Preface

Soil is a natural resource that supports life on earth. It provides a natural medium for plant growth, raw materials for industries, and energy production. Soil is composed of mineral grains that come from weathering of the rocks which finally constitute soil particles like sand, silt, and clay. Soil formations are very slow processes that take centuries as a result of physical, chemical, and biological processes. Human interventions, climate, and living organisms are involved in this extremely slow process which ensues in soil formation. Soil is the largest reservoir of biodiversity which contains almost one-third of all living organisms. Soil performs different functions ranging from the provision of livelihood and habitats of humans, animals, plants, and soil organisms to sustainability of environmental quality. Being a natural and universal sink for a variety of pollutants, soil occupies a pivotal position in the environment and maintains its quality. The soil plays an important role in purification and recycling of air, water, and nutrients and thus maintains different natural cycles with ensuring the sustainability of life on earth. Soil purifies and transforms nutrients and other chemical substances and thus maintains the quality of groundwater, provides plants with nutrients and affects the climate. Soil is the primary production factor for agriculture and forestry. Fertile soils provide the basis for the entire food chain, and thus the soil is inevitable for sustaining life on earth. However, its improper use and the underestimation of its importance are a matter of serious concern that may have dire consequences over a period of time. Environmental pollution is affecting soil productivity and thus its capacity to sustain life on earth. Different types of pollutants are added into soils like agricultural nutrients and pollutants, as well as local contamination and pollution at abandoned sites. In addition to pollutant load, soil sustainability is threatened by soil erosion caused by wind and water. Soil erosion not only depletes soil fertility but also affects environmental quality. Soil erosion is the result of intensive agriculture and unscientific management of soil resources. In this book, we have tried to integrate literature focusing on the issue related to soil productivity, different practices to manage these issues, and then the role of the soil in environmental and agricultural sustainability. We greatly appreciate their commitment. We thank the Kindle Publication for their generous cooperation at every stage of the book production.

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Gavaskar

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LIST OF ABBREVIATIONS

%	-	Percentage
&	-	and
°C	-	Degree Celsius
/	-	Per
@	-	At the rate of
ANOVA	-	Analysis of variance
Av	-	Average
C.D.	-	Critical Difference
d.f.	-	Degree of freedom
DAS	-	Days after sowing
SSE	-	Sum of Square due to Error
EC	-	Electrical conductivity
et al.	-	And others
F.cal.	-	Calculated value of ‘F’
F.tab.	-	Table value of ‘F’
Fig	-	Figure
g	-	Gram
ha	-	Hectare
ha^{-1}	-	Per hectare
i.e.	-	That is
J	-	Journal
K	-	Potassium
Kg	-	Kilogram
kg^{-1}	-	Per kilogram
MSSE	-	Mean Sum of Squares due to Error
MSSR	-	Mean Sum of Squares due to Replication
SSM	-	Sum of Square due to Mean
m	-	Meter
m^2	-	Meter square
Max.	-	Maximum

Min.	-	Minimum
mm	-	Millimeter
MOP	-	Muriate of Potash
MSS	-	Mean Sum of Squares
MSST	-	Mean Sum of Squares due to Treatment
N	-	Nitrogen
No.	-	Number
NS	-	Non-significant
OC	-	Organic carbon
P	-	Phosphorus
ppm	-	Part per million
q	-	Quintal
r	-	Replication
S	-	Significant
S.Em (±)	-	Standard Error of mean
S.S.	-	Sum of Squares
S.S.L.	-	Sum of Square due to N P K

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.)] is one of the important legume vegetable crops grown in India. It is also known as black eye pea, southern pea and Crowder pea, well adapted to many areas of the humid tropics and sub-tropical zones. It is grown throughout India for its long, green vegetable pods, seeds and foliage for fodder. There is world-wide consensus that sole dependence on chemical input-based agriculture is not suitable in long run and only integrated plant nutrient system (IPNS) involving a combination of fertilizer, organic manures and bio-fertilizers are essential to sustain crop production, preserve soil health and biodiversity. In addition to this, the organic manures help in improving the use efficiency of inorganic fertilizers (Singh and Biswas 2015).

The crop gives such a heavy vegetative growth and covers the ground so well that it checks the soil erosion in problem areas and can later be ploughed down for green manure. This may be due to more accumulation of nutrient to the plant and leaf fall and left over in the field. It has considerable promise as an alternative pulse crop. Cowpea is highly responsive to fertilizer application. Among the various constraints to low productivity of cowpea, inadequate use of fertilizers and lack of improved package of practices are important. Nitrogen plays an important role in various metabolic process of plant. Nitrogen is an essential constituent of protein, chlorophyll and is present in many other compounds helps in plant metabolism. Phosphorus is an essential constituent of nucleic acids and stimulates root growth as well as increase nodule activity in plant.

It is grown for grain, fodder, vegetable and green manuring purposes. It has protein content about 24.6 percent and rich source of calcium and iron. Cowpea production in Rajasthan is about 11644 tonnes from an area about 124407 hectares (Agriculture Statistics at Glance, 2009-10). Cowpea is short duration, high yielding and quick growing crop and provided quick and thick cover on the ground thus helping in conservation of soil. It is grown as alternative crop in dry land farming.

Cowpea is loaded with various types of nutrients. It is rich in fiber, protein, iron, potassium, low in fat and calories. The cup of cowpea possesses 11.1 g fiber, 13.22 g protein, 35.5 g carbohydrate, 4.29 mg iron, 475 mg potassium, 0.91 g fat and 198 calories. Along with that, various amino acids such as 0.612 g of tryptophan, 0.41 g of histidine, 0.188 g of Methionine and 0.894 g of lysine is contained in this seed. The per capita availability of pulses in India is 35.5 g per day as against the minimum requirement of 70 g per day per capita as advocated by Indian Council of Medical Research. It is, therefore, imperative to increase the productivity of pulse crops especially those of minor importance.

Cowpea is mainly grown in Africa about 90 per cent of the total world acreage is in Africa. It is also grown in Asia, North and South America, Australia, Central and Southern parts of Europe. As a legume, cowpea fixes substantial amounts of atmospheric nitrogen to meet its requirement. In India it is cultivated mainly in UP, MP, Bihar, Punjab, Haryana, Rajasthan, HP etc, where it is grown for both vegetable and pulse purposes and is a highly remunerative crop. Review of existing literature indicates that there is no consensus of opinion on the desirability of inorganic nitrogen for cowpea. Pulses contain a higher percentage of quality protein nearly three times as much as cereals, thus they are cheaper source to overcome protein malnutrition among human being. It is generally believed that a starter dose of nitrogen enhances the yield of crop.

The basic concept of integrated nutrient management system is the maintenance of plant nutrients supply to achieve a given level of crop production by optimizing the benefits from all possible sources of plant nutrients in an integrated manner, appropriate to each cropping system and farming system (Mahajan and Sharma 2005). The advantage of combining organic and inorganic sources of nutrients in integrated nutrient management has been proved superior to the use of each component separately (Palaniappan and Annadurai 2007).

Nutrients are directly related with the growth and yield of cowpea. Application of nutrients through integrated approach reduce the cost of cultivation and also maintain as well as improve soil health by increasing the fertility, whereas, non-monetary inputs like spacing also play an important role for boosting the yield by increasing the plant population per unit area (Biswan *et al.*, 2002).

The organic sources besides supplying N, P and K also make unavailable sources of elemental nitrogen, bound phosphates, micronutrients, and decomposed plant residues into an available form to facilitate to plant to absorb the nutrients. But it is also the fact that optimum yield level of maize production can't be achieved by using only organic manures because of their low nutrient content. Efficacy of organic sources to meet the nutrient requirement of crop is not as assured as mineral fertilizers, but the joint use of chemical fertilizers along with various organic sources is capable of improving soil quality and higher crop productivity on long-term basis. Highest productivity of crops in sustainable manner without deteriorating the soil and other natural resources could be achieved only by applying appropriate combination of different organic manures and inorganic fertilizers (Chandrashekara *et al*., 2000)

Organic manures *viz*., FYM, Vermicompost (VC), poultry manure (PM) and oilcakes help in the improvement of soil structure, aeration and water holding capacity of soil. Further, it stimulates the activity of micro-organisms that makes the plant to get the macro and micro-nutrients through enhanced biological processes, increase nutrient solubility, alter soil salinity, solidity and pH. (Alabadan *et al*., 2009). Organic compost is a very important method of providing the plants with their nutritional requirements without having an undesirable impact on the environment (Adeoye *et al*., 2011*)*. There has been much discussion on the effect of organic fertilizer and waste compost from pig manure, farmyard manure (FYM), crop residues and ashes on soil properties and crop quality (Abdel-Rahman *et al.*, 2009).

Vermicompost has been emerging as an important source in supplementing chemical fertilizer in agriculture in view of sustainable development after Rio Conference, vermicompost is a bio fertilizer enriched with all beneficial soil microbes and also contains all the essential plant nutrients like N, P and K. Since vermicompost helps in enhancing the activity of microorganisms in soil which further increase solubility of nutrients and their consequent availability to plants is known to be altered by microorganism by reducing soil pH at microsites, chelating action of organic acids produced by them and intraphyl mobility in the fungal filaments (Parthasarathi *et al.*, 2008).

Biofertilizers is a natural product carrying living microorganisms derived from the root or cultivated soil. So, they don't have any ill effect on soil health and environment. Besides their role in atmospheric nitrogen fixation and phosphorous solubilization, these also help in stimulating the plant growth hormones providing better nutrient uptake and increased tolerance towards drought and moisture stress. A small dose of biofertilizers is sufficient to produce desirable results because each gram of carrier of biofertilizers contains at least 10 million viable cells of a specific strain (Anandaraj and Delapierre, 2010).

Rhizobium inoculation increased the root nodulation through better root development and more nutrient availability, resulting in vigorous plant growth and dry matter production which resulted in better flowering, fruiting and pod formation and ultimately there was beneficial effect on seed yield (Sardana *et al*., 2006). A judicious use of organic manures and biofertilizers may be effective not only sustaining crop productivity and in soil health, but also in supplementing chemical fertilizers of crop (Jaipal *et al.,* 2011). Among the various fertilizers, biofertilizers are important sources of nutrients. Biofertilizers are natural fertilizers containing micro-organism which help in enhancing the productivity by Biological nitrogen fixation or solubilization of insoluble phosphate or producing hormones, vitamins and other growth regulators required for plant growth (Bhattacharya, 2000).

OBJECTIVES

Keeping these things, the present investigation **"Assessment of integrated nutrient on soil properties and yield of cowpea [*Vigna unguiculata* (L.)]"** will be under taken during *Kharif* 2019 with the following Objectives**:**

1. To assess the effect of different levels of NPK, *Rhizobium* and Vermicompost on Physical and chemical properties of soil.
2. To evaluate the interaction effect of different levels of NPK, *Rhizobium* and Vermicompost on growth and yield of cow pea.
3. To calculate benefit-cost ratio (C: B) of different treatment combinations of cowpea [*Vigna unguiculata* (L.)].

REVIEW OF LITERATURE

Patel *et al.,* (2006) reported that the effect of integrated nutrient management (INM) in cluster bean. The combination of FYM and vermicompost with two kinds of bio-fertilizers (Azotobacter and PSB) and reduced doses of chemical fertilizers were tested in comparison with RDF. The yield parameters viz. number of clusters [plant, number of pods in a cluster, length and diameter of pod varied notable owing to the different INM treatment. The treatment 75 % of suggested dose of inorganic fertilizers and 25 % RDF through vermicompost along with biofertilizers (*Rhizobium* at 25 g kg^{-1} seed + PSB at 5 kg ha^{-1}) recorded significantly highest pod yield (159.58 g $plant^{-1}$), and lesser crude fibre content (2.18 g per 100g). Hence, it was concluded that, tor getting optimum growth and higher pod yield of the crop should be supplied with the 75 % of recommended dose of inorganic fertilizers and 25 % RDF by vermicompost along with biofertilizers (*Rhizobium* at 25 g kg^{-1} seed + PSB at 5 kg ha^{-1}) with vermicompost at the rate of I t ha^{-1} andPSB.

Balachandran *et al.,* (2006) reported the effect of seed inoculated with *Rhizobium* and phosphate solubilizing bacteria (Pseudomonas and Bacillus sp.) in various permissible combinations with 1/2 dose or without chemical fertilizers along with 2.5 and 5t ha pressmud on green gram. The data showed fertilizers along with 2.5 and 5t ha pressmud on green gram. The data showed that 1/2 RDF + 5 tonnes PM + Rh + PSB consequently maximize the plant height, number of branches, leaf area, dry matter production and number and dry weight of root nodules. The same treatment combination proved most effective in improving the yield and yield contributing parameters viz., 100 seed weight, length of pod, number of seeds pod^{-1}, number of pods plant and harvest index. Thus, application of pressmud at 5 tonnes ha along with *Rhizobium* and PSB helped in reducing the dose of suggested chemical fertilizers by 50 % with 42.30 0 increase in yield over RDF. Without application of chemical fertilizers, application of pressmud at 5 t ha^{-1} with seed inoculation of *Rhizobium* and PSB also helped in increasing the yield by 10 % over RDF significantly. These results indicate that along with biofertilizers addition of organic matter proved to be useful in achieving the yields without use of fertilizers.

Rajput *et al*., (2009) reported that the influence of organic, inorganic and biofertilizers on french bean. The soil was sandy loam with pH 7.42. It was medium fertile, being low in organic carbon, nitrogen, sulphur and zinc and medium in phosphorus, potassium and iron. The experimental field laid out in split-plot design with 3 replications. Five fertility levels combining inorganic (NPR) and organic (vermicompost) were allocated to main plot and 7 different combinations of biofertilizers (*Rhizobium*+*Bacillus polymyxa*+*Pseudomonas fluorescence*) and micronutrients (Zn and Fe) were subjected to sub-plot. Being at par with 100 % NPK+50 % N resulted in consequence improvement in growth character, plant height, branches per plant, trifoliate leaves per plant and dry matter plant, yield parameters (pod length, pods per plant and grains per pod), yield (grain and straw, harvest index) and nutrient (N, P, K, S, Zn and Fe) uptake. However, unfilled pods per pant was lesser with this fertility level. Gross and net returns were maximum with 100 % NPK+50 % N fertility level but B:C ratio was maximum under 100 % NPK+ 25 % N level. The combined effect of biofertilizers and micronutrients (biofertilizer + Zn + Fe treatment) was significantly better than their individual effects as this treatment significantly improved growth characters, yield attributes, yield, harvest index, nutrient uptake and B:C ratio. Furthermore, integration of 100 % NPK + 25 % N and biofertilizer + Zn + Fe was conducive for getting significantly optimum yield.

Rather *et al.*, (2009) revealed that a significant improvement in soil properties and fertility status was found under treatment (T_{20}) comprising of 100% Rec. NPK + Vermicompost + Zinc + PSB. Organic carbon content of soil improved from 3.0 to 4.6 g kg^{-1} soil, Bulk density reduced from 1.50 to 1.32 Mg m^{-3}, water holding capacity increased from 20.32 to 23.72 %, available N from 197.0 to 219.0 kg ha^{-1}, available P from 13.0 to 19.1 kg ha^{-1}, available K from 113.0 to 130.4 kg ha^{-1} and available Zn from 1.50 to 1.87 mg kg^{-1} soil by the integration of organics with inorganic. However, the pH and electrical conductivity of soil were not reflected to a considerable extent.

Gunjal (2010) found the uptake of NPK was significantly increased with increased levels of FYM. Further it was observed that nitrogen uptake showed graded response to increase levels of FYM. Recommended dose of fertilizer when applied with organics *i.e.* FYM 5 t ha^{-1} recorded significantly higher total uptake of N, P and K (218, 28.48 and 125.51 kg ha^{-1}) over the control (135.84, 14.66 and 82.68 kg ha^{-1}) increasing the soil fertility status (available NPK) up to of 50 kg N + 75 kg P_2O_5 + 50 kg K_2O + 5 t FYM ha^{-1}(N 237.32, P 26.30 and K 337.03 kg ha^{-1}). The soil fertility status declined in control treatment at initial value of available NPK. This might be owing to increased supply of nutrient source to the crop as well as due to indirect effect resulting from reduced loss of organically supplied nutrient.

Subbarayappa *et al.,* (2011) reported that application of 100 per cent RDF + FYM consequentially maximize the uptake of major nutrients, N, P and K (39.5, 20.36, 41.90 kg ha^{-1} respectively) followed by 75 per cent RDF+FYM. Application of 100 per cent RDF + FYM significantly maximize the pod length (15.85), seed yield 1586 kg ha^{-1}, Stover yield 5124 kg ha^{-1}, harvest index (0.23) and consequently higher net return of Rs. 22,372 ha^{-1}. Higher B:C ratio was recorded in 100 per cent RDF + FYM followed by 75 per cent RDF + FYM."

Das *et al.,* (2011) reported that the influence of various sources of nutrient on growth attributes like the plant height, number of leaves and branches per plant, yield parameters, nutrient uptake and soil nutrient status of cowpea were consequently maximized to a great extent by the application of 75 % RDF + Vermicompost + *Rhizobium* + PSB as compared with RDF alone". It indicated a saving of 25 % chemical fertilizer. Different sources of nutrient on growth parameter and yield parameters, nutrient uptake and soil nutrient status of cowpea variety (Pusa Komol).

Dekhane *et al.,* (2011) reported that effect of bio fertilizer and fertility levels on yield, protein content and nutrient uptake of cowpea. Sixteen treatments comprising of four levels of bio fertilizer viz. without inoculation, with PSB inoculation, liquid PSB inoculation and *Rhizobium* inoculation and four fertility levels viz. 0, 50, 75 and 100 % RDF were applied in factorial randomized block design with four replications. The response of the experiment showed that consequently the maximal grain and stover yield of 1441 and 1716 kg ha^{-1} respectively, was recorded in seed inoculation by *Rhizobium* over rest of the treatments. The maximum amount in RDF significantly increased seed and stover yield. Inoculated with *Rhizobium* consequently increased protein and N, P content as well as uptake of N and P by grain and stover. The 100 % RDF recorded the highest protein content as well as content and uptake of N and P by grain and stover but was par with 75 % RDF. Consequence improvement in available N and P status in soil was also observed due to *Rhizobium* inoculation".

Abdel *et al.,* (2012) reported that the interaction effects of potassium and farm yard manure (FYM) application on growth and soil properties of forage cowpea (*Vigna* *unguiculata* L. local variety). Factors and treatments are: K-application rate: O, 48, 96 and 144 kg K ha^{-1} (K0, Kl, K2 and K3, respectively); K-application timing: pre-seeding during seedbed preparation and post seeding 20 days after seeding (Tl and T2, respectively); FYM rates: O, 25, 50 and 75 m ha^{-1} (MO, Ml, and 3 NL, respectively). Plant growth and soil property parameters were beneficially affected by K and FYM application singly or combined. The addition ratio of 1:2:3 for either K or M application rates gave yields of nearly the same ratios. The lowest yield and NPK uptake were obtained by T_l K_0 M_0 while, the highest increases of 130 to 210 % were obtained with T_l M3 k3 or Tl K2 M3. Increasing K application from K0 to Kl or K2 decreased the bulk density (BD) (values being 1.549, 1.539, 1.510 and 1.519 mg per m due to K0, Kl, K2 and K3 respectively). Increasing FYM increased BD (values being 1.615, 1.520, 1.495 and 1.490 mg per m due to MO, 3 Ml, N'12 and M3, respectively). Field capacity (FC) and available water (AW) increased with increasing both K and FYM. FC = 10.81, 11.90, 13.47 and 15.91 % due to KO, Kl, K2 and K3, respectively; 9.72, 13.05, 14.75 and 15.73 % due to MO, MI, M2 and NL, respectively. AW=9.37, 12.43, 12.07 and 13.61 % for K0, Kl, K2 and K3, respectively".

Prasad *et al*., (2012) studied nine treatment combination of *Rhizobium*, PSB and P_20_5 designated as T1-control, T2-P_20_5 @ 40 kg ha^{-1}, T3-P_20_5 kg ha^{-1}, T4-*Rhizobium*, T5-P_20_5 @ 40 kg ha^{-1} + *Rhizobium*, T6-P_20_5 @ 80 kg ha^{-1} + *Rhizobium*, PSB, TS-P_20_5 kg ha^{-1}+ PSB, P_20_5 kg ha^{-1} + PSB. It is conducted that application of *Rhizobium* and PSB imposed with phosphorus is beneficial for optimum growth and nodule formation of cowpea cv. Kashi Kanchan.

Khandelwal (2012) studied during *kharif*, 2006 at Jobner (Rajasthan). The soil was loamy sand, having 8.1 pH, 1.20 dSm^{-1} electrical conductivity, 0.13% organic carbon, 130.2 kg ha^{-1} available nitrogen, 16.5 ha^{-1} available phosphorus and 151.9 kg ha^{-1} available potassium. The application of 75 % of recommended dose of fertilizer i.e. 15 kg N and 30 kg P_2O_5 ha-^{1} along with seed inoculation by *Rhizobium* + PSB proved significantly superior over rest of treatment combinations and provided significantly higher nitrogen uptake (68.78kg ha^{-1}), phosphorus uptake (8.85kg ha^{-1}). Similarly, in seed inoculation combined i.e. *Rhizobium* + PSB treatment provided significantly higher pods per plant (8.52), seeds per pod (8.11), seed yield (9.20q ha^{-1}), straw yield (20.12q ha^{-1}), nitrogen uptake (75.29 kg ha^{-1}), phosphorus uptake (9.32 kg ha^{-1}) .

Devi *et al.,* (2013) carried out experiment in which the effect of organic, biological and organic manures on nodule formation and yield of soybean and soil properties was analyzed. The experiment consists of nine treatments viz., Tl-Absolute control, T2-FYM (Farmyard manure) at the rate of 5 t ha^{-1} T3-Vermicompost at the rate of I t ha^{-1}, T4-100 % RDF (Recommended dose of fertilizer), T5-100 % RDF + PSB, T6-75 % RDF + vermicompost at the rate of I t ha^{-1}, T6-75 % RDF + vermicompost at the rate of I t ha^{-1} + PSB, Ts – 50 % RDF + vermicompost at the rate of I t ha^{-1} and T9-50 % RDF + vermicompost at the rate of I t ha^{-1} + PSB. The experiment was replicated thrice in randomized block design. The consequence showed that integration of 75 % RDF with vermicompost at the rate I t ha^{-1} and PSB produced significantly maximum plant height, number of nodules per plant, dry weight of nodules per plant, pods per plant and seed index than the other treatments. As such, significant higher grain and stover yield were founded from the application of 75 % RDF as inorganic fertilizer in incorporation with vermicompost at the rate of I t ha^{-1} followed by seed treated with PSB. The oil and protein content of seed were maximized remarkably owing to the application of 75 % RDF combination.

Nkaa (2014) assess the consists of five phosphorus levels (0 kg ha^{-1}, 20 kg ha^{-1}, 40 kg ha^{-1}, 60 kg ha^{-1} and 80 kg ha^{-1}) each of which contains seven replicates. Phosphorus fertilizer significantly enhanced growth and yield characters of the cowpea varieties used; plant height, leaf area, number of leaves and number of branches in all the weeks of measurement were significantly improved. Phosphorus also had a significant effect ($p>0.05$) on seed yield per treatment, weight of 50 seeds, number of nodules, weight of nodules and total aboveground dry matter in all varieties used. However, variations were observed in the responses of the different cowpea varieties to phosphorus application. High yield values were observed in variety three; IT99K-573-2-1, followed by variety two; IT99K-573-1-1 and variety one; IT97K-499-35. Highest value in all the yield characters measured was observed in variety three: IT99K-573-2-1 at phosphorus fertilizer rate of 40 kg ha^{-1}. When phosphorus is available, IT99K-573-2-1and 40 kg ha^{-1} phosphorus application rate is recommended.

Meena *et al.*, (2014) reported that the effect of fertility levels and biofertilizers on yield, quality and economic of cowpea. They conducted experiment (during *Kharif*) 2013 on sandy loam soil. Results shown that application of 100 % RDF + VC @ 2 t ha^{-1} significantly increases the number of pods plant, number of seeds per pods, seed, straw and biological yield, protein and net returns and remained at par with 75 % RDF+ VC @ 2 t ha^{-1} over control. But seed inoculated with *Rhizobium* and PSB consequentially maximal number of pod per plant number of seeds per pod, seed, straw and biological yield, protein and net returns over rest of the treatments. However, the test weight unchanged under different levels of fertility and biofertilizers".

Meena *et al.,* (2014) reported that through *kharif* to the effect of integrated nutrient management on greengram. Three sources of nutrients viz. inorganic, organic and bio-fertilizers were used in tweleve combinations with randomized block design. Among different combinations, consequential improvement in number of nodules per plant (80.97), dry weight of nodules (32.89 mg plant), yield attributes, seed yield (12.34 q ha^{-1}), harvest index (28.32 %), nutrient content, available NPR and organic carbon after harvest in soil were observed with application of nutrients by 75 % RDF + 2.5 t ha^{-1} vermicompost + *Rhizobium* + Phosphate solubilizing bacteria (PSB) as compared to other combinations and control, but it was at par with 100 % RDF + 2.5 t ha^{-1} vermicompost and 100 RDF + *Rhizobium* + PSB.

Shalini *et al*., (2014) suggested field experimental trial to study the effect of integrated nutrient on yield and nutrient uptake by pea (*Pisum sativum* L.). The trial was dissipate in 3x2x2 factorial with randomized block design with three level of NPR @ NO , PO, KO kg ha^{-1}, @ N 15 ,P_20, K_20 kg ha^{-1} @ N 30 P 60 K 40 kg ha^{-1}, two level of FYM @ O t ha^{-1} and two level of *Rhizobium* @ 0 and 200 g per 10 Kg seed. The treatments were replicated three times and were allocated at random in each replication. The treatment combination of TIL [@N30, P60, K40 kg ha^{-1}+ @ FYM 15t ha^{-1} + *Rhizobium* @ 200 g 10 kg of seed], shows the best result with respect to plant height 79.33 cm, number of leaves per plant 54.00, number of pods per plant 17.10, number of seeds per pod 8.55 and nutrient uptake in plant. It gave highest yield 103.70 q ha^{-1}. The same treatment combination resulted a slight change in pH 7.56 and EC 0.2 dsm^{-1} increase in OC % 0.58 %. From the economical point of view, the same treatment combination gave the maximum profit of 57299 Rs. ha^{-1} with B: C ratio of 1:2.23.

Kaur *et al.*, (2015) assess vermicomposting is a cost-effective and eco-friendly process used to treat organic waste. Vermicompost is nutrient rich, with microbiologically-active organic amendment which results from the interactions between earthworms and micro-organisms by the breakdown of organic matter. Earthworms convert the waste material into small particles by breaking in the gut and obtain the nutrients from the microbes that harbour upon them. This process increases the rate of degradation of the organic waste matter, modifies the physico-chemical properties of the matter and leads to formation of humus in which unstable waste matter is completely oxidized. Various physico-chemical and biological characteristics of soil are enhanced by amendment with vermin compost as well as it aggregates stability of soil, growth of plants, increases microbial activity and enzyme production. Research has shown that vermin compost has an effective role in improving growth and yield of different field crops, including vegetables, ornamentals, cereals and fruit crops.

Satodiya *et al.*, (2015) reported the effect of planting density and integrated nutrients on flowering, growth and yield of vegetable cowpea. The experiment was laid out in split plot design with three replications. From the three year data, it was found that plating density cm recorded the highest plant height however, it was comparable with cm. Planting density 45><45 cm recorded maximum pod weight and green pod yield which remained at par with planting density cm. Whereas, planting density did not show any significant effect on flower initiation period, days to 50 per cent flowering, number of branches per plant, pod length and number of seeds pod. Application of nutrients 30+60+0 kg NPK ha^{-1} recorded significantly the earliest flowering. Application of fertilizer resulted in significant decreased in nodule production. However, any nutrients treatment did not observe the significant difference for days to 50 per cent flowering, plant height, number of branches per plants, yield attributing characters and green pod yield".

Verma *et al.*, (2015) the result indicated that the application of nitrogen @ 40 kg ha^{-1} gave the maximum and significantly higher the N, P and K uptake and residual content in soil and remained at par with 20 and 30 kg N ha^{-1} over control. Results further indicated that the application of phosphorus @ 80 kg ha^{-1} gave the maximum and significantly higher the N, P and K uptake and residual content in soil and remained at par with 40 and 60 kg P_2O_5 ha^{-1} over control.

Sharma *et al*., (2015) reported that the "influence of organic manures and inorganic fertilizers on yield and economics of cowpea variety Pusa Komal. The result explains consequential maximal plant height (54.42 cm), number of leaves plant-I (36.92) and number of branches plant-I (7.57) was approximate in 03 (vermicompost 5 t ha^{-1}) at 45 DAS. The treatment 12 kg NPK ha^{-1}) was observed the maximal plant height (55.01 cm), number of leaves plant-I (30.82), and number of branches plant I (7.81) at 45 DAS. Interaction effect of treatments combination (03 12) was also observed high values viz. plant height (58.66 cm), number of leaves plant-I (44.26), and number of branches per plant (8.76) again at 45 DAS. Yield attributing traits viz. number of pods plant-I (18.66), number of seeds pod-1(14.33), pod weight (10.77g), pod length (24.54 cm), pod yield plant-I (201.0 g), pod yield plot 1(8.44 kg) and pod yield ha^{-1} (10.42 t ha^{-1}) of cowpea were also disclose in consequential maximal in treatment combination (03 12) with net return of Rs. 72806 ha^{-1} and benefit-cost ratio 1:2.39, but maximum C: B ratio 1:2.62 was obtained in 04 12 (Goat manure 5 t ha^{-1} + kg NPK ha^{-1}) due to low expenditure Rs. 44509 ha^{-1} as compared to treatments 03 12".

Chauhan *et al*., (2016) evaluated that "the effect of various sources of nutrient including organic, inorganic, biofertilizers and its combinations on growth, yield and protein content of cowpea cv. Pusa Komol. Regarding the growth parameters the maximal plant height (56.66 cm), number of leaves (70.06), branches (12.73), inter-nodal length (3.26 cm) and leaf area (6.53 cm^2) per plant were reported by application of (75%) RDF + biofertilizers (*Rhizobium* + PSB). In reference of yield per hectare and over all yield responsible factors, such as number of cluster per plant (5.40), pods per cluster (4.60), pod diameter (0.7 cm), length of pods (20.66 cm), pod yield (102.96 q ha^{-1}) and seeds per pod (15.00) recorded significantly higher in the treatment of (50%) RDF + (50%) vermicompost + biofertilizers (*Rhizobium* + PSB). Protein content (25.20%) was found significantly maximum".

Kumar and Pandita (2016) reported that in cowpea (*Vigna unguiculata*.) Main plot treatments were at par but sub plot INM treatments differed significantly for plant height, seed yield, number of pods plant^{-1}, pod length, number of seeds pod^{-1}, 1000-seed weight, seed germination and vigour indices. Integrated use of inorganic fertilizers + Vermicompost 2.5 t ha^{-1} (4.76, 4.16 q ha^{-1}) performed significantly better than the control (3.32, 2.79 q ha^{-1}) for seed yield and its attributes as well as seed quality parameters during

*Kharif*2012 and 2013, respectively. It was at par with combined use of inorganic fertilizers + biofertilizer inoculation (*Rhizobium* + PSB) + VAM 10 Kg ha^{-1} Also, the mean cost benefit ratios (2.04, 1.90) were highest for combination of biofertilizer inoculation (*Rhizobium* + PSB) + VAM 10 Kg ha^{-1} +inorganic fertilizers 100% and 75% RDF, respectively.

Ashwani *et al*., (2016) carried out to assess effect of inorganic fertilizers, vermicompost, Vesicular Arbuscular Mycorrhizae (VAM) and biofertilizers [*Rhizobium* and Phosphate solubilizing bacteria (PSB)] inoculation on seed yield and quality of cowpea (*Vigna unguiculata*). The experiment was carried in a split plot design for two successive cropping seasons, *kharif* with two main plot treatments of inorganic fertilizers i.e. 100 % and 75 % recommended dose of fertilizers (RDF) and nine sub plot integrated nutrient management (INM) treatments including control (No organic fertilizer). Main plot treatments were at par but sub plot INM treatments differed significantly for plant height, seed yield, number of pods per plants, pod length, number of seeds per pod, 1000-seed weight, seed germination and vigor indices. Integrated use of inorganic fertilizers + Vermicompost 2.5 t ha^{-1} (4.76, 4.16 q ha^{-1}) accomplished consequentially better than the control (3.32, 2.79 q ha^{-1}) for seed yield and its assigned as well as seed quality parameters during *Kharif* 2012 and 2013, respectively. It was at par with combined use of inorganic fertilizers + biofertilizer inoculation (*Rhizobium* + PSB) + VAM 10 Kg IWI Also, the mean benefit-cost ratios (2.04, 1.90) were highest for combination of biofertilizer inoculation (*Rhizobium* + PSB) + VAM 10 Kg ha^{-1} + inorganic fertilizers 100 % and 75 % RDF, respectively.

Joshi *et al.,* (2016) reported that effect of organic manures (FYM, vermi-compost, poultry manure, neem cake and castor cake) on growth and green pod yield of cowpea during summer season in randomized block design with four replications. Application of suggested dose of fertilizer 20-40-0 NPK kg ha^{-1} observed consequential higher green pod, and yield contributing characters viz. number of green pods plant-I, number of seeds pod^{-1} over different organic sources; However, application of 2 t ha^{-1} vermicompost was at par with RDF. The plant population per meter row length at 25 DAS and at final picking and number of branches plant-I and plant height at 30 DAS showed no consequential difference between different treatments, but at 60 DAS and at final picking consequently higher plant height was recorded due to use of RDF 20-40-0 NPK kg ha^{-1}.

Khichi *et al.*, (2016) reported that the response of different sources of nutrient including organic, inorganic, biofertilizers and its combinations on growth, field and protein content of cowpea cv. Pusa Komol. Regarding to the growth parameters the maximum plant height (56.66 cm), number of leaves (70.06), branches (12.73), inter-nodal length (3.26 cm) and leaf area (6.53 cm^2) per plant (*Rhizobium* were reported by application of (75 %) RDF + biofertilizers + PSB). In respect of yield per hectare and over all yield contributing factors, such as number of cluster per plant (5.40), pods per cluster (4.60), pod diameter (0.7 cm), length of pods (20.66 cm), pod yield (102.96 q ha^{-1}) and seeds per pod (15.00) recorded significantly higher in the treatment of (50 %) RDF + (50 %) vermicompost + biofertilizers (*Rhizobium* + PSB). Protein content (25.20 %) was found significantly maximum with the treatment vermicompost + neem cake + mustard cake + biofertilizers (*Rhizobium* and PSB).

Amruta *et al.*, (2016) found nutrient levels and spacing through the application of 50:100:100 + black gram rhizobia (250 g ha^{-1}) + PSB- *B. megaterium* (250 g ha^{-1}) with planting geometry 60 x 10 cm recorded more mean seedling length (34.40 cm), mean seedling dry weight (58.30 mg),and field emergence (90.24 %) lowest electrical conductivity (0.776 dS m^{-1}) compared to control. The application of 50:100:100 + Black gram rhizobia (250 g ha^{-1}) + PSB- *B. megaterium* (250 g ha^{-1}) with planting geometry 60 x 10 cm were considered as seed quality improvement approach in black gram, therefore conjunctive use of inorganic fertilizers and bio-fertilizer may be suggested for higher seed quality parameters along with overall betterment of crop.

Yadav *et al*., (2017) reported that the response of cowpea (*Vigna unguiculata* L.) viz. growth and yield performance to different organic manures alone and in combination with biofertilizers was evaluated by conducting a field experiment in clay soil. The growth parameters of cowpea viz. plant height, branches per plant, leaf area and leaf area index (LAI) was found highest in treatment involving the combined application of FYM + Vermicompost + *Rhizobium* + PSB culture. Similarly, the root growth and nodules were counted also found higher in the treatment receiving combined application of organic manures with biofertilizers. The yield of cowpea was increased by 46 % under the treatment receiving organic manures and biofertilizers as compared to control treatment. The results of the present study revealed that the cowpea crop responded positively to the combined application of organic manures and biofertilizers towards growth, growth and yield attributes and yield.

Panda *et al*., (2017) reported that with the aim of analyzing the impact of integrated nutrient management on production of quality seeds in cowpea was conducted with treatments Tl (RDF), T2 (RDF + lime), T3 (75 % RDF + lime), RDF +25 % FYM), Ts (75 % RDF+ 25 % vermicompost), T6 (75 % RDF+ 25 % FYM+1ime), T7 (75 % RDF + 25 % vermicompost + lime), Ts (50 % RDF + 25 % FYM + 2 foliar spray), T9 (50 % RDF + 25 % vermicompost + 2 foliar spray), T10 (50 % RDF + 25 % FYM + lime + 2 foliar (50 % RDF+25 % vermicompost + lime 2 foliar spray) and three replications. Observations on seed quality characters like vigour index, germination percentage and seedling dry weight were taken and conclusion were made respectively. Treatment Ts recorded maximum 100-seed weight of 13.0 g followed by 12.67 g in T7, T: and T 10 recorded maximum germination percentage of 91.0 % followed by 90.33 % in T7 and 87.67 in T3".

Maurya *et al*., (2017) reported Effect of integrated nutrient management on growth and yield of table pea (*Pisum sativum* L.) cv. AP-3, during *Rabi*. Results indicate that the six treatments viz., Tl (Full dose of NPK through chemical fertilizer @ 40:60:40 kg ha^{-1}), Tz (FYM @ 10 t ha^{-1} + 1/2 dose of NPK through chemical fertilizer), Ts (Vermicompost @ 2.5 t ha^{-1} + 1/2 dose of NPK through chemical fertilizer), T4 (Pressmud @ 5 t ha^{-1} + 1/2 dose of NPK through chemical fertilizer), T5 (Sewage sludge @ 10 t ha^{-1} + 1/2 dose of NPK through chemical fertilizer) and T6 (Poultry manure @ 2.5 t ha^{-1} + 1/2 dose of NPK through chemical fertilizer) were tested in RBD with three replications and cultivar Azad Pea-3 was used. The field observations (Days to 50% flowering, Pod length (cm), Pod width (mm), Number of pod per plant, Number of seed in a pod and Pod yield kg per plot & q ha^{-1}) were recorded. Among different treatments result indicate that highest Pod length (cm), Pod thickness (mm), Number of pod per plant, Pod weight plant-I (g), Pod yield plot-I (kg) and Pod yield (q ha^{-1}) were observed in the T3 (Vermicompost @ 2.5 t ha^{-1} + 1/2 dose of NPK through chemical fertilizer). However maximum No. of grains pod^{-1} (avg. 10 pods) were recorded in the T, (Sewage sludge @ 10 t ha^{-1} + 1/2 dose of NPK through chemical fertilizer) and highest Pod weight [avg. of 10 pods (g)] were recorded in the, T4 (Pressmud @ 5 t ha^{-1} + 1/2 dose of NPK through chemical fertilizer).

Pandey *et al.*, (2019) reported that soil test based integrated fertilizer prescription for targeted green pod yield of cowpea. The computed basic parameters viz. nutrient requirement (NR) and percent contributions of nutrients from soil (CS), fertilizer (CF) and Farm yard manure were 63.6, 145.2 and 17.3 for nitrogen; 63.6, 24.4 and 9.7 for phosphorus and 56.1, 79.5 and 22.1 for potassium, respectively. These parameters were used for immediate reckoners of fertilizer recommendations for the range of soil test values of N, P and K for desired yield target (5 to 10 % of potential yield of the variety) of green cowpea pod.

MATERIALS AND METHODS

The present study entitled **“Assessment of Integrated nutrient on soil properties and yield of cowpea (*Vigna unguculata* L.)”** comprised of a field experiment that was carried out at the Research Farm of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during *Kharif* 2019. The details of the experimental site, soil and climate are described in this chapter together with the experimental design, plan of layout, cultural practices and techniques employed for present study.

3.1 : Experimental site:

The experiment was conducted at the crop Research farm of the Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P. which is located on the south of the Prayagraj city. It is situated at 250^{o} SW, 25^{0}24’23’’N latitude and 81° 50’38’’ E longitude and 98 m above the mean sea level.

3.2 : Climatic condition in the experimental area:

The area of Prayagraj district comes under subtropical belt in the South east Uttar Pradesh, which experience extremely hot summer and fairly winter. The maximum temperature of the location reaches up to 46^{0} C-48^{0} C and seldom falls as 4^{0}C – 5^{0}C. The relative humidity ranged between 20 to 94 percent. The average rainfall in this area is around 1100 mm annually.

3.3 : Soil Sampling

The soil of experimental area falls in order of Inceptisols and in Experimental plot was alluvial soil. The soil samples were randomly collected from each plots in the experiment plot after to tillage operation from a depth of 0-15 cm. the size of the soil sample will be reduced by conning and quartering the composites soil sample to air dry and pass through a 2 mm sieve by way of preparing the sample for physical and chemical analysis.

3.4 : Meteorological condition:

The Prayagraj district comes under sub-tropical climate receiving the mean annual rainfall of about 290 mm. Major rain fall received from July to end of September. However, occasional precipitation is also not uncommon during winter. The winter months are cold while summer months are very hot and dry. The minimum temperature during the crop season was 2.1 ^{0}C and the maximum was 44.8.^{0}C the minimum humidity was 24 and maximum was 93. The meteorological data during experimental period are given in table.

Table: 3.1 Meteorological data during experimental period:

Months	Weeks	Temperature (^0C)		Relative Humidity (%)		Rainfall (mm)
		Max.	Min.	Max.	Min.	
July	1st week	36.04	28.00	86.00	40.00	03.06
	IInd week	38.04	27.00	85.00	41.00	03.26
	IIIrd week	36.06	26.04	98.00	43.00	07.00
	IVth week	36.06	26.00	87.00	43.00	17.06
August	1st week	36.04	26.00	91.00	46.00	18.47
	IInd week	34.08	26.04	96.00	50.00	39.25
	IIIrd week	34.08	26.06	93.00	52.00	12.03
	IVth week	37.04	27.00	95.00	48.00	26.07
September	1st week	36.06	26.00	95.00	51.00	09.04
	IInd week	36.00	27.00	92.00	52.00	04.45
	IIIrd week	36.06	26.00	90.00	57.00	09.73
	IVth week	28.08	26.00	95.00	59.00	18.86
October	1st week	36.02	26.00	91.00	51.00	22.03
	IInd week	35.06	26.06	91.00	56.00	10.00
	IIIrd week	36.02	25.00	91.00	50.00	NIL
	IVth week	35.06	26.00	90.00	52.00	NIL

Source: Agro-metereologycal Observation Unit, Department of Enviornmental Science and NRM, College of Forestry, SHUATS, Prayagraj.

3.4 Experimental details:

Plan of Layout:

The experiment was carried out in Randomized Block Design with three levels of NPK, *Rhizobium*, and Vermicompost. The treatments were replicated three times and were allocated at random block design (RBD) in each replication. The plan of layout of experiment has been drawn in Fig.3.4.1.

Crop	:	Cowpea (*Vigna unguculata L.*)
Variety	:	Kashi Kanchan
Season	:	*Kharif* 2019
Design	:	RBD
No. of Replication	:	3
No. of Treatment	:	9
No. of Plot	:	27
Net Plot Size	:	2m x 2m
Width of Main Irrigation Channel	:	1m
Width of Sub Irrigation Channel	:	0.5m
Width of Bund	:	0.3m
Net Cultivated Area	:	27x4=108 m^2
Total cultivated Area	:	196.24 m^2
Total Width of Plot	:	8.8m
Total Length of Plot	:	22.3m
Spacing's to RxR and PxP	:	30 and 10 cm.
Seed Sowing Depth	:	2.5 - 3 cm

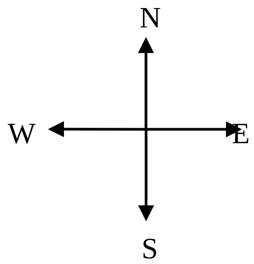

Fig 3.1 Layout design of the experimental plots

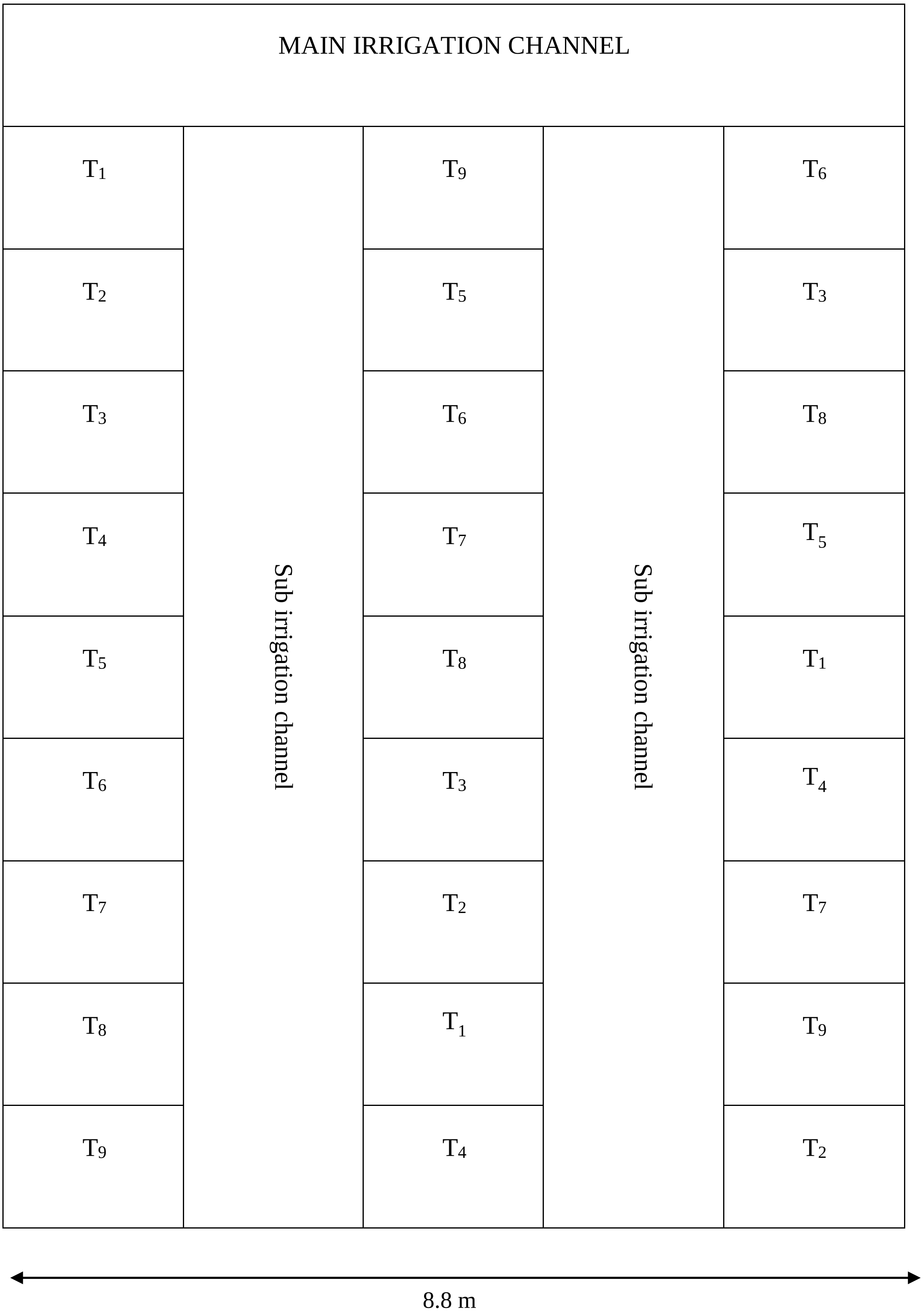

Table: 3.2 Details of Treatment

Treatment	Dosage ha^{-1} in percentage	Symbol
Level of N, P & K		
	100% NPK as SSP and MOP	N_1
	50% NPK as SSP and MOP	N_2
Level of *Rhizobium*		
	100% *Rhizobium*	R_1
	50% *Rhizobium*	R_2
Level of Vermicompost		
	100% Vermicompost	V_1
	50% Vermicompost	V_2

Table: 3.3 Treatment Combinations

Symbol	Treatment Combination
(T_1= Control)	(Control)
($T_2=N_2 + V_2$)	(@ 50 % RDF + 1 q ha^{-1} Vermicompost)
($T_3=N_1 + V_2$)	(@ 100 % RDF + 1 q ha^{-1} Vermicompost)
($T_4=N_2 + V_1$)	(@ 50 % RDF + 2 q ha^{-1} Vermicompost)
($T_5=N_1 + V_1$)	(@ 100 % RDF + 2 q ha^{-1} Vermicompost)
($T_6= N_2+ R_2$)	(@ 50 % RDF + 10 g kg^{-1} seed *Rhizobium*)
($T_7= N_1+ R_2$)	(@ 100 % RDF + 10 g kg^{-1} seed *Rhizobium*)
($T_8= N_2+ R_1$)	(@ 50 % RDF + 20 g kg^{-1} seed *Rhizobium*)
($T_9= N_1+ R_1$)	(@ 100 % RDF + 20 g kg^{-1} seed *Rhizobium*)

Dose of fertilizer: -

1) 100% NPK = (100% N:P:K =20:60:40 kg)

2) 50% NPK = (50% N:P:K =10:30:20 kg)

3) 100% *Rhizobium* = 20 g kg^{-1} seed *Rhizobium*

4) 50% *Rhizobium* = 10 g kg^{-1} seed *Rhizobium*

5) 100% Vermicompost = 2 q ha^{-1} Vermicompost

6) 50% Vermicompost = 1 q ha^{-1} Vermicompost

Table: 3.4 Fertilizer Application

Treatment	Dose (Kg or t ha^{-1})	Source (%)	Quantity of fertilizer applied (g $plot^{-1}$)
Nitrogen	12.5 kg N ha^{-1}	Urea (46 % N)	10.84 g $plot^{-1}$
Phosphorus	25 kg P ha^{-1}	SSP (16 % P)	62.48 g $plot^{-1}$
Potassium	12.5 kg K ha^{-1}	MOP (60 % K_2O)	8.32 g $plot^{-1}$
Rhizobium	20 g kg^{-1} seed	*Rhizobium*	5 g $plot^{-1}$
	10 g kg^{-1} seed	*Rhizobium*	2.5 g $plot^{-1}$
Vermicompost	2 q ha^{-1}	Vermicompost	2 kg $plot^{-1}$
	1 q ha^{-1}	Vermicompost	1 kg $plot^{-1}$

3.5 Physical and chemical analysis of soil samples (pre-sowing)

The samples were preserved in polythene bags for analysis of various physical and chemical properties.

3.5.1 Physical analysis

The physical analysis was done with graduated measuring cylinder method for bulk density, particle density, pore space (%). The results of analysis are as under.

Table: 3.5 Physical analysis of soil

Ingredient	Percentage	Method employed
Bulk density (Mg m^{-3})	1.25	Muthuaval *et al.,* (1992)
Partical density (Mg m^{-3})	2.85	Muthuaval *et al.,* (1992)
Pore space (%)	56.25	Muthuaval *et al.,* (1992)
Water holding capacity (%)	54.14	Black (1965)

3.5.2 Chemical analysis

The chemical analysis of soil pre sowing was done for pH, EC, % organic carbon, available Nitrogen, Phosphorus and Potassium. The results and various methods employed are represented under the following table.

Table 3.6: Chemical analysis of soil

Particulars	Method employed	Results
Soil pH (1:2)	**(Jackson, 1958)**	6.5
Soil EC (dSm^{-1})	**(Wilcox, 1950)**	0.9
Organic Carbon (%)	**(Walkley and Black, 1947)**	0.59
Available Nitrogen (kg ha^{-1})	(**Subbiah and Asija, (1956)**	293.48
Available Phosphorus (kg ha^{-1})	**(Olsen *et al*., 1954)**	24.04
Available Potassium (kg ha^{-1})	**(Toth and Prince, 1949)**	158.65

Source: soil water and plant analysis manual practical (Jaiwal, 2006)

Both the Physical and chemical analysis of soil was done before the start of experiment to ascertain the initial fertility of the soil. Soil samples (0-15 cm) were collected from 12 locations at random prior to tillage operation, the collected samples were mixed and its size was reduced by coning and quoting air dried and passed through 2 mm sieve. The composite soil sample was taken for the mechanical and chemical analysis of soil.

3.6 Planting Material:

Cowpea crop variety Kashi Kanchan was taken as test crop. This variety has been tested under different field conditions in various agro-climatic zones of India.

3.7 Land Preparation:

The field prepared by ploughing with a tractor drawn disk plough followed by cross harrowing and planking. The field was leveled and weeds, grasses were removed with the help of rake. Thereafter field was laid out as per plan of layout manually.

3.8 Fertilizer Application:

Before sowing, fertilizers were weighed and packets were prepared according to treatment combination for the application in the plots where it mixed thoroughly with soil.

3.9 Source of Nitrogen:

The nitrogen requirement was met with UREA (46%). The nitrogen was applied at sowing as basal dose.

3.9.1 Source of Organic Manure:

The organic manure requirement was met with Vermicompost. The Vermicompost was applied before 30 days of sowing the seed with two different levels i.e. (control), 1.2 kg plot^{-1} and 2.4 kg plot^{-1}.

3.10 Sowing:

The variety Kashi kanchan was selected for sowing. This variety matures within 75-85 days. The seeds were sown @ 15-20 kg ha^{-1} in rows with a row to row distance of 30 cm and plant to plant distance of 10 cm. The seeds were covered with soil immediately after sowing.

3.11 Irrigation:

One light Irrigation was given 20 days after sowing and second irrigation was given 40 days after sowing by flooding the field.

3.12 Thinning:

Thinning was done to maintain proper spacing of 10 cm between plants within the rows at 15 days.

3.13 Weeding:

In order to keep field free from weeds two-hand weeding were done at 20 days and 45 days.

3.14 Harvesting and post-harvesting operation

3.14.1 Picking:

The first picking of green pods was done at 50 days, second picking was done at 60 days respectively.

Calendar of field operation

A. Pre – sowing operation

S. No.	Date	Operation	Remark
1	19/07/2019	Tillage operation opens ploughing	by mould board
		Plough followed by harrowing and ploughing	
2.	20/07/2019	Layout and demarcation	Manually
3.	20/07/2019	Collection of soil sample	Randomly from a depth of 0-15cm
4.	23/07/2019	Inorganic fertilizer application	N dose as DAP P_2O_5, and K_2O as MOP
5.	24/07/2019	Sowing	Manually

3.15 Observation Recorded

1. Pre- harvest observations

A) Plant height (cm)

Height of crop plants under different treatments was recorded at 20, 35 and 50 days interval. For this, five plants were randomly selected from each plot and tagged for observation to be recorded. Height of plants in cm. recorded from ground level up to the base of the last fully opened leaf of the main shoot.

B) No. of pods plant^{-1}

Total No. of pods per plant under different treatments were recorded at 50 days of crop maturity. For this, five plants were randomly selected from each plot and tagged for observation to be recorded.

2. Post - Harvest observations

A) Pod Length (cm)

Length of pod under different treatments was recorded at maturity of crop. For this, five plants were randomly selected from each plot and tagged for observation to be recorded. Length of pod in centimeter recorded from shoot tip to end point of pod.

B) No. of Seeds pod^{-1}

No. of seeds per pod under different treatments was recorded at crop maturity. For this, five plants were randomly selected from each plot and tagged for observation to be recorded.

C) Pod yield (q ha^{-1})

The pod yield from the net plot area was recorded in kg plot^{-1} and figure converted into q ha^{-1}.

Preparation and analysis of soil samples

Soil samples from each plot at 0-15cm depth were collected at different stages were air-dried, grind and passed through 2mm sieve and finally stored in polythene bags for analysis of different physic-chemical parameters and changes in available N, P, K and Zn content. The soil sample was analyzed for Bulk density, particle density, water holding capacity, %pore space, soil texture, pH, EC, Organic carbon, Available N, P and K.

Determination of soil Bulk density (Mg m^{-3})

The mass of dry soil per unit volume including the air space. The bulk volume is determined before drying to constant weight at 100^0C. The bulk density of soil organic matter is usually between 1.3 and 1.5 Mg m^{-3}. The bulk density was calculated on Graduated Measuring Cylinder (Black, 1965).

$$\text{Bulk density } (gcm^{-3}) = \frac{\text{Weight of dry soil (g)}}{\text{Total volume of soil}}$$

Determination of soil Particle density (Mg m^{-3})

The mass per unit volume of the soil particles. The value of particle density of the soil varies between 2.65 and 2.75 g cm^{-3}. The particle density was calculated from the 100 ml graduated measuring cylinder (Black, 1965).

$$\text{Particle density} = \frac{\text{Weight of dry soil}}{\text{Volume of soil} - \text{pore space volume}}$$

Determination of pore space%

The volume percentage of the total soil bulk not occupied by soil particles. The pore Space % was calculated from the 100 ml graduated measuring cylinder (Black, 1965)

$$\text{Pore Space \%} = \frac{(V_1 + V_2) - V_3}{V_1} \times 100$$

Where,

V1 = Volume of soil

V2 = Volume of distilled water taken

V3 = Volume of soil + water

Determination of Soil pH (1:2) w/v

The soil pH determined in 1:2 soil water suspensions with the help of systolic digital electric pH meter (Jackson 1958). The instrument being a potentiometer required to be calibrated before use with the help of buffers solution of known pH value of 4.0, 7.0 and 9.2 at 25^0C.

Determination of Electrical conductivity of Soil (dS m^{-1})

After the determination of pH, the soil water suspension was kept overnight in undisturbed conditions & electrical conductivity measured by using electrical conductivity meter. The instrument was calibrated with 0.01 M standard KCI solution at 25^0C.

Determination of Organic carbon in Soil (%)

Organic carbon was estimated by wet digestion method of Walkey and Black, (1947). The method is mainly based on the principle of wet oxidation of organic carbon in an acid dichromate solution followed by Back titration of the remaining dichromate with ferrous ammonium sulphate.

Determination of Available Nitrogen in Soil (kg ha^{-1})

Available nitrogen was determined by using alkaline potassium permanganate method as given by Subbaih and Asija, (1956). In this method soil distillate with alkaline potassium permanganate solution (0.32%) and 2.5% NaOH which give ammonia (NH_3) liberated, absorbed by boric acid solution with mixed indicator which is determined volumetrically and serve as an index of available nitrogen status.

Determination of Available Phosphorus in Soil (kg ha^{-1})

Available phosphorus is determined with the help of Olsen colorimetric method, (1954). Phosphorus determination in soil is a two –step process i.e., extraction of phosphorus from the soil by sodium bicarbonate. After extraction from the soil, phosphate in the extract measured by the reaction of phosphate with ammonium molybedate in an acid medium to form molybdo phosphoric acid. The molybdophosphric acid is reduced to a blue coloured complex (reduced phosphomolybenum blue) through reaction with ascorbic acid. The ascorbic acid method has provided to be reliable and less subjected to interference in colour development than the $SnCl_2$ method. The colour is stable for 24 hours. The absorbance reading was taken at a 660 nm wavelength using a spectrophotometer. The standard curve constructed from absorbance reading standards is used to deduce phosphate concentration of sample.

Determination of Available Potassium in Soil (kg ha^{-1})

Available phosphorus is determined with the help of Toth and Prince method, (1949) Available potassium was extracted with natural ammonium acetate and estimation was carried out with the help of Flame photometer, the analysis of the flame photometer is based on the measurement of the intensity of characteristics wavelength given by the element to be determined. When a solution of salt is sprayed into a flame, the solid gets separated into its component atoms because of high temperature. The energy provided by flame excites the atom unexcited state emitted radiation of characteristics wavelength (Line emission spectrum). The intensity of these radiations is proportional to the concentration of the particular element in solution, which is measured through a photocell in the flame photometer.

3.16 Statistical analysis

The data recorded during the course of investigation will subjected to statistical analysis by analysis of variance (ANOVA) technique (Fisher 1960) The significant and non-significant of treatment effect was judged with the help of 'F' (variance ratio) table. The significant different between the mean were tested against the critical difference at 5% level for testing the hypothesis the following table is used.

Analysis of variance

Analysis of variance will be carried out according to the procedure of Randomized block Design (RBD) for each character as per methodology advocated by Panse and Sukhatme, (1967).

Standard Error (SE)

The standard error is a statistical term that measures the accuracy with which a sample represents a population.

In statistics a sample mean deviates from the actual mean of population this deviation is the standard error.

Critical Difference (CD)

Which refers to a value indicating least significant difference at values greater than which all the differences are significant is presented.

3.6 Table of Statistical analysis

Source of variation	**d.f.**	**S.S.**	**M.S.S.**	**F(cal.)**	**F(tab.)**
Due to replication	r – 1	S.S.R.	M.S.S.R		
Due to treatment	t – 1	T.S.S.	M.T.S.S.	M.T.S.S E.M.S.S	F(T – 1)(R – 1) (t -1) 5%
Due to error	(r – 1) (t – 1)	E.S.S.	E.M.S.S		
Total	rt – 1	T.S.S.			

C.D. = S.Em x t-test (error d.f.) at 5%

$$S.Em = \sqrt{\frac{2\ E.M.SS}{r}}$$

Where,

r = replication

t = treatment

T = total

d. f. = Degree of freedom

S.S. = Sum of square

T.S.S. = Sum of square due to treatment

S.S.R. = Sum of square due to replication

M.S.S. = Mean sum of square

E.S.S. = Error sum of square

E.M.S.S. = Error mean sum of square

F cal. = calculated value of F

F tab. = tabulated value of F

RESULTS AND DISCUSSION

The present investigation entitled **"Assessment of integrated nutrient on soil properties and yield of cowpea [*Vigna unguiculata* (L.)]"** was carried to evaluate effect of different levels of NPK, *Rhizobium* and vermicompost on Physio-chemical properties of soil during *Kharif* 2019. Data were recorded on 16 characters and results are discussed with the help of available literature. The results of the present experiment are detailed and discussed in the light of works done under the following headings.

A. Post-harvest soil properties

1. Soil Texture
2. Soil Colour
3. Bulk density (Mg m^{-3})
4. Particle density (Mg m^{-3})
5. Pore space (%)
6. pH of soil
7. Electrical conductivity (ds m^{-1})
8. Organic carbon (%)
9. Available nitrogen (kg ha^{-1})
10. Available phosphorus (kg ha^{-1})
11. Available potassium (kg ha^{-1})

B. Growth and yield Parameters

12. Plant height (cm)
13. Pods $plant^{-1}$
14. Pod length
15. Seed pod^{-1}
16. Pod yield

C. **Economics**

17. Cost of cultivation of Cowpea per hectare
18. Cost of different treatment combinations
19. Benefit-cost ratio

A. Post-harvest soil properties

4.1 Soil Texture

The figure4.1 depicted the Soil Texture (Sand, Silt and Clay %) of different departments of Departmental Research Farm, the soil sample was taken on depth of 0-15 cm. 55% sand, 30% silt and 15% clay was observed which indicates the soil texture-sandy loam.

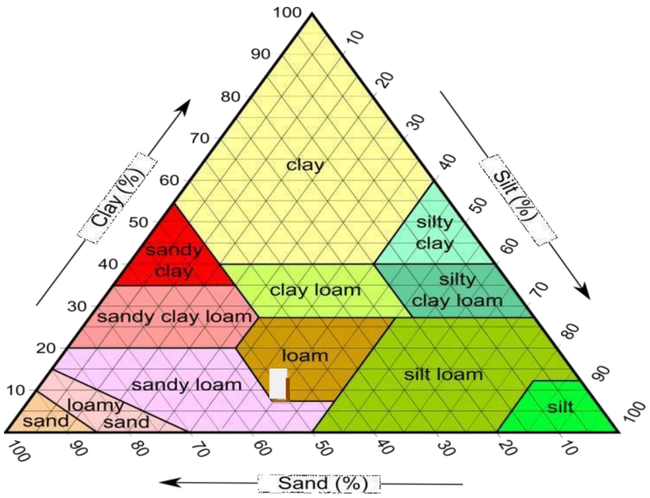

Fig. 4.1: Effect of different levels of N P K, *Rhizobium* and vermicompost on the Soil Texture (Sand, Silt and Clay %) after crop harvest.

4.2 Soil Colour

The table 4.1 depicted the soil colour (dry and wet method) of Departmental Research Farm. The soil sample was taken on depth of 0-15 cm and the soil colour- light yellowish brown was found at dry condition. At wet condition the soil colour- olive brown was found.

Table 4.1: Effect of different levels of N P K, *Rhizobium* and vermicompost on the Soil Colour (Dry and Wet Method) after crop harvest

Parameters	Hue	Value	Chroma	Soil Colour
Dry condition	2.5YR	6/	/4	(2.5YR6/4) Light Yellowish Brown
Wet condition	2.5 YR	4/	/4	(2.5YR 4/4) Olive Brown

4.3 Bulk density (Mg m^{-3}) of soil after crop harvest.

The data presented in table 4.2 and depicted in fig. 4.2 clearly shows the Bulk density (Mg m^{-3}) of soil as influenced by different levels of N P K, *Rhizobium* and vermicompost. The response Bulk density (Mg m^{-3}) of soil was found to be significant in levels of different levels of N P K, *Rhizobium* and vermicompost. The maximum Bulk density (Mg m^{-3}) of soil was recorded 1.35 Mg m^{-3} in treatment T_1 (control) and minimum Bulk density (Mg m^{-3}) of soil was recorded 1.03 Mg m^{-3} in treatment T_9 (100 % RDF+100 % *Rhizobium*). Similar results were also reported by Meena *et al.,* (2014) and Prasad *et al*., (2012).

Table 4.2: Effect of different levels of N P K, *Rhizobium* and vermicompost on the Bulk density (Mg m^{-3}) of soil after crop harvest

Treatment	Post-harvest Bulk Density (Mg m^{-3})
T_1	1.35
T_2	1.34
T_3	1.34
T_4	1.23
T_5	1.21
T_6	1.18
T_7	1.06
T_8	1.05
T_9	1.03
F-test	S
SE. d(±)	0.02
C.D. (P= 0.05)	0.05

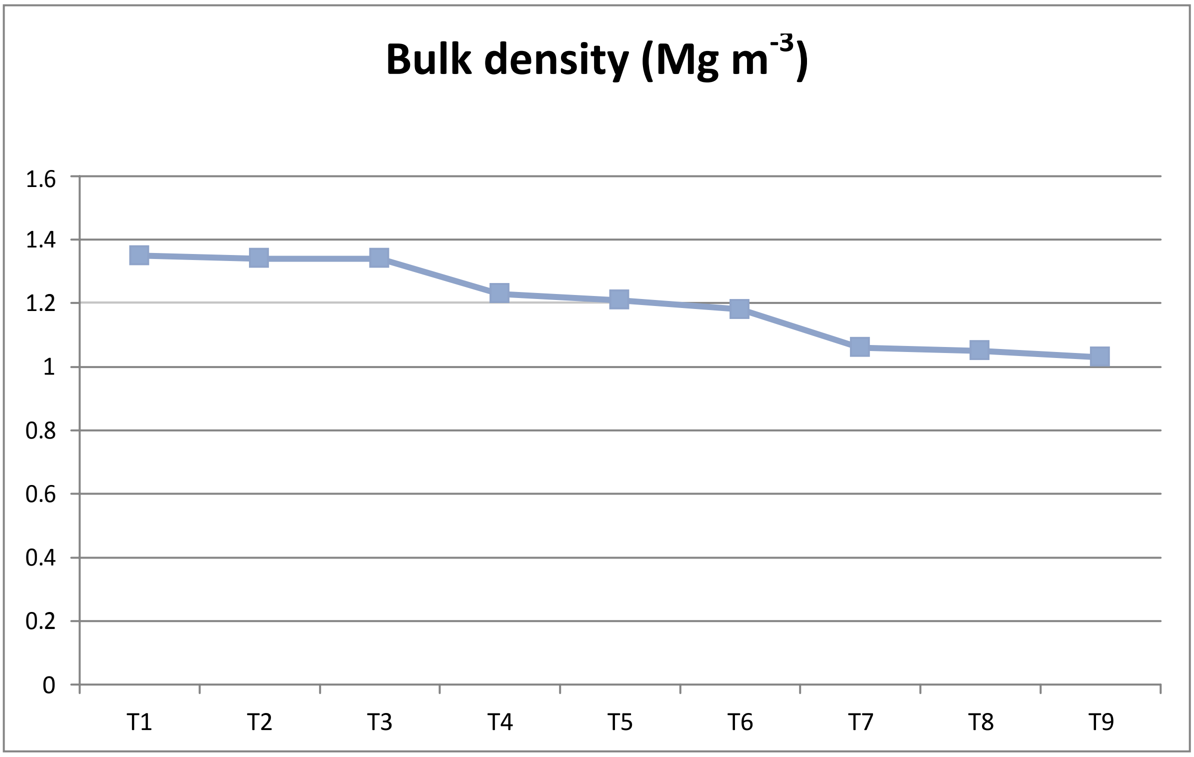

Fig. 4.2: Effect of different levels of N P K, *Rhizobium* and vermicompost on the Bulk density (Mg m^{-3}) of soil after crop harvest.

4.4 Particle density (Mg m^{-3}) of soil after crop harvest

The data presented in table 4.3 and depicted in fig. 4.3 clearly shows the Particle density (Mg m^{-3}) of soil as influenced by different levels of N P K, *Rhizobium* and vermicompost. The response Particle density (Mg m^{-3}) of soil was found to be significant in levels of N P K, vermicompost and *Rhizobium*. The maximum particle density (Mg m^{-3}) of soil was recorded 2.48 Mg m^{-3} in treatment T_9 (100 % RDF+100 % *Rhizobium*) and minimum particle density (Mg m^{-3}) of soil was recorded 2.32 Mg m^{-3} in treatment T_1 (control). Similar results were also reported by Meena *et al.*, (2014) and Prasad *et al.*, (2012).

Table 4.3: Effect of different levels of N P K, *Rhizobium* and vermicompost on the Particle density (Mg m^{-3}) of soil after crop harvest

Treatment	Post-harvest Particle Density (Mg m^{-3})
T_1	2.32
T_2	2.37
T_3	2.40
T_4	2.41
T_5	2.41
T_6	2.44
T_7	2.44
T_8	2.47
T_9	2.48
F-test	S
SE. d($\pm$)	0.02
C.D. (P= 0.05)	0.05

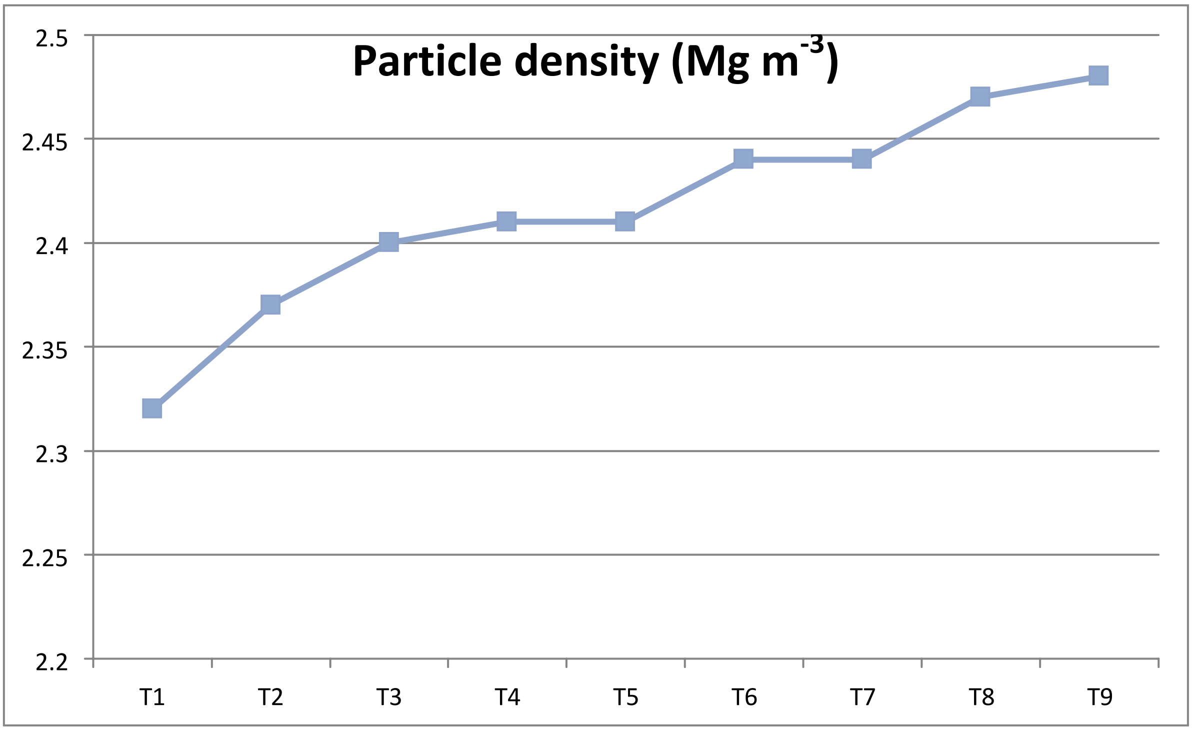

Fig. 4.3: Effect of different levels of N P K, *Rhizobium* and vermicompost on the Particle density (Mg m^{-3}) of soil after crop harvest.

4.5 Percentage Pore space of soil after crop harvest

The data presented in table 4.4 and depicted in fig. 4.4 clearly shows the % pore space of soil as influenced by different levels of N P K, *Rhizobium* and vermicompost. The response of soil pore space was found to be significant in levels of N P K, *Rhizobium* and vermicompost. The maximum soil pore space was recorded 58.46 % in treatment T_9 (100 % RDF + 100 % *Rhizobium*) and at par soil pore space was recorded 41.80 % in treatment T_1 (Control). Similar results were also reported by Meena *et al.,* (2014) and Prasad *et al*., (2012).

Table 4.4: Effect of N P K, *Rhizobium* and vermicompost on % pore space of soil after crop harvest

Treatment	Post harvesting Pore space (%)
T_1	41.80
T_2	43.45
T_3	44.16
T_4	48.96
T_5	49.79
T_6	51.63
T_7	55.56
T_8	57.48
T_9	58.46
F-test	S
SE. d(±)	0.52
C.D. (P= 0.05)	1.11

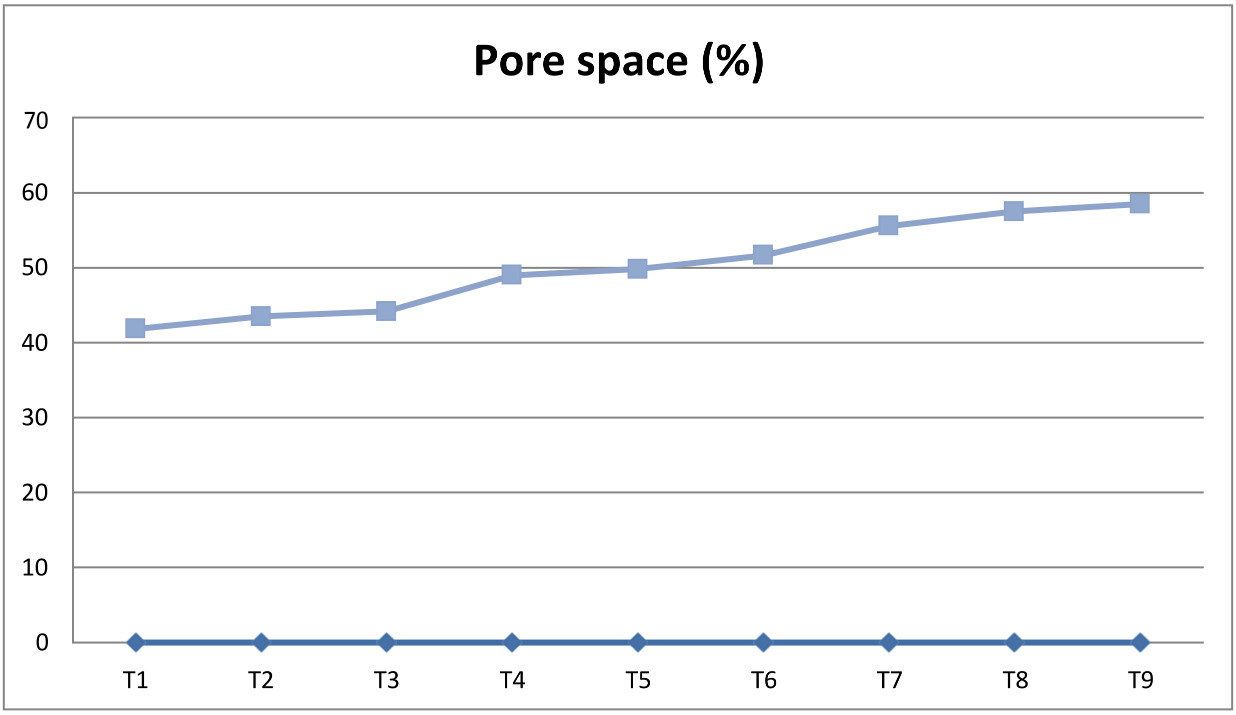

Fig. 4.4: Effect of N P K, *Rhizobium* and vermicompost on % pore space of soil after crop harvest.

4.6 pH (1:2) W/V of soil after crop harvest

The data presented in table 4.5 and depicted in fig. 4.5 clearly shows the pH of soil as influenced by N P K, *Rhizobium* and vermicompost. The response of soil pH was found to be significant in levels of N P K, *Rhizobium* and vermicompost. The maximum soil pH was recorded 7.70 in treatment T_1 (control) and minimum soil pH was recorded 7.20 in treatment T_9 (100 % RDF + 100 % *Rhizobium*) Meena *et al.*, (2014) and Prasad *et al.*, (2012).

Table 4.5: Effect of different levels of N P K, *Rhizobium* and vermicompost on pH of soil after crop harvest

Treatment	Post-harvest pH
T_1	7.70
T_2	7.63
T_3	7.63
T_4	7.45
T_5	7.38
T_6	7.33
T_7	7.26
T_8	7.21
T_9	7.20
F-test	S
SE. d($\pm$)	0.04
C.D. (P= 0.05)	0.09

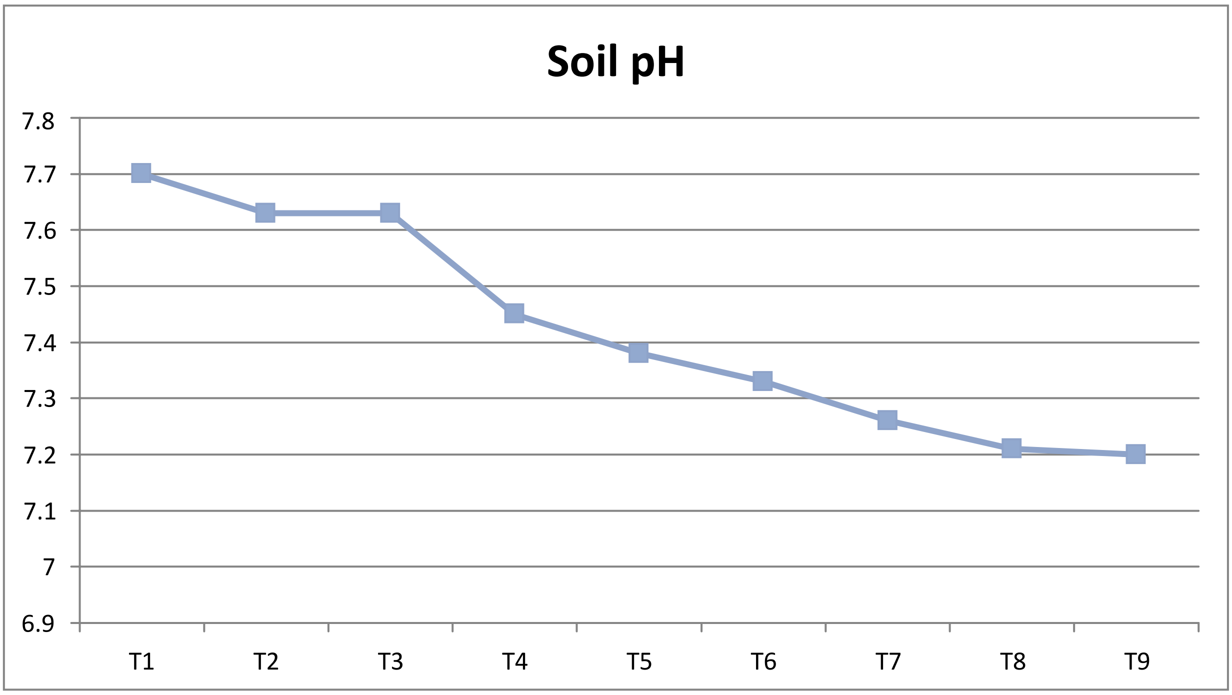

Fig. 4.5: Effect of different levels of N P K, *Rhizobium* and vermicompost on pH of soil after crop harvest.

4.7 EC (dS m^{-1}) of soil after crop harvest.

The data presented in table 4.6 and depicted in fig. 4.6 clearly shows the EC (dS m^{-1}) of soil as influenced by N P K, *Rhizobium* and vermicompost. The response of EC (dS m^{-1}) of soil was found to be significant in levels of N P K, *Rhizobium* and vermicompost. The maximum EC (dS m^{-1}) of soil was recorded 0.18 dSm^{-1} in treatment T_9 (100 % RDF + 100 % *Rhizobium*) and minimum EC (dS m^{-1}) of soil was recorded 0.12 dSm^{-1} in treatment T_1 (control). Similar results were also reported by Meena *et al.,* (2014) and Prasad *et al*., (2012).

Table 4.6: Effect of different levels of N P K, *Rhizobium* and vermicompost on the EC (dS m^{-1}) of soil after crop harvest

Treatment	Mean Value of Post-harvest EC (dS m^{-1})
T_1	0.12
T_2	0.13
T_3	0.13
T_4	0.14
T_5	0.14
T_6	0.16
T_7	0.16
T_8	0.17
T_9	0.18
F-test	S
SE. d(±)	0.01
C.D. (P= 0.05)	0.02

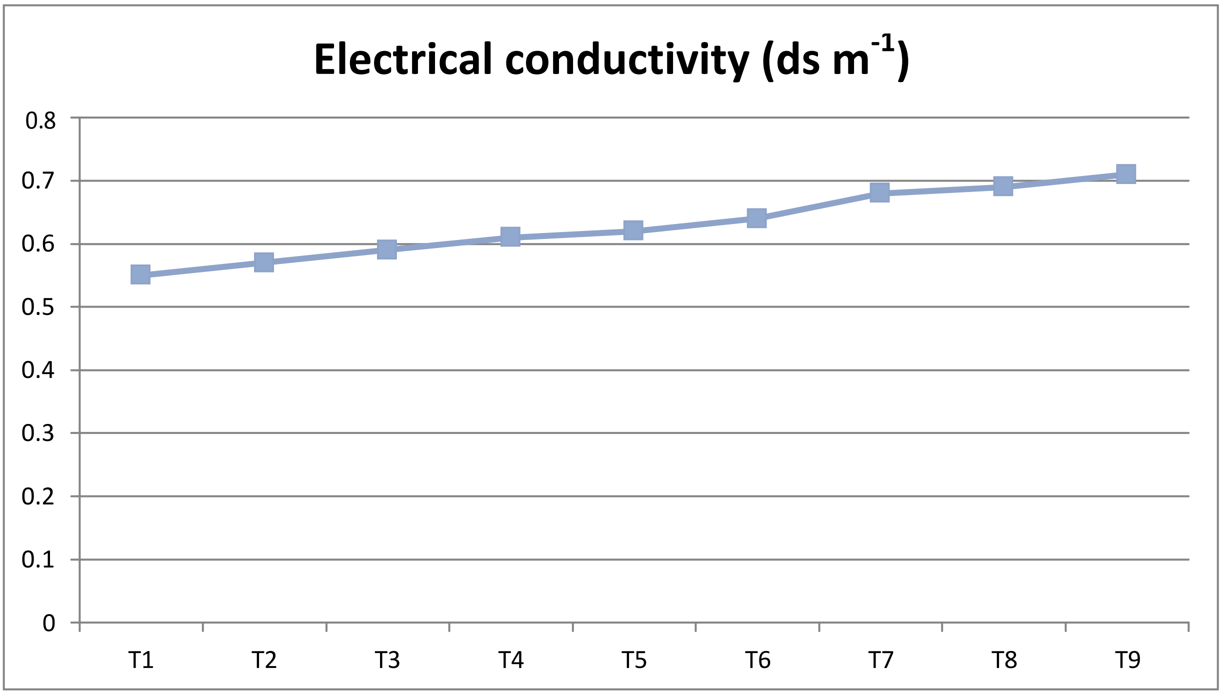

Fig. 4.6: Effect of different levels of N P K, *Rhizobium* and vermicompost on the EC (dS m^{-1}) of soil after crop harvest.

4.8 Percentage organic carbon in soil after crop harvest

The data presented in table 4.7 and depicted in fig. 4.7 clearly shows the % organic carbon in soil as influenced by N P K, *Rhizobium* and vermicompost. The % organic carbon in soil increased significantly with the increase in levels of N P K, *Rhizobium* and vermicompost. The maximum % organic carbon in soil was recorded 0.71 % in treatment T_9 (100 % RDF + 100 % *Rhizobium*) followed by T_8 which was significantly higher than any other treatment combination and at par Organic carbon (%) in soil was recorded 0.55 % in treatment T_1 (control). Legumes have potential to improve soil nutrients status through biological nitrogen fixation and incorporation of biomass in to the soil as green manure. Similar findings were recorded by Meena *et al.*, (2014) and Prasad *et al*., (2012).

Table 4.7: Effect of different levels of N P K, *Rhizobium* and vermicompost on the % Organic carbon in soil after crop harvest

Treatment	Post harvesting Organic carbon (%)
T_1	0.55
T_2	0.57
T_3	0.59
T_4	0.61
T_5	0.62
T_6	0.64
T_7	0.68
T_8	0.69
T_9	0.71
F-test	S
SE. d(±)	0.01
C.D. (P= 0.05)	0.02

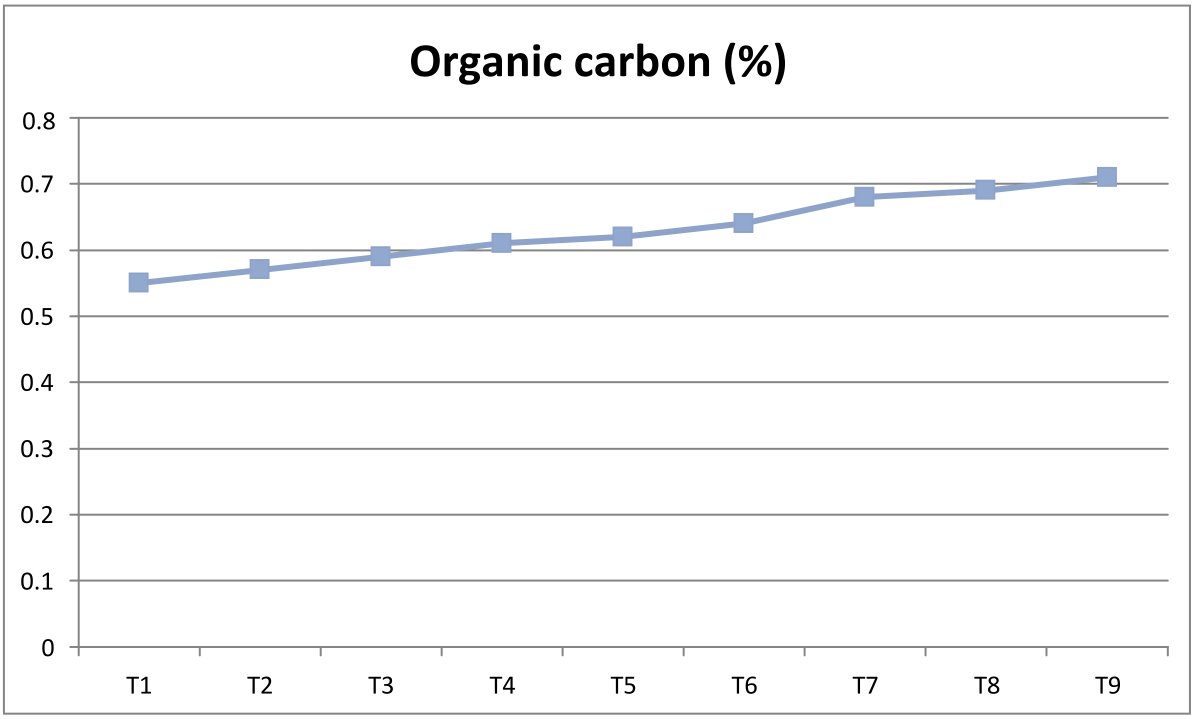

Fig. 4.7: Effect of different levels of N P K, *Rhizobium* and vermicompost on the % Organic carbon in soil after crop harvest.

4.9 Available Nitrogen (kg ha^{-1}) in soil after crop harvest

The data presented in table 4.8 and depicted in fig. 4.8 clearly shows the available Nitrogen in soil as influenced by N P K, *Rhizobium* and vermicompost. The available Nitrogen in soil increased significantly with the increase in levels of N P K, *Rhizobium* and vermicompost. The maximum available Nitrogen in soil was recorded 317.25 (kg ha^{-1}) in treatment T_9 (100 % RDF + 100 % *Rhizobium*) followed by T_8 which was significantly higher than any other treatment combination and at par available Nitrogen in soil was recorded 248.49 (kg ha^{-1}) in treatment T_1 (control). The increase in available Nitrogen in soil after crop harvest by vermicompost and neem-cake seed inoculation might be due to increased efficiency of Nitrogen fixing capacity and nodule formation. Legumes have potential to improve soil nutrients status through biological nitrogen fixation and incorporation of biomass in to the soil as green manure. Similar findings were also recorded by Meena *et al.*, (2014) and Prasad *et al*., (2012).

Table 4.8: Effect of different levels of N P K, *Rhizobium* and vermicompost on the available nitrogen (kg ha^{-1}) in soil after crop harvest

Treatment	Post-harvest available Nitrogen (kg ha^{-1})
T_1	248.49
T_2	268.29
T_3	277.09
T_4	281.73
T_5	288.11
T_6	293.89
T_7	303.42
T_8	312.22
T_9	317.25
F-test	S
SE. d($\pm$)	1.09
C.D. (P= 0.05)	2.32

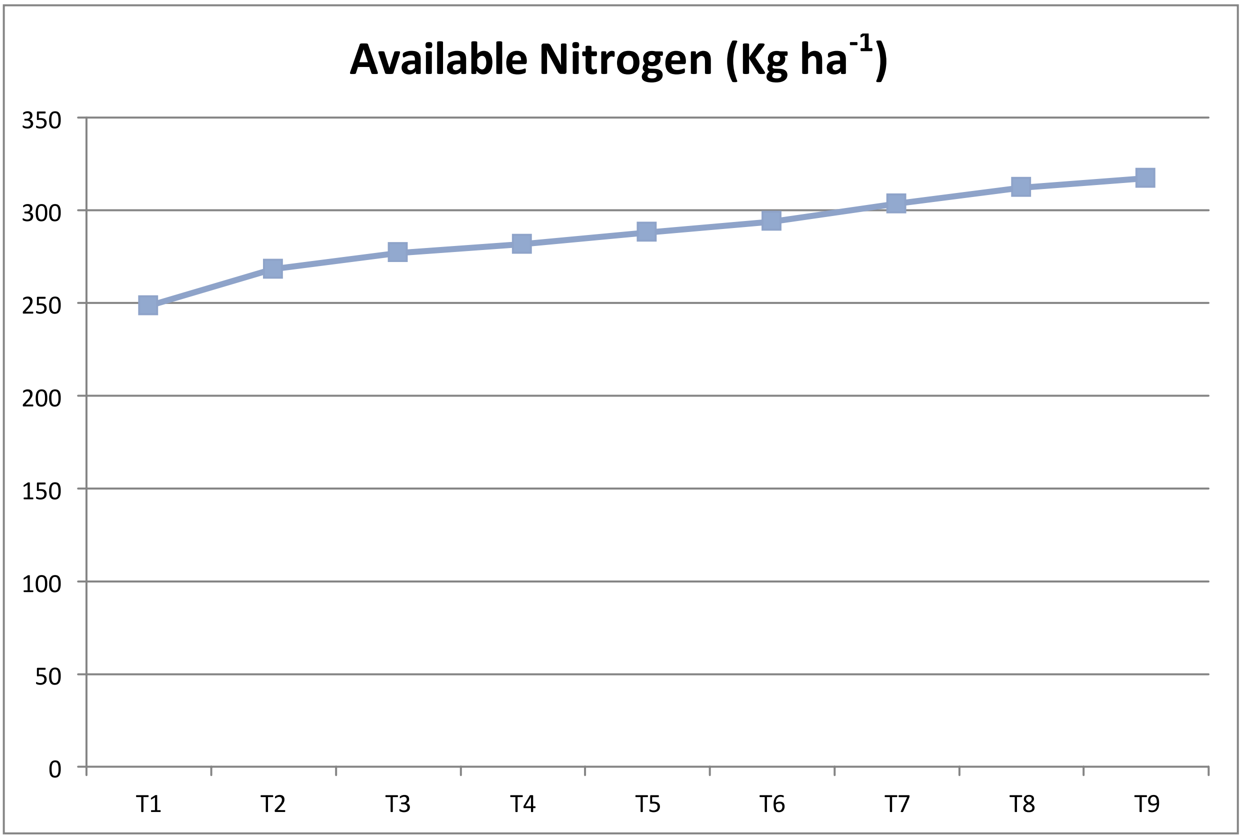

Fig. 4.8: Effect of different levels of N P K, *Rhizobium* and vermicompost on the available nitrogen (kg ha^{-1}) in soil after crop harvest.

4.10 Available Phosphorus (kg ha^{-1}) in soil after crop harvest

The data presented in table 4.9 and depicted in fig. 4.9 clearly shows the available Phosphorus in soil as influenced by N P K, *Rhizobium* and vermicompost. The available Phosphorus in soil increased significantly with the increase in levels of N P K, *Rhizobium* and vermicompost. The maximum available Phosphorus in soil was recorded 32.99 (kg ha^{-1}) in treatment T_9 (100 % RDF+100 % *Rhizobium*) which was significantly higher than any other treatment combination and the minimum available Phosphorus in soil was recorded 23.57 (kg ha^{-1}) in treatment T_1 (control). Legumes have potential to improve soil nutrients status through biological nitrogen fixation and incorporation of biomass in to the soil as green manure. Similar findings were also recorded by Meena *et al.*, (2014) and Prasad *et al*., (2012).

Table 4.9: Effect of different levels of N P K, *Rhizobium* and vermicompost on the available phosphorus (kg ha^{-1}) in soil after crop harvest

Treatment	Post-harvest available phosphorus (kg ha^{-1})
T_1	23.57
T_2	26.72
T_3	27.50
T_4	27.79
T_5	28.05
T_6	28.85
T_7	30.13
T_8	31.27
T_9	32.99
F-test	S
SE. d(±)	0.67
C.D. (P= 0.05)	1.42

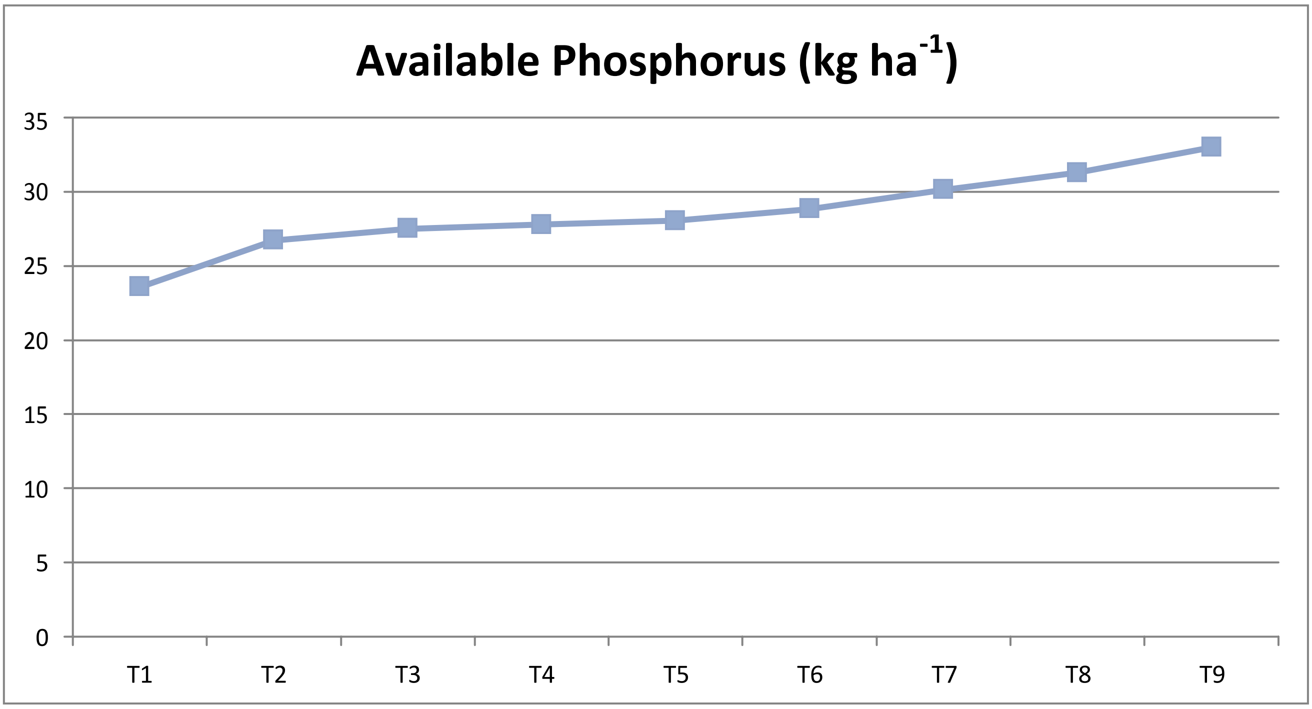

Fig. 4.9: Effect of different levels of N P K, *Rhizobium* and vermicompost on the available phosphorus (kg ha^{-1}) in soil after crop harvest.

4.11 Available potassium (kg ha^{-1}) in soil after crop harvest

The data presented in table 4.10 and depicted in fig. 4.10 clearly shows the available Potassium in soil as influenced by N P K, *Rhizobium* and vermicompost. The available Potassium in soil increased significantly with the increase in levels of N P K, *Rhizobium* and vermicompost. The maximum available potassium in soil was recorded 210.38 (kg ha^{-1}) in treatment T_9 (100 % RDF + 100 % *Rhizobium*) which was significantly higher than any other treatment combination and at par available potassium in soil was recorded 130.58 (kg ha^{-1}) in treatment T_1 (control). Legumes have potential to improve soil nutrients status through biological nitrogen fixation and incorporation of biomass in to the soil as green manure. Similar findings were also recorded by Meena *et al.,* (2014) and Prasad *et al*., (2012).

Table 4.10: Effect of different levels of N, P, K, *Rhizobium* and vermicompost on the available potassium (kg ha^{-1}) in soil after crop harvest

Treatment	Post-harvest available potassium(kg ha^{-1})
T_1	130.58
T_2	138.95
T_3	147.15
T_4	160.38
T_5	172.42
T_6	182.69
T_7	189.71
T_8	198.67
T_9	210.38
F-test	S
SE. d(+)	0.90
C.D. (P= 0.05)	1.91

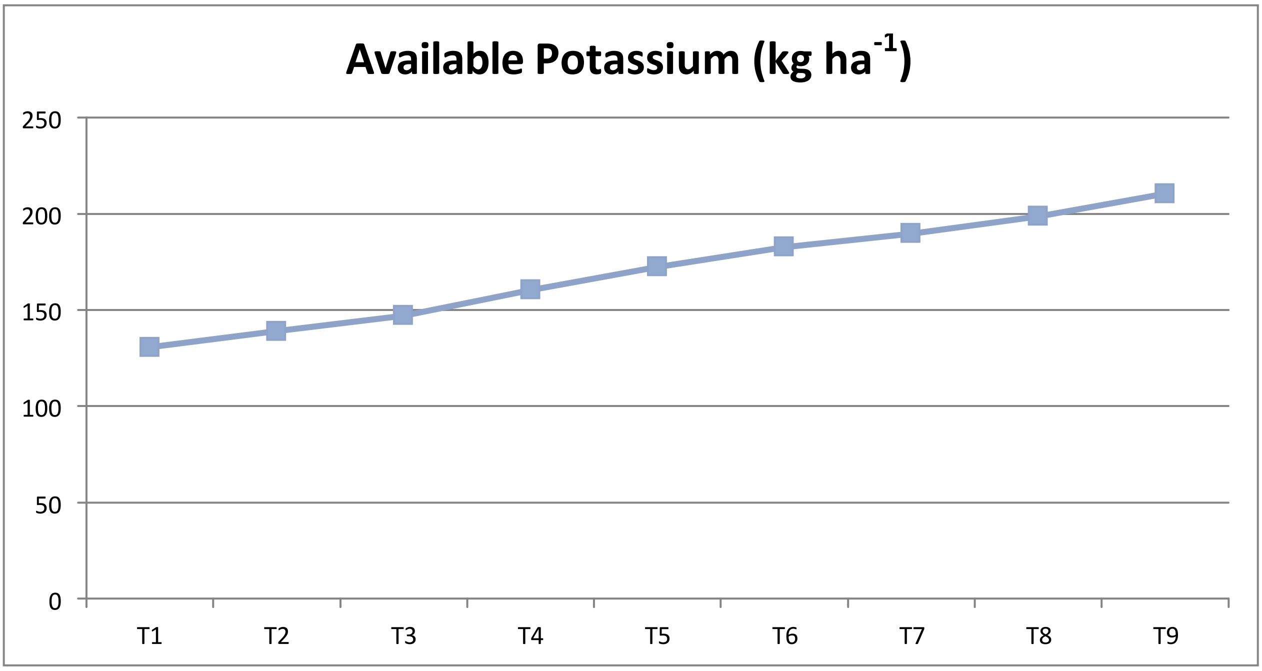

Fig. 4.10: Effect of different levels of N P K, *Rhizobium* and vermicompost on the available potassium (kg ha^{-1}) in soil after crop harvest.

B. Growth and yield Parameters

4.12 Plant height (cm)

The data presented in table 4.11 and depicted in fig.4.11 clearly shows the response of plant height of pea recorded at 20 DAS, 35 DAS and 50 DAS as influenced by different levels of N P K, *Rhizobium* and vermicompost. The plant height of cowpea was found to be increased significantly with the increase in levels of N P K, *Rhizobium* and vermicompost. The maximum plant height was recorded as 24.49 cm, 34.38 cm and 64.40 cm in T_9 (100 % RDF + 100 % *Rhizobium*) at 20 DAS, 35 DAS and 50 DAS respectively followed by T_8 and at par plant height was recorded as 10.30 cm, 18.63 cm and 43.63 cm in T_1 (control) at 20 DAS, 35 DAS and 50 DAS respectively. Increase in plant height due to increase in N P K, *Rhizobium* and vermicompost may be due to adequate supply of nutrients which in turn helps in vigorous vegetative growth of plants and subsequently increase the plant through cell elongation, cell division, photosynthesis and turbidity of plant cell. The increase in nodulation and nitrogen fixation leads to more plant height. Similar findings were reported by Ashwani *et al.,* (2016), Yadav *et al.*, (2017), Abdel *et al.,* (2012) and Maurya *et al.*, (2017).

Table 4.11: Effect of different levels of N P K, *Rhizobium* and vermicompost on the Plant height (cm) 20, 35 and 50 DAS

Treatment	Plant height (cm)		
	20 Days	35 Days	50 Days
T_1	10.30	18.63	43.63
T_2	11.16	21.17	45.37
T_3	13.37	23.38	47.79
T_4	14.73	24.73	51.19
T_5	16.37	26.37	53.71
T_6	18.77	28.80	55.78
T_7	20.53	30.56	58.07
T_8	22.22	33.22	61.19
T_9	24.49	34.38	64.40
F-test	S	S	S
SE. d($\pm$)	0.31	0.32	0.28
C.D. (P= 0.05)	0.67	0.69	0.58

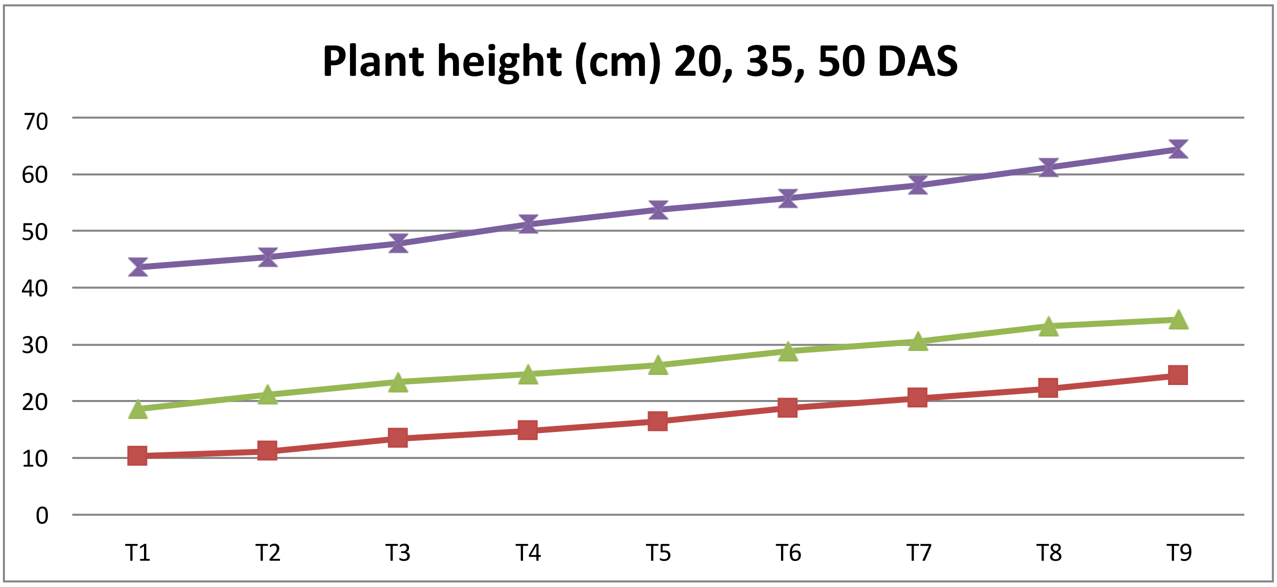

Fig. 4.11: Effect of different levels of N P K, *Rhizobium* and vermicompost on the Plant height (cm plant^{-1}) 20, 35 and 50 DAS.

4.13 Pods plant^{-1}

The data presented in table 4.12 and depicted in fig.4.12 clearly shows the response of pods plant^{-1} of cowpea recorded at 50 DAS as influenced by different levels N P K, *Rhizobium* and vermicompost. The number of pods plant^{-1} of cowpea was found to be increased significantly with the increase in levels of N P K, *Rhizobium* and vermicompost. The maximum number of pods was recorded as 19.00 in T_9 (100 % RDF+ 100 % *Rhizobium*) at 50 DAS and the minimum number of leaves were recorded as 9.33 in T_1 (control) at 50 DAS. Increase in number of pods may be due to adequate nutrients supply which enhanced the vegetative growth of plant and subsequently the number of pods. Similar findings were reported by Ashwani *et al.,* (2016), Yadav *et al.*, (2017), Abdel *et al.,* (2012) and Maurya *et al.*, (2017).

Table 4.12: Effect of different levels of N P K, *Rhizobium* and vermicompost on the number of pods plant^{-1} at 50 DAS

Treatment	Number of pods plant^{-1}
T_1	9.33
T_2	10.42
T_3	12.00
T_4	13.30
T_5	14.47
T_6	15.53
T_7	16.70
T_8	17.80
T_9	19.00
F-test	S
SE. d(±)	0.12
C.D. (P= 0.05)	0.26

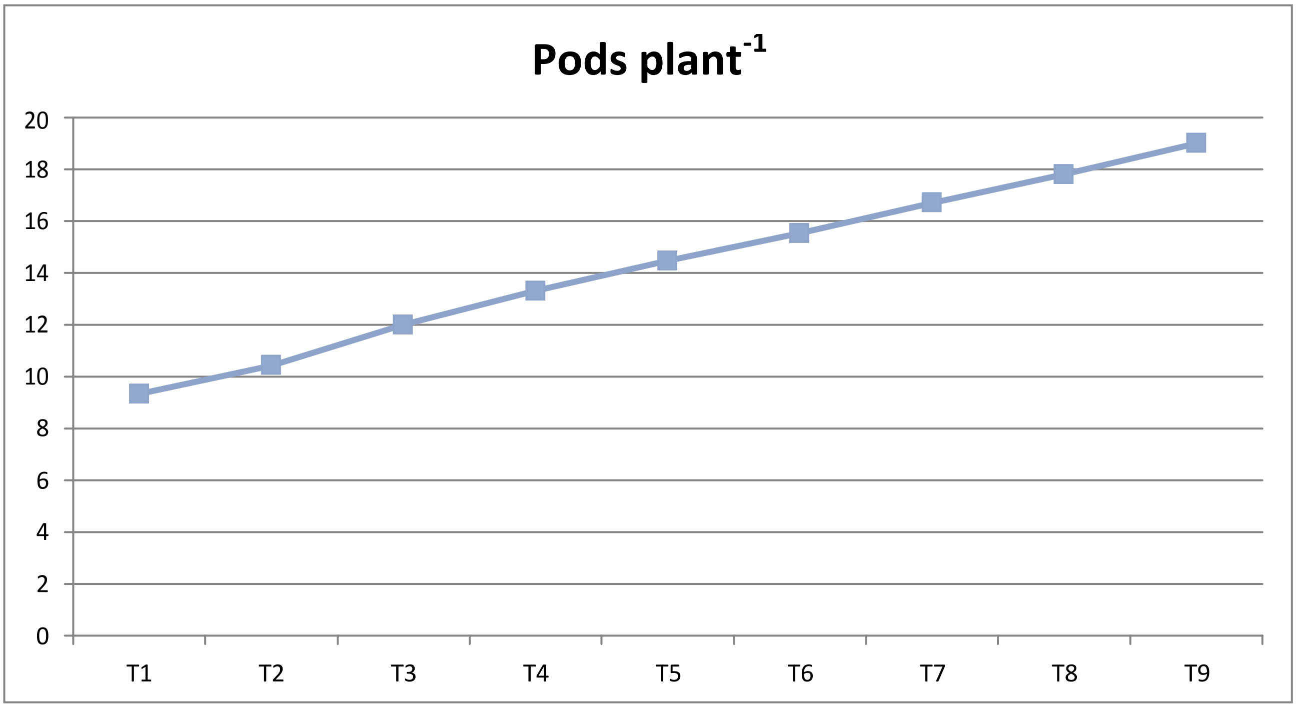

Fig. 4.12: Effect of different levels of N P K, *Rhizobium* and vermicompost on the number of pods plant^{-1} at 50 DAS.

4.14 Pod length

The data presented in table 4.13 and depicted in fig.4.13 clearly shows the response of pod length of cowpea recorded as influenced by different levels N P K, *Rhizobium* and vermicompost. The pod length plant^{-1} of cowpea was found to be increased significantly with the increase in levels of N P K, *Rhizobium* and vermicompost. The maximum pod length was recorded as 34.15 in T_9 (100 % RDF+ 100 % *Rhizobium*) and the minimum pod length was recorded as 14.01 in T_1 (control). Increased in pod length may be due to adequate availability of nutrients during reproductive stage of crop results in the increased pod length. Similar results were also reported by Ashwani *et al*., (2016), Yadav *et al*., (2017), Abdel *et al*., (2012) and Maurya *et al*., (2017).

Table 4.13: Effect of different levels of N P K, *Rhizobium* and vermicompost on the pod length (cm)

Treatment	Pod length (cm)
T_1	14.01
T_2	18.71
T_3	23.87
T_4	19.97
T_5	21.80
T_6	26.77
T_7	21.70
T_8	27.67
T_9	34.15
F-test	S
SE. d(±)	1.06
C.D. (P= 0.05)	2.25

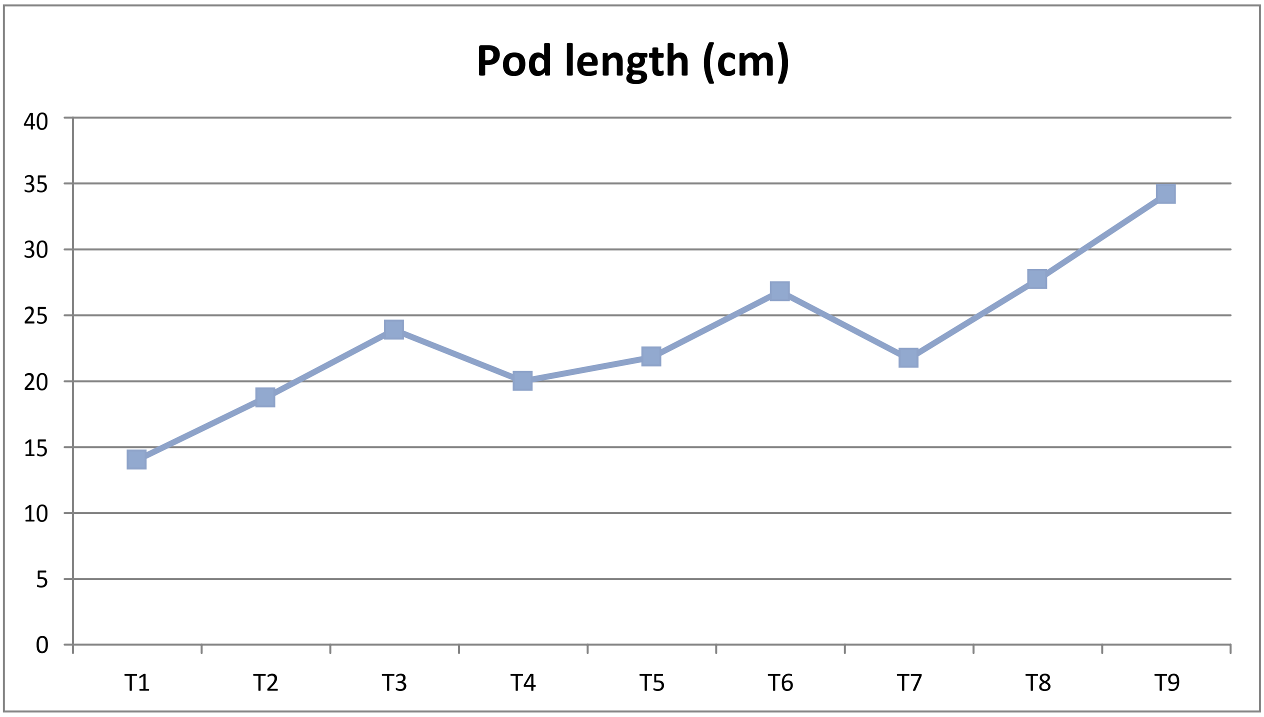

Fig. 4.13: Effect of different levels of N P K, *Rhizobium* and vermicompost on the pod length.

4.15 Seeds pod^{-1}

The data presented in table 4.14 and depicted in fig. 4.14 clearly shows the response of seeds pod^{-1} of cowpea recorded as influenced by different levels N P K, *Rhizobium* and vermicompost. The number of seeds pod^{-1} of cowpea was found to be increased significantly with the increase in levels of N P K, *Rhizobium* and vermicompost. The maximum number of seeds pods^{-1} was recorded as 10.67 in T_9 (100 % RDF+ 100 % *Rhizobium*) and at par number of seeds pod^{-1} were recorded as 6.00 in T_1 (control). Increase in number of seeds pod^{-1} may be due to adequate availability of nutrients during reproductive stage of crop results in the formation of more seeds. Similar results were also reported by Ashwani *et al.,* (2016), Yadav *et al*., (2017), Abdel *et al.*, (2012) and Maurya *et al*., (2017).

Table 4.14: Effect of different levels of N P K, *Rhizobium* and vermicompost on the seeds pod^{-1}

Treatment	**Seeds pod^{-1}**
T_1	6.00
T_2	6.67
T_3	7.67
T_4	6.67
T_5	8.67
T_6	9.67
T_7	7.67
T_8	10.00
T_9	10.67
F-test	S
SE. d($\pm$)	0.84
C.D. (P= 0.05)	1.77

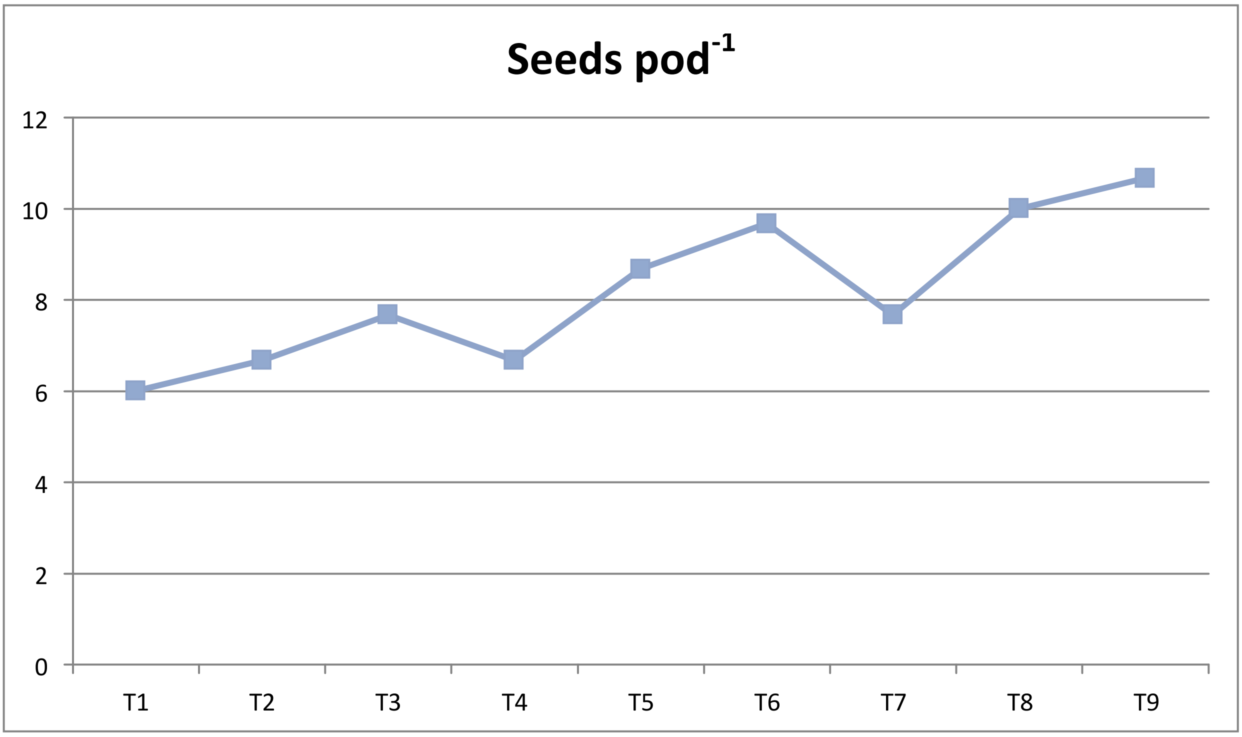

Fig. 4.14: Effect of different levels of N P K, *Rhizobium* and vermicompost on the seeds pod^{-1}

4.16 Pod yield

The data presented in table 4.15 and depicted in fig. 4.15 clearly shows the response of pod yield of cowpea recorded as influenced by different levels N P K, *Rhizobium* and vermicompost. The pod yield of cowpea was found to be increased significantly with the increase in levels of N P K, *Rhizobium* and vermicompost. The maximum pod yield was recorded as 164.13 in T_9 (100 % RDF+ 100 % *Rhizobium*) followed by T_8 and at par pod yield was recorded as 132.33 in T_1 (control). Increase in pod yield may be due to adequate availability of nutrients during reproductive stage of crop results in the formation of more pods. Similar results were also reported by Ashwani *et al.*, (2016), Yadav *et al.*, (2017), Abdel *et al.*, (2012) and Maurya *et al.*, (2017).

Table 4.15: Effect of different levels of N P K, *Rhizobium* and vermicompost on the pod yield (q ha^{-1})

Treatment	Pod yield (q ha^{-1})
T_1	132.33
T_2	146.00
T_3	153.33
T_4	138.33
T_5	144.17
T_6	154.20
T_7	156.27
T_8	159.07
T_9	164.13
F-test	S
SE. d(±)	1.32
C.D. (P= 0.05)	2.80

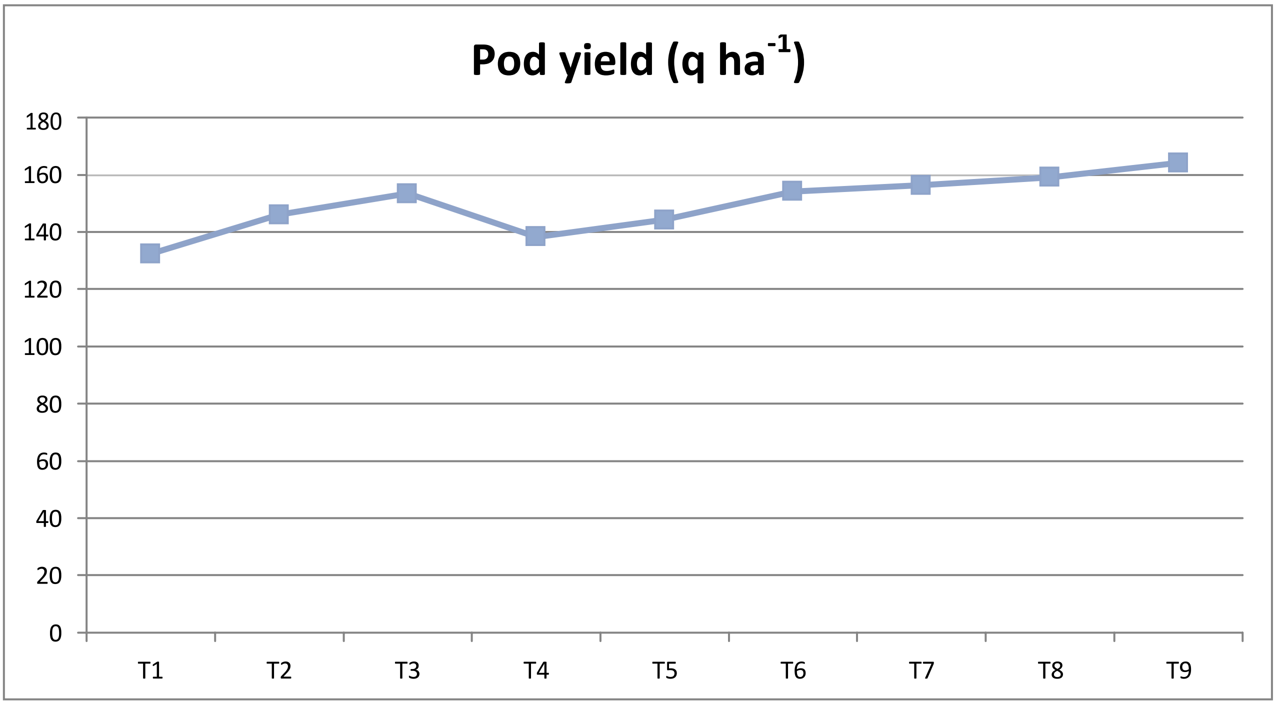

Fig. 4.15: Effect of different levels of N P K, *Rhizobium* and vermicompost on the pod yield.

Table 4.16: Cost of cultivation of cowpea crop ha^{-1}

S. No.	Particular	Units	Rates (₹)	Total cost
(A)	**Land Preparation**			
1.	Ploughing with (Mould Board plough)	2 hr	@500 ha^{-1}	1100.00
2.	Ploughing with (Harrow)	3 hr	@400 ha^{-1}	1200.00
3.	Levelling of field (Leveller)	3 hr	@300 hr^{-1}	900.00
(B)	**Sowing & Irrigation Charge**			
1.	Cluster bean seed	20 Kg ha^{-1}	@600 x 20 Kg	12000.00
2.	Sowing Charge	15 labour	@200/ labour	3000.00
3.	Irrigation Charge (2 Irrigation)	6 hr^{-1} Irrigation	@50 ha^{-1} x 2	600.00
4.	Irrigation labour Charge	4 labour	@200/day/labour	1600.00
(C)	**Weeding and Harvesting**			
1.	2 weeding were done	330 labour	@200 / day/labour	12000.00
2.	Harvesting	30 labour	@200 / day / labour	6000.00
(D)	**Rental value of land**			
1.	Field Rent	For 6 Months	6000 ha^{-1}	6000.00
2.	Supervision	2 Months	@2500/Months	5000.00
(E)	Miscellaneous	-	-	1500.00
	Total General Cost			50900.00

(F) Cost of N P K, vermicompost and *Rhizobium*

Cost of urea for 20 Kg nitrogen	43 kg urea	@ 6 kg^{-1}	258.00
Cost of SSP for 60 Kg Phosphorus	374 Kg SSP	@ 5 kg^{-1}	1870.00
Cost of MOP for 40 Kg Potassium	66 Kg MOP	@ 7 kg^{-1}	462.00
Vermicompost	2 q	@ 10 kg^{-1}	2000.00
Rhizobium	400 gm	@ 400 kg^{-1}	160.00

Table 4.17: Cost of cultivation for different treatment hectare^{-1}

Treatment	Particular	Units	Rates (₹)	Cost/Unit (₹)	Cost of Cultivation	Total cost of Cultivation
T_1	--	Control	--	--	50900 +0	50900
T_2	@ 50 % RDF + 1 q ha^{-1} Vermicompost	10:30:20 + 1 q	(258 + 1870 + 462) + 10 ₹ Kg^{-1}	1295 + 1000	50900 + 2295	53195
T_3	@ 100 % RDF + 1 q ha^{-1} Vermicompost	20:60:40 + 1 q	(258 + 1870 + 462) + 10 ₹ Kg^{-1}	2590 + 1000	50900 + 3590	54490
T_4	@ 50 % RDF + 2 q ha^{-1} Vermicompost	10:30:20 + 2 q	(258 + 1870 + 462) + 10 ₹ Kg^{-1}	1295 + 2000	50900 + 3295	54195
T_5	@ 100 % RDF + 2 q ha^{-1} Vermicompost	20:60:40 + 2 q	(258 + 1870 + 462) + 10 ₹ Kg^{-1}	2590 + 2000	50900 + 4590	55490
T_6	@ 50 % RDF + 10 g kg^{-1} seed *Rhizobium*	10:30:20 + 200 g	(258 + 1870 + 462) + 400 ₹ Kg^{-1}	1295 + 200	50900 + 1495	52395
T_7	@ 100 % RDF + 10 g kg^{-1} seed *Rhizobium*	20:60:40 + 200 g	(258 + 1870 + 462) + 400 ₹ Kg^{-1}	2590 + 200	50900 + 2790	53690
T_8	@ 50 % RDF + 20 g kg^{-1} seed *Rhizobium*	10:30:20 + 400 g	(258 + 1870 + 462) + 400 ₹ Kg^{-1}	1295 + 400	50900 + 1695	52595
T_9	@ 100 % RDF + 20 g kg^{-1} seed *Rhizobium*	20:60:40 + 400 g	(258 + 1870 + 462) + 400 ₹ Kg^{-1}	2590 + 400	50900 + 2990	53890

Table 4.18: Effect of different benefit-cost ratio (C:B) of Different Treatment Combination with cowpea crop.

Treatment	Yield (q ha^{-1})	Yield (₹ q^{-1})	Gross return (₹ ha^{-1})	Total cost of cultivation (₹ ha^{-1})	Net profit (₹ ha^{-1})	Benefit-cost ratio (C: B)
T_1	132.33	1000	132330	50900	81430	1: 2.59
T_2	146.00	1000	146000	53195	92824	1: 2.74
T_3	153.33	1000	153330	54490	98840	1: 2.81
T_4	138.33	1000	138330	54195	84135	1: 2.55
T_5	144.17	1000	144170	55490	88680	1: 2.60
T_6	154.20	1000	154200	52395	101805	1: 2.94
T_7	156.27	1000	156270	53690	102580	1: 2.91
T_8	159.07	1000	159070	52595	106475	1: 3.02
T_9	164.13	1000	164130	53890	110240	1:3.05

Selling price of cowpea (Seed yield) = 1000 ₹ q^{-1}

According to following table: - The economy of different treatment concerned, the treatment $\mathbf{T_9}$ provides highest net profit of ₹1,10,240.00 with highest benefit-cost ratio of 1: 3.05 however, the minimum net profit of ₹81,430.00 was recorded in the treatment $\mathbf{T_1}$ with benefit-cost ratio is 1:2.59.

SUMMARY AND CONCLUSION

An attempt was made to study **"Assessment of integrated nutrient on soil properties and yield of cowpea [*Vigna unguiculata* (L.)]"** was carried out in the Research Farm, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University Agriculture Technology & Sciences during the *Kharif* season of 2019. The Experiment was laid out in a Randomized Block Design with 9 treatments and 3 replications. The main findings of this experiment are summarized and concluded as below.

As for as the growth and yield parameters are concerned maximum plant height 64.40 cm, pods plant^{-1}19.00, pod length 34.15, seeds pod^{-1} 10.67 and pod yield 164.13 remained with T_9 (*i.e.*100 % RDF+100 % *Rhizobium*) followed by T_8 (*i.e.*50 % RDF+100 % *Rhizobium*). Minimum plant height 43.63 cm, pods plant^{-1} 9.33, pod length 14.01, seeds pod $^{-1}$6.00 and pod yield 132.33 was observed in the treatment T_1 (*i.e.* Control).

Soil pH before sowing was 7.50 and after harvesting decreased to 7.20 which was recorded in T_9 (*i.e.* 100 % RDF+100 % *Rhizobium*) and T_8 7.21 (*i.e.* 50 % RDF+100 % *Rhizobium*) followed by 7.26 by T_7 (*i.e.* 100 % RDF+50 % *Rhizobium*).

Electrical conductivity (dSm^{-1}) of soil before sowing was 0.19 and after harvesting was 0.18 recorded with T_9 (*i.e.* 100 % RDF+100 % *Rhizobium*) followed by T_8 0.17 (*i.e.* 50 % RDF+100 % *Rhizobium*) and T_7 0.16 (*i.e.* 100 % RDF+50 % *Rhizobium*).

Organic carbon (%) of soil before sowing was 0.39 and in soil after harvesting was 0.70 % in T_9 (*i.e.* 100 % RDF+100 % *Rhizobium*), followed by T_8 (0.68 %) (*i.e.* 50 % RDF+100 % *Rhizobium*).

Available nitrogen in pre-sowing soil was 228.4 kg ha^{-1} increased up to 317.25 kg ha^{-1} after harvesting and highest was in T_9 (*i.e.* 100 % RDF+100 % *Rhizobium*) followed by T_8 312.22 kg ha^{-1} (*i.e.* 50 % RDF+100 % *Rhizobium*).

Available phosphorus in pre-sowing soil was 20.0 kg ha^{-1} increased up to 32.99 g ha^{-1} after harvesting and highest was in T_9 (*i.e.* 100 % RDF+100 % *Rhizobium*) followed by T_8 31.27 kg ha^{-1} (*i.e.* 50 % RDF+100 % *Rhizobium*).

Available potassium in pre-sowing soil was 148.30 kg ha^{-1} increased up to 210.38 kg ha^{-1} after harvesting and highest was in T_9 (*i.e.* 100 % RDF+100 % *Rhizobium*) followed by T_8 130.58kg ha^{-1} (*i.e.* 50 % RDF+100 % *Rhizobium*).

The Maximum gross return of 1,64,130.00 and Maximum net profit of 1,10,240.00 was in treatment T_9 (*i.e.* 100 % RDF+100 % *Rhizobium*) was best in increasing plant height, number of leaves, number of branches, yield, physical and chemical properties of soil like- bulk density, particle density, pore space (%), EC, organic carbon, N, P, K, in cowpea plants.

Maximum benefit-cost ratio of (1: 3.05) was in the treatment combination T_9 (*i.e.* 100 % RDF+100 % *Rhizobium*) followed by (1: 3.02) in T_8 (*i.e.* 50 % RDF+100 % *Rhizobium*)

CONCLUSION

It was concluded from the trail that treatment T9 - [100 % RDF + 100 % (20 g Rhizobium kg^{-1} seed)] gave best results in terms of soil properties *i.e.* Bulk density, particle density, percentage pore space, specific gravity, pH, EC (dS m^{-1}), available nitrogen, phosphorus, potassium and organic carbon percentage, growth parameters and pod yield 164.13 q ha^{-1} respectively. Followed by T_8 - [50 % RDF + 20 g Rhizobium kg^{-1} seed) and was found to be at par than any other treatment In treatment T_9 gave best higher gross return of Rs. 1,64,130.00 and net profit was Rs. 1,10,240.00 with benefit-cost ratio (C: B) (1: 3.05) for Cowpea.

Since the results were based on one-year experimental data. It is suggested that the further work could be carried out for more than one season.

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APPENDIX

Bulk density

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	0	0	74.19	2.59	**NS**
Treatments	8	0.4	0.05	3.39	3.89	**S**
Error	16	0.01	0			
Total	26	0.42				

Particle density

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	0.001	0.001	0.25	2.59	**NS**
Treatments	8	0.06	0.001	8.06	3.89	**S**
Error	16	0.015	0.0009			
Total	26	0.074				

% pore space

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	0.73	0.36	0.89	2.59	**NS**
Treatments	8	110.33	13.79	33.77	3.89	**S**
Error	16	6.53	0.41			
Total	26	117.59				

Soil pH

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	0.01	0.001	1.12	2.59	**NS**
Treatments	8	0.89	0.11	41.34	3.89	**S**
Error	16	0.04	0.001			
Total	26	0.94				

Electrical conductivity

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	0.0003	0.0001	0.75	2.59	**NS**
Treatments	8	0.01	0.0013	7.19	3.89	**S**
Error	16	0.003	0.0002			
Total	26	0.014				

Organic carbon

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	0.0008	0.0004	3.45	2.59	**NS**
Treatments	8	0.076	0.0096	86.32	3.89	**S**
Error	16	0.002	0.0001			
Total	26	0.789				

Available nitrogen

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	10.08	5.04	2.81	2.59	**NS**
Treatments	8	11467.36	1433.42	800.57	3.89	**S**
Error	16	28.65	1.79			
Total	26	11506.08				

Available phosphorus

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	0.75	0.38	0.56	2.59	**NS**
Treatments	8	179.33	22.42	33.14	3.89	**S**
Error	16	10.82	0.68			
Total	26	190.91				

Available potassium

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	2.69	1.34	1.10	2.59	**NS**
Treatments	8	18419.99	2302.50	1892.88	3.89	**S**
Error	16	19.46	1.22			
Total	26	18442.14				

Plant height at 20 DAS

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	0.45	0.22	1.51	2.59	**NS**
Treatments	8	589.50	73.69	498.10	3.89	**S**
Error	16	2.37	0.15			
Total	26	592.31				

Plant height at 35 DAS

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	0.77	0.38	2.42	2.59	**NS**
Treatments	8	694.11	86.76	547.72	3.89	**S**
Error	16	2.53	0.16			
Total	26	697.42				

Plant height at 50 DAS

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	0.69	0.34	3.01	2.59	**NS**
Treatments	8	1216.38	152.05	1332.95	3.89	**S**
Error	16	1.83	0.11			
Total	26	1218.89				

Pod per plant

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	0.10	0.05	2.18	2.59	**NS**
Treatments	8	262.88	32.86	1408.11	3.89	**S**
Error	16	0.37	0.02			
Total	26	263.35				

Pod length

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	9.36	4.68	2.76	2.59	**NS**
Treatments	8	816.84	102.10	60.23	3.89	**S**
Error	16	27.12	1.70			
Total	26	853.31				

Seeds per pod

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	5.85	2.93	2.78	2.59	**NS**
Treatments	8	65.41	8.18	7.78	3.89	**S**
Error	16	16.81	1.05			
Total	26	88.07				

Pod yield

ANOVA						
Source	**df**	**SS**	**MSS**	**F calculated**	**F tabulated**	**Significance**
Replications	2	14.47	7.24	2.76	2.59	**NS**
Treatments	8	2543.12	317.89	121.40	3.89	**S**
Error	16	41.89	2.62			
Total	26	2599.49				

LIST OF PLATES OF EXPERIMENTAL FIELD

Plate No.1 Field preparation for sowing of Cowpea

Plate No.2 Picking of Cowpea Pods in Field

Plate No.3 Analysis of soil pH and EC by digital pH and digital EC meter

Plate No.4 Determination of potassium by (Toth and Prince, 1949)