rajkhowa D J, Gogoi A K, Kandali R and Rajkhawa K M. 2000. Effect of vermicompost on greengram nutrition. *Journal of Indian Society of Soil Science* **48**: 207-208.

Rajput A M, Shroff V N and Deshpande S L. 1995. Impact of mixed organic farming (organic farming + fertilizer) on Soybean and Potato. *Crop Research.* **10**(3):258-260.

Ramamurthy V and Shivashankar K. 1996. Effect of organic matter and phosphorus on growth and yield of soybean (*Glycine max* L. Merril). *Indian Journal of Agronomy* **41**(1): 65-68.

Ramasamy M, Srinivasan K and Sankaran N. 2001. Effect of phosphorus mobilize and different level of phosphorus on growth and yield of soybean (*Glycine max* L. Merril). *Madras Agricultural Journal* **87**(10-17): 675-676.

Ramesh P, Singh M and Subba Rao A. 2006. Organic Farming: Its relevance to the Indian context. *Current Science* **88**(4): 561-568.

Rana R and Badiyala D. 2014. Effect of integrated nutrient management on seed yield, quality and nutrient uptake of soybean (*Gylcine max* L.) under mid hill conditions of Himachal Pradesh. *Indian Journal of Agronomy* **46**(1): 135-140.

Richards L A. 1954. Diagnosis and improvement of saline and alkali soils. *Agricultural Handbook No*. **60**, USDA, Washington.

Roy D K, Singh B P and Paramjit Singh. 2004. Effect of vermicompost and fertility levels on growth, yield and yield attributes of malt barley (*Hordeum vulgare* L.). *Annals of Agricultural Research* **25**(1): 87-91.

Roy S and Md. Abul kashem. 2014. Effect of organic manures in changes of some soil properties at different incubation periods. *Open Journal of Soil Science* **4** 2014: 81-86.

Sailaja Kumari M S and Usha Kumara K. 2002. Effect of vermicompost enriched with rock phosphate on the yield and uptake of nutrients in green gram (*Vigna radiata* L.). *Journal of Tropical Agriculture* **40**: 27-30.

Sardana V. 1990. Integrated nutrient management in Indian rape (*Brassica compestrisvar*. Toria) and gobhisarson (*Brassica napus*) inter-cropping system. M.Sc. (Ag.) Thesis, PAU, Ludhiana.

Saxena S C and Chandel A S. 1992. Effect of zinc fertilization on different varieties of soybean (*Glycine max*). *Indian Journal of Agricultural Sciences* **62**: 695-697.

Saxena S C, Nainwal R C and Joshi A. 2013. Optimization of nutritional levels for newly released soybean (*Glycine max* L. Merril) varieties in mollisols of Uttarkhand. *Soybean Research* **11**(2): 43–54.

Sharma A R and Gangaiah B. 2009. Agronomic terminology (Fifth revised edition), Indian Society of Agronomy, Division of Agronomy, IARI, New Delhi.

Shepherd M A and Withers P J. 1999. Application of poultry litter and triple super phosphate fertilizer to a sandy soil: Effect of soil phosphorus status and profile distribution. *Nutrient cycle and Agro Ecosystem* **54**: 233-242.

Siag R K and Yadav B S. 2004. Effect of vermicompost and fertilizer on productivity of gram and soil fertility. *Indian Journal of Agricultural Sciences* **74**(11): 781-784.

Singh A B, Ramesh P, Pawar N R and Ramana S. 2008. Nutritional quality of soybean (*Glycine max* L. Merril) and chick pea (*Cicer arietinum*) and soil biological properties as influenced by different organic manures. *Indian Journal of Agricultural Sciences* **78**(9): 781-784.

Singh A K, Singh M, Singh P K, Sharma S K and Gupta R C. 2012. Effect of integrated nutrient management on growth, yield, quality and economics of soybean. *Journal of Oilseeds Research* **299**(2): 121-124.

Singh M and Kumar N. 2006. Effcet of FYM, vermicompost, vermiwash and NPK on growth, microbial biomass and yield of soybean. *Soybean Research* **10**: 60-66 (2012)

Singh R K and Thomas Abraham. 2001. Effect of rhizobium inoculation and phosphorus on growth and yield of soybean (*Glycine max* L. Merril). *Agronomy Digest* **1**: 97-98.

Singh R and Rai R K. 2004. Yield attributes, yield and quality of soybean (*Glycine max* L.) as influenced by integrated nutrient management. *Indian Journal of Agronomy* **49**(4): 271-274.

Singh R, Sharma H B, Kumar P, Paliwal D K and Kumar P. 2013. Effect of integrated nutrient management on growth, yield and quality of soybean (*Glycine max*) cultivars. *Indian Journal of Agronomy* **58**(3): 379-383.

Singh U P, Maurya S and Singh D P. 2003. Antifungal activity and induced resistance in pea by aqueous extract of vermicompost for control of powdery mildew of pea and balsam???

Subbiah B V and Asija G L. 1956. A rapid procedure for the determination of available nitrogen in soil. *Current Science* **25**: 259–60.

Suppadit T, Sangla L and Matsui T. 2006. Utilization of broiler litter as a substitute for chemical fertilizer in soybean (*Glycine max* L. Merril) production. *Indian Journal of Agricultural Sciences* **78**(7): 632-637.

Tagoe S O, Horiuchi T and Matsui T. 2010. Effect of carbonized poultry manure on the growth, nodulation, yield, nitrogen and phosphorus content of four grain legumes. *Journal of Plant Nutrition* **33**(5): 684-700.

Taiwo M A, Olaskan A O and Kevin E E. 2014. Impact of poultry manure and NPK fertilizer on soil physical properties and growth and yield of carrot. *Journal of Horticultural Research* (2017) **25**(1): 81-88.

Vairavan K. 2011. Integrated nutrient management in *rabi* blackgram. *Madras Agricultural Journal* **98**(10-12): 367-369.

Virkar A T and Tumbare A D. 2011. Effect of integrated nutrient management on growth and yield of soybean-wheat cropping sequence. *Journal of Agricultural Research and Technology* **36**(3): 358-363.

Vyas M D, Jain A K and Tiwari R J. 2003. Long-term effect of micronutrients and FYM on yield and nutrient uptake by soybean on a Typic Chromustert. *Journal of the Indian Society of Soil Science*, **51** : 45 – 47.

Waghmare Y M, Gokhale D N and Pawar H D. 2012. Effect of integrated nutrient management on yield, yield attributes and quality of soybean (*Glycine max* L.). *Journal of Agricultural Research and Technology* **37**(3): 370-372.

Yadav R S. 2007. Response of FYM (particularly cattle dung) on the growth of *Vigna radiate* Cv. T-9 and their comparison with artificial fertilizers (Diammonium sulphate). *Plant Archieves* **7**(1): 349-350.

Yeptho K, Singh A K, Kanaujia S P and Singh V B. 2012. Quality production of *kharif* onion (*Allium cepa*) and its response to biofertilizers inoculated organic manures. *Indian Journal of Agricultural Sciences* **82**(3): 236-240.