“EFFECT OF INORGANIC AND ORGANIC FERTILIZER ON GROWTH AND YEILD OF BLACK GRAM (*Vigna muugo* L. Hepper) UNDER GUAVA (*Psidium guajava*) BASED AGRI-HORTI SYSTEM”

THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD TO THE DEGREE OF

MASTER OF SCIENCE (AGRICULTURE)

IN

AGRO FORESTRY

Submitted by

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CERTIFICATE

To,

The Registrar
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Through: The Head**,** Department of Agronomy**,** Institute of Agricultural Sciences**,**
Banaras Hindu University, Varanasi- 221005.

Dear Sir,

I have great pleasure in forwarding the thesis entitled **"Effect of Inorganic andorganic fertilizer on growth and yield of urdbean under guava based Agri horticulture system''** submitted by **Mr. Anil Kumar Yadav, I.D. No. AGF-15202, Enrolment No: 376516**in partial fulfillment of the requirements for the degree**Master of Science (Agriculture)** in **Agroforestry**.

I certified that the work has been carried out under my guidance and the data forming on the basis of this thesis, to the best of our knowledge are original and genuine and no part of the work has been submitted for any other degree or dissertation.

Thanking you.

Yours faithfully

FORWARDED BY

(*V. K. Srivastava)*
Supervisor

HEAD

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ABBREVIATIONS AND SYMBOLS USED

@	**:**	At the rate of
et al.	**:**	and others
Cm	**:**	Centimeter
CD	**:**	Critical difference
cv.	**:**	Cultivar
DAP	**:**	Diammonium Phosphate
DAS	**:**	Days After Sowing
d.f.	**:**	Degree of freedom
^{o}C	**:**	Degree Celsius
Fig.	**:**	Figure
gm	**:**	Gram
ha	**:**	Hectare
kg	**:**	Kilogram
m	**:**	Meter
mg	**:**	Milligram
Mha	**:**	million hectares
mm	**:**	Millimeter
N	**:**	Nitrogen
P	**:**	Phosphorus
K	**:**	Potassium
Viz.	**:**	Namely
SEm±	**:**	Standard error Mean
i.e.	**:**	that is
NS	**:**	Non Significant
Max.	**:**	Maximum
Min.	**:**	Minimum
SW	**:**	Standard week
T	**:**	Tonnes
RHZ	**:**	Rhizobium
VC	**:**	Vermicompost
FYM	**:**	Farm yard manure

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INTRODUCTION

In developing countries like India, the land resources are shrinking due to continuous increase in population and it is very difficult to maintain present arable land (142.0 m/ha) and also the food security to the population. An integrated approach of land management to sustain the food security is thus urgently required. Increasing the land productivity is one of the most variable option, for food, fodder and fuel production in developing countries including India will have to be increased by 60% in the next 25 years to meet the needs of growing population. However, efforts are made being to increase productivity of agricultural land by advocating agroforestry as one of the most practical way for meeting the needs of food, fodder and fuel. Agroforestry systems are often claimed to be superior to agricultural systems because of their ability to contribute to sustained production of crops. These systems also play a promising role for environmental protection. It is an established fact that there is reduction in crop yield when crops are grown with tree plantations particularly at later stage of tree growth, but overall productivity remains higher than the either of individual one.

The country has the advantage of growing different horticultural crops in various agro-climatic zones. There is ample scope to exploit the interspaces of the fruit plantation during the initial 6-7 years by growing arable crops (Gill and Bisaria, 1995). Gill and Gangwar (1992) also stated that interspaces of custard apple and aonla orchards can be exploited by intercropping grain and fodder crops during initial years of establishment of fruit trees.

India producing 14.76 million tons of pulses from an area of 23.63 million hectare, which is one of the largest pulses producing countries. However, about 3 million tons of pulses are important annually to meet the domestic consumption requirement. Thus, there is need to increase production and productivity of pulses in the country by more intensive interventions. Pulses can even be grown under soil moisture stress and as low input. Sustainable agriculture is cheapest and main source of quality protein which contains 20-25 percents.

The major pulse growing states are Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, and Andhra Pradesh which together accounts for 82 per cent of the production from an area of about 74per cent in India. Black gram occupies 3.10million hectares and contributes to 1.45 million tonnes in pulse production.

In agroforestry system, the selection of suitable crops and cropping system maybe one of the strategies to mitigate the problems related to drought. The duration of traditional crops grown in rainfed areas are often proved longer than the effective season length. The crop usually experiences moisture stress, mostly during grain filling period. Introduction of relatively short duration cultivars/crops are found favourable with the environments in rainfed areas. Short duration crops may be intercropped to make the best use of resources in an agroforestry system in which perennial fruit trees and crops usually grown together. Besides the efficient resource use, the techniques used for crop production in agroforestry, trees also share benefits due to interculture, weed control, tillage, mulching etc.

Black gram (*Vigna mungo* L.) or urdbean is basically a warm season crop, however in India it is grown in zaid and kharif, even up to 1800 m altitude. It is grown in cropping as a sole crop, mixed crop, catch crop and sequential crop. It is quite drought resistant but intolerant to prolonged cloudiness. It is normally grown in areas with an average temperature of 25-35°C and an annual rainfall of 600-1000 mm. In higher rainfall areas, it may be grown in the dry season on residual moisture. It is considered to have been domesticated in India from its wild ancestral form *Vigna mungo* var. silvestris. Centre of genetic diversity is found in India (Zeven and de Wet 1982). Natural distribution of V. mungo var. silvestris ranges from India to Myanmar (Tateishi 1996). In India, it is grown in an area about 3.06 m ha. with a total production of 1.7 mt with an average productivity of 555 kg/ha (2013-14 source www.iipr.res.in). Andhra Pradesh ranks first in area and production followed by Madhya Pradesh, Odisha and Maharashtra, while Karnataka leads in productivity followed by Andhra Pradesh. The Guntur District ranks first in Andhra Pradesh for the production of black gram.

Guava (*Psidium guajava* L.) is one the important fruits crops which distributed throughout the tropics and is pre-eminently a desert fruit. It is normally eaten fresh which contain vitamin C (35-42 mg/100 g) which is slightly higher than in grape fruit.

Beside vitamin C it has high nutrient value of thiamine, potassium and dietary fibre. It's wood is a good source of firewood; the light-yellow sapwood and brownish heartwood are soft, light in weight and weak. Green fruits, seeds and leaves have effective vermicidal and insecticidal properties. Leaves, shoots, bark and roots have been reported to have medicinal properties. The unripe fruit is astringent, and the root is a drastic purgative. It can be planted as a shade tree and also suitable for growing with short duration arable crops. Like urdbean, mungbean, chickpea, maize, etc.

Agri-horti systems have emerged as a viable option for achieving cover on one hand and to fulfil the increasing, requirement on other hand. In this system, we can increase the total output from land by growing mainly short duration crops within the alleys of such fruits crops. Commonly preferred horticulture based agroforestry system which envisages the growing of trees and woody perennial in the field as intercrops, as alley cropping in the shape of the hedge row type of plantation etc. the crop species grown in association with *Psidium guajava, Annona squamosa, Aegle marmelos, Carisa carandus, Morus alba, Emblica officinalis* etc. Agricultural crops like black gram, green gram, sorghum, pearl millet, gaur, etc. may be taken during *kharif* season. They are normally grown in the interspaces of fruits trees planted at a spacing of 5-7 m. apart. The fruit trees are managed for 30-35 years and the give regular income. Intercultivated agricultural crop provide seasonal returns. The black gram performed well under wider spacing of (*Psidium guajava).*

Guava fruits are used for Jam and Jelly making. Some important guava cultivars are Allahabad Safeda. Lucknow-49 (Sardar Guava) Other new promising guava varieties shewta, Lalit, Punjab pink, Arka Amulya, Pant Prabhat.

Nitrogen (N) is essential for the normal growth of plants. All vital physiological processes are related to this nutrient. It is a basic constituent of many compounds of primary physiological importance to plant metabolism, such as chlorophyll, nu-Cleotilde, proteins, alkaloids, enzymes, hormones and vitamins. Hence nitrogen is a nutrient required by plants in comparatively large amounts than the other soil borne elements. Nitrogen must be supplied to the plant through inorganic fertilizer for an optimal yield and replenishment of removed soil nitrogen.

There is a need to improve nutrient supply system in terms of integrated nutrient management involving the use of inorganic and organic sources of nutrients in each cropping system. It is necessary to find out optimum quantity of P and N, respectively, to urdbean (legume) and wheat (cereal) crops under double cropping system of urdbean followed by wheat when organic manure was applied. Under present energy cri-sis situation, it is necessary to work out energy budgeting for each crop production system under different situations. Keeping the above aspect in view, a study was undertaken to determine optimum the doses of P and N to urdbean when FYM was applied for efficient use of energy and other natural resources. There is a great possibility to increase production of legume plants by exploiting better colonization of their root and rhizosphere through *rhizobial* inoculation, which can fix atmospheric nitrogen and protect nature from pollution. Legumes, has the ability to fix atmospheric nitrogen through symbiotic association with *Rhizobia*. The ability of symbiotic fixation offers an opportunity to improve nitrogen status of the soil and crop productivity under rainfed conditions.

Traditional use of chemical fertilizers in agriculture production cannot be over emphasized. The cost of chemical fertilizers is becoming unaffordable for the farmers of rainfed areas in addition to creating soil and water hazards. There is great need to supplement or substitute chemical fertilizers with organic manures or to explore biological means to improve the soil health. The organic manures are not available in the Bidar region and whatever is available, the people use it as fire wood rather than to use it for soil fertility. Therefore, there is need to explore the potential of *Rhizobia* as legume inoculants under agro climatic conditions of the Bidar region. *Rhizobium* spp. invades the root hairs of legumes and result in the formation of nodules, where free air nitrogen is fixed. These bacteria, although present in most of the soils vary in number, effectiveness in nodulation and N-fixation. It has been argued that usual native soil rhizobial populations are inadequate and are ineffective in biological nitrogen fixation. To ensure an optimum *rhizobial* population in the rhizosphere, seed inoculation of legumes with an efficient *rhizobial* strain is thus necessary. This helps improve nodulation, N2 fixation solicit crop growth and yield of leguminous crops (Henzell, 1988). *Rhizobia* is one of the dominant symbiotic nitrogen fixing bacteria with legumes but a number of factor including low number of *Rhizobia* and ineffective native *Rhizobia* lead to poor nodulation and nitrogen fixation in legumes. Legume and *Rhizobium* symbiosis contributes at least 90 x 106 metric tonnes of N per year all over the world (Subba Rao, 1982). Many researchers carried out experiments on *rhizobium* inoculation with and without fertilizers on legume crops (Malik *et al*., 2002; Ashraf, 2003; Hayat *et al.*,2004; Muhammad *et al.,* 2004; Nadeem *et al.,* 2004) and found increased nitrogen contents of seed, number of nodules, yield and yield components.

Phosphorus is an important plant nutrient which is referred to as the "master key" element in crop production (pierre,1938). It is associated with several vital functions like seed germination, cell division, flowering, fruiting, synthesis of fat, starch, and in almost every biochemical metabolic activity. It also induces root proliferation and nodulation.

Phosphorus has novel function of special importance in the process of energy storage and transfer. Most of the grain legumes have responded well due to its favourable effects on roots proliferating nodules development, bacterial activity and nitrogen fixation. Among the various factors responsible for maximization of yield of this crop, integration of NPK (20:40:20 Kg ha-1 and30:50:30 Kg ha-1) with farm yard manure is most important factor, for maximizing the yield, it is essential that black gram should not suffer due to inadequate mineral nutrient especially nitrogen and phosphorus. Since chemical fertilizers are scare and costly, it is necessary to use them economically and in combination with organic fertilizer, Blackgram showed high response of **organic and inorganic fertilizer on growth and yield of blackgram under guava based agri-horti system**, and therefore this experiment was conducted with following objectives.

1. To study the effect of organic manure (FYM, vermicompost, rhizobium) on yield of blackgram.
2. To study the effect of inorganic fertilizer (N, P, K) on yield of black gram.
3. To study the combination of organic and inorganic fertilizer on growth and yield of black gram.
4. To work out relative economics of the treatments.

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REVIEW OF LITERATURE

Pulses are the second important group of crops after cereals. Pulses have contributed significantly in providing nutritionally balanced food for predominantly vegetarian population in India. Presently, pulse production has remained around 13-15 million tonnes while annual domestic demand has risen to 18-19 million tonnes. This shortfall in pulses is mainly due to near stagnation in production at 13-15 million on account of poor spread of improved varieties and technologies, abrupt climate changes, complex weed pest disease syndrome and declining factor productivity. In order to narrow down the demand supply gap, the country resorts to import of pulses to the tune of 3-4 million tonnes every year. In order to ensure self-sufficiency, a paradigm shift in the research and technology generation is thus required (Shanmugasundaram and Arros, 2009).

India is the largest producer and consumer of pulses in the world contributing around 25-28% of the total global production. The production of total pulses is presently about 15 million tons covering an area of about 22-23 million hectares, majority of which is falling under rain-fed, resource poor and harsh environments frequently prone to drought and other abiotic stress conditions. Due to stagnant production, the net availability of pulses had come down from 60g/day/person in 1951 to 33g/day/person at present (Reddy, 2009).

Mungbean and Urdbean are grown in *Kharif* (monsoon), winter and spring/summer seasons in different agro-ecological regions. These two crops have strategic positions in South East Asian countries for nutritional security and sustainable crop production. Being rich in quality protein, minerals, and vitamins they are inseparable ingredients of in the diets of the vast majority of Indian population. When supplemented with cereals they provide a perfect mix of essential amino acids with high biological value. These crops have the ability to fix atmospheric nitrogen (58-109 kg/ha in Mungbean and 55-140 kg/ha in Urdbean) in symbiotic association with Rhizobium bacteria, which enables them to meet their own nitrogen requirements. Outside of Asia, Mungbean is grown in Australia, East Africa, the

United States, Western South America, and the Caribbean region. The major Mungbean-exporting countries are Thailand and Australia, but Mungbean is frequently exported from Burma, China, India, Kenya and Peru (Handbook of Agriculture, 2009).

Mungbean and Urdbean Crops are grown as sole crop or as inter crops with sugar cane, cotton, groundnut, sorghum, maize, pearl millet and pigeon pea during Kharif or sole relay crop in rice fallows during winter and a sole catch crop during spring/summer seasons. The phenology and morphology of these crops are extremely plastic depending on the genotype, growing seasons and ecological regions.

Short duration varieties of Mungbean and Urdbean maturing 60-70 days with the yield potential 8-10q/ha have been developed for different states. Mungbean and Urdbean varieties suitable for Rabi season have been developed. Potential of summer Mungbean/Urdbean has been realized in terms of productivity and economic returns. The agronomy of these crops had been worked out, according to which 25 March for spring season Mungbean/Urdbean and 10 April for summer Mungbean have been found ideal for planting 10 kg N and 30 kg P2O5 per hectare when planted after wheat, mustard, sugarcane and no fertilizer application when planted after potato had been recommended (Ali and Kumar, 2006).

2.1 Effect of Organic and Inorganic Fertilizer on Growth and Yield of Black Gram

2.1.1 Growth Parameter

Soumare *et al.* (2003); Moller (2009) investigated organic materials which hold great promise as a source of multiple nutrients and ability to improve soil characteristics. Since the effect of organic nutrients on crop yield is long term and not immediate, thus farmers are reluctant to use organic fertilizers in their cropping system.

Gour. (1993) stated that Black gram is a grain legume widely cultivated in Pakistan, India and other Asian countries. It is part of diet for millions of people in these countries and a cheap source of protein with 17 - 34% of protein in seeds. Mahmood and Athar (2008); Mandal *et al.* (2009) reported an important feature of the mashbean plant is its ability to establish a symbiotic partnership with specific bacteria, setting up the biological N2-fixation process in root nodules by rhizobia that may supply the plant's needs for N.

Pawar *et al.* (2014) reported that *rhizobium* species are group of bacteria that capable of fixing atmospheric nitrogen symbiotically and thus stimulate the growth of plants. In the present study, root nodulating bacteria were isolated from root nodules of Soybean (Glycine max L.) on yeast extract mannitol agar (YEMA) medium. The isolates were identified by their cultural, morphological and biochemical characterization. *Rhizobium* isolates were found to be rod shaped, gram negative, acid and mucous producing. Optimum temperature and pH of the *Rhizobium* was found to be 36°C and 7.0 respectively. While evaluating antibacterial and antifungal activity of *Rhizobium* against rhizospheric bacteria and pathogenic fungi (*Aspergillus niger* and *Fusarium oxysporum*), it was found that *Rhizobium* did not inhibit the rhizospheric bacteria but inhibited the growth of pathogenic fungi which indicates that *Rhizobium* may secrete antifungal compounds. In pot assays of *Rhizobium*, seed inoculation was more effective than soil inoculation. In case of seed germination on the growth of Bengal gram (*Cicer arietinum*), Moth beans (*Vigna aconitifolia*), Green gram (*Phaseolus aureus* Roxb.) and Peas (*Pisum sativum*) crop plants, it was noted that it enhanced the growth rate, hence *Rhizobium* can be used as bioinoculant.

David (1991) found that nodules on roots of legumes are responsible for fixing atmospheric nitrogen and *Rhizobium* plays an important role for nodulation in leguminous plants. *Rhizobium* also improves the yield significantly in many legume crops.

Patil and Shinde (1980) reported similar effect of *Rhizobium* inoculation in root and shoot length of black gram.

Yugandhar and Savithramma (2013) reported nitrogen and phosphorus are most important plant nutrient for crop production. Nitrogen as constituent of chlorophyll, harnesses solar energy and fixes atmospheric CO2 as carbohydrates. Phosphorus play important role in root development, nodulation, flowering, fruiting and is usually a constituent of phospholipids, nucleic acid, protein, coenzyme, NAD, NADP, and ATP.

Mehmet (2008) stated the prime necessity to maintain optimum plant population by maintaining inter and intra row spacing properly. Maximum or minimum plant density may minimize yield of Blackgram causing physiological change in plant. Hence appropriate Fertilizer dose with adequate plant population may increase crop yield of Blackgram.

Pookpakdi and Pataradilok, (1993) reported optimum row spacing plays an important role in contributing to the high yield because thick plant population will not get proper light for photosynthesis and can easily be attacked by diseases. On the other hand, very small population less than optimum will also reduce the yield.

Keating and Carberg(1993) investigated the uniform spacing generally gives a greater yield than hill groupings under favorable moisture conditions. Blackgram is highly responsive to nitrogen and phosphorus. Leaf area is made up of the total green lamina area of emerged leaves.

Muchow (1985) found that greater leaf area is necessary to have superior yield and yield components in grain legumes.

Saini and Thakur (1996) stated that moderate doses of nitrogen and phosphorus (30:60 kg N:P per hectare) significantly increased the plant height, branches plant-1 and leaf area index of grain legumes compared to no N and P.

Kumar *et al*. (2011) reported that the FYM play an important role in improving the fertility and productivity of soils through its positive effects on soil physical, chemical and biological properties and balanced plant nutrition. It improves the structure and water holding capacity of soil. Due to low and unstable production with increasing population pressure, per capita availability of pulses decreasing from 69 g in 1961 to about 31.6 g in 2010-11, against the minimum requirement of 80 g per capita per day. To make up minimum 50 g pulses per capita per day and further demand from burgeoning population at least 23.88 m tonnes of pulses are required by 2015 which is expected to touch 29.30 million tonnes by 2020. To satisfy the demand of pulses requirement of ever increasing population, the production of pulses has to be increased only by increasing the yield/unit area/day.

Rathore *et al.* (2010) conducted a field experiment during 2003-04 and 2004-05 to develop suitable integrated nutrient supply system for black gram-wheat cropping system. The study was aimed to find out the effect of integration of chemical source of phosphorus with bio-fertilizers on black gram and their residual effect on succeeding wheat crop at Udaipur. Incorporation of FYM @ 5 t ha-1 considerably decreased the bulk density and increased the porosity, cation exchange capacity, organic carbon and available N, P and K status of the soil. Study showed the application of FYM @ 5 t ha-1 or application of 40 kg P2O5 ha-1 significantly increased the seed and Stover yield of black gram as well as of succeeding wheat grown in sequence. Dual inoculation to black gram also increased the yield of black gram and succeeding wheat crop grown in sequence.

Rice fallow pulse cropping system would sustain the returns to the growers by fetching more price than cereals in spite of lower yields particularly for poverty-striken small farmers. It also improves the sustainability of rice production system (Bastia *et al*., 2008 and Prasad *et al*., 2013).

Proper fertilization is essential to improve the productivity of blackgram. It can meet its nitrogen requirements by symbiotic fixation of atmospheric nitrogen. The nutrients which need attention are phosphorus and sulphur (Thakur and Negi, 1985; Nandal*et al*., 1987).

The yield and nutritional quality of blackgram is greatly influenced by application of FYM and nutrient elements. FYM is known to play an important role in improving the fertility and productivity of soils through its positive effects on soil physical, chemical and biological properties and balanced plant nutrition (Kumar *et al*., 2011).

Mir *et al.* (2013) investigated the effect of levels of phosphorus, sulphur and Phosphorus Solubilizing Bacteria (PSB) on growth, yield and nutrient content of blackgram for consecutive two years 2004 and 2005. The crop growth parameters viz., plant height, number of nodules and number of leaves per plant, yield and nutrient content increased significantly with the application of high levels of phosphorus, sulphur with or without bio-fertilizer inoculation. Application of 60 kg P2O5 ha-1 recorded maximum plant height (49.9 cm), number of leaves plant-1(50.8), number of nodules plant-1(27.8), haulm yield (28.9 q ha-1), grain yield (8 q ha-1) and phosphorus, sulphur and protein content of grain (0.356 %, 0.253% and 22.64%, respectively) as compared to lower levels. Application of Sulphur @ 40 kg ha-1 recorded maximum plant height (47.31 cm), number of leaves plant-1 (49.80), number of nodules plant-1 (25.58), haulm yield (28.80 q ha-1), grain yield (7.92 q ha-1) and phosphorus, sulphur and protein content (0.295, 0.281 and 21.79%, respectively). Inoculation of blackgram seeds with phosphorus solubilizing bacteria recorded slightly higher grain yield (7.49 q ha-1) as compared to no inoculation (7.39 q ha-1).

2.1.2 Yield Attributes and Yield

Islam *et al.* (2011) conducted Front Line Demonstrations (FLD) on urdbean through the Krishi Vigyan Kendra, East Sikkim, ICAR Sikkim Centre, Ranipool in the district for 4 consecutive years starting from 2005 to 2008 during the kharif season in 20 villages spreading over 14 blocks to disseminate the improved agro-technology of urdbean for boosting productivity and highest seed yield (1340 kg ha-1) was recorded under FLD in the year 2006 as against 890 kg ha-1 under farmers' practices. Fifty four percent increase in the yield was obtained under FLD over farmers' practice during the year 2007. The lowest yield of 812 kg ha-1 was registered under FLD vis-à-vis 530 kg ha-1 in farmers' practices during 2008.

Kumar *et al.* (2015**)** conducted a field experiments in *Kharif* 2013 and 2014 in Muzaffarnagar district of Uttar Pradesh on black gram (Urd) to assess the contribution of growth boosters commercially available in the market. For this purpose, Aminos, Biozyme, Tracel and Planofix were sprayed on standing crop at 30 and 50 days after sowing. The seed of black gram was inoculated prior to sowing for all the treatments except control. Growth boosters were applied as alone and also their dual combinations. The data were recorded on plant growth characters at 40 and 70 days after sowing and yield attributing character were recorded at harvest. Among single applied growth boosters, Aminos (yield 8.90 and 9.32 q/ ha) contributed more to promote plant growth and yield attributing characters followed by planofix (yield 8.66 and 9.11 q/ ha), tracel (yield 8.33 and 8.86 q/ ha) and biozyme (yield 8.10 and 7.86 q/ ha).Highest plant growth, yield attributing character and grain yield (yield 10.10 and 10.66 q/ ha) observed from dual application of aminos + planofix followed by aminos+ tracel (yield 9.90 and 10.35 q/ ha) aminos+ biozyme (9.86 and 10.26 q/ ha), biozyme+ planofix, planofix+ tracel and biozyme+ tracel from both the years of experiments.

Singh *et al.* (1993) reported the higher grain yield of blackgram is associated with significantly superior yield attributes e.g. effective number of pods per plant and 1000 seed weight. Keeping this in view of above facts, it was imperative to undertake an investigation to find out optimum level of nitrogen, phosphorus and the optimum plant density for the AKU-07-04 genotype in Kharif season.

Ghanshyam and Jat (2010), Sharma and Abraham (2010), Shete *et al*. (2011) and Tomar *et al*. (2013) found that the seed and stover yield of blackgram significantly increased due to application of farm yard manure. FYM applied @ 5 t/ha produced significantly higher seed (1149 kg/ha) and stover yields (2652 kg/ha), which was to the tune of 10.16 and 19.08 per cent higher as compared to control. The marked increased in grain and stover yield due to beneficial effect of FYM on various growths and yield attributes like plant height and number of branches and finally their cumulative effect on yield.

Kadam *et al*. (2014) conducted a field experiment to study the effect of phosphorus, vermicompost and PSB inoculation on growth, yield and quality of black gram during Kharif 2011 on the farm of Agronomy department, at college of

Agriculture, Latur. The research showed that the application of 75 kg P2O5ha-1 recorded highest seed yield (1194 kg ha-1) and yield attributes as well as high economic returns but it was found at par with 50 kg P2O5ha-1. The higher B: C ratio (1.58) was recorded at 50 kg P2O5ha-1. Therefore, it is recommended to apply 50 kg phosphorus ha-1 to black gram crop.

Ganajaxi *et al.* (2014) conducted the experiment at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad during 2009 -2011 under rainfed condition to find out optimum appropriate P and N dose for urdbean - wheat system. The treatments comprising two levels of organic manures (FYM @ 0 and 5 t/ha) and three levels of phosphorus to rainy season urdbean (0, 25 and 50 kg/ha) and three levels of nitrogen (25, 37.5 and 50 kg/ha) to winter wheat were applied. Common recommended dose of nitrogen (25 kg/ha) and phosphorus (25 kg/ha) to urdbean and wheat, respectively, was applied. Pooled data of three years indicated that the application of 5 t FYM/ha in rainy season increased the yield of urdbean and succeeding wheat significantly over 0 t FYM. Among the P_2O_5 levels, 25 and 50 kg/ha were on par with each other to have effect on both urdbean and wheat yield. Among the N levels of wheat, 50 kg/ha proved significantly superior over the reduced doses of nitrogen (37.5 and 25 kg/ha) on wheat yield. When wheat equivalent yield, net returns, B:C ratio and energy use efficiency were considered, application of 5 t FYM/ ha was able to reduce the P dose to urdbean to fifty percent and N dose of succeeding wheat to twenty five percent.

2.2 Effect of Integration of Inorganic and Organic Fertilizers

2.2.1 Growth Parameters

Jain *et al.* (2003) observed the effect of organic and phosphorus fertilizer on the growth and nutrition of chickpea. The organic treatments produced higher yield through improved plant height, dry matter accumulation and number of branches per plant respectively compared to the control treatment. However, application of P at 50 kg per hectare showed 9.99, 34.33 and 16.46 per cent higher values for these growth parameters respectively, compared to the control.

2.2.2 Yield Attributes and Yield

Srinivas *et al.* (2002) observed the effects of N (0, 20, 40 and 60 kg per hectare) and P (0, 25, 50 and 75 kg per hectare), along with seed inoculation with *rhizobium* culture on the growth, yield and yield components of green gram. Plant height, number of seed per pods, number of pods per plant, phytomass per plant etc, generally increased with increasing rates of P as well as N up to 40 kg per hectare, however further increase in N decreased the yield.

2.3 Effect of Agri-horti System on Arable Crops

2.3.1 Growth Parameter

Ram and Kumar (2009) conducted an experiment at Indian Grassland and Fodder Research Institute, Jhansi on sandy loam soil in 6-year-old established Annona orchard and observed that the plant height and number of branches per plant of legumes significantly increased with the application of phosphorus and potash @ 60 and 45 kg per hectare over their lower levels and the control. Similar findings were also reported by Bhattacharya *et al*. (2004). Growth parameters of Annona were remained unaffected due to two legumes intercropping. However, significant increase in height (3.5 m) collar diameter (6.3cm) and canopy spared (3.9 cm) of *Psidium guajava* was recorded with the application of 40 kg phosphorus and 30 kg potassium over control.

Jama *et al.* (1991) assessed performance of *Acacia albida* and other nitrogen fixing multipurpose trees. Growth performance at 8 densities and rotationally intercropped with maize and green gram for a 5-year period. Mean height and diameter at breast height of intercropped *A. albida* were respectively 140 and 24per cent higher than the tree alone(control) by the fifth year. Crop growth was reduced in the intercropping treatments, especially under higher tree densities.

Yadav *et al*. (1993) found that plant density in mustard crop declined with increasing tree canopy spread or decreasing the crop distance from the tree stem in alley cropping system. Increasing the spacing and crop distance resulted cooperatively better growth in plants. Maximum growth was found in various tree + crop interaction (Chauhan *et al*., 1995). Dhillon *et al.* (1997) also reported that the growth of wheat increased with increasing the crop distance from the base. Dry matter of wheat per hill was significantly higher in the control than under tree canopy at different spacing. The minimum growth of intercrop at closer tree has also been reported by Biasaria *et al*. (1997).

Korwar *et al.* (1999) investigated the performance of green gram (cv. ML-267), black gram (cv. T-9) and cowpea (cv. C-152) sown as mono cropped or intercropped with *F. albida* trees at densities 625 or 156 plants/ha (4 x 4 and 8 x 8 m spacing), respectively. Growth of green gram and black gram were more under the higher tree density, whereas lower growth of cowpea under the trees at both densities than when monocrop.

Thakur *et al*. (2002) studied the effects of different canopy management treatments in 5-year-old *Morus alba* trees on growth potential of urdbean and pea. Results showed that growth *viz*. parameters like plant height, number of branches/plant, number of flowers/plant, leaf area and leaf area index were found to have maximum magnitude in the control (without tree) followed by plants under least shade (75per cent crown removal). The values decreased with increasing shade (less transmission) in both urdbean and pea. Better growth was observed on northern aspect than southern aspect.

2.3.2 Yield Attributes and Yield

Malik and Sharma (1990) reported reduction of yield when 30 percent of the crops grown at the distance of less than 10 m from the tree line. Thus, despite the use of drought -adopted plants, water competition is likely to play a major role in the productivity of agro forestry system, especially in dry areas.

Yadav *et al.* (1993) reported that the plant density of mustard crop declined with increasing tree canopy spread or by decreasing the crop distance from the tree stem in alley cropping system. Increasing the spacing and crop distance resulted co-operatively higher yield of plants and maximum yield was found in various tree and crop interaction (Chauhan *etal*., 1995). Sharma *et al*. (1996) also reported crop yield with increasing the crop distance from the base.

Ramshe (1990) evaluated effect of growing pearl millet, red gram and sunflower between rows of *Leucaena, Azadirachta indica, Eucalyptus* hybrid and *Dalbergia sissoo* and found that grain yield of the crop was not affected by trees initially thereafter reduced the grain yield especially at closer spacing. On an average

5.0, 7.5 and 10.0 m alley widths reduced grain yield by 39, 29 and 25 per cent, respectively. Sunflower yields were reduced most by the tree species followed by red gram and pearl millet.

Harwood and Owino (1992) suggested that sparse and narrow crowns and deep rooting habit are desirable attributes. Crop varieties which establish rapidly and develop extensive root system may compete more effectively with trees for below-ground resources.

Kater *et al.* (1992) and Kessler (1992) reported that sorghum and millet yield in the Sahel was correlated with incident radiation under the tree (*Acacia spp.*) canopy. Lehmann *et al.* (1998) working with a Kenyan alley crop, found greater water competition between *Acacia sp.* and sorghum in the first 0.45 m of the soil, even though the roots reached 1.5 m depth.

Gupta *et al.* (1998) evaluated tree-crop interactions on varying tree densities (1666, 833 and 417 stems/ha) and different intercrops (*Vigna mungo, Cyamopsis tetragonoloba, Vigna aconitifolia* and *Pennisetum glaucum*). During the tree establishment phase, *Prosopis cineraria* did not compete with the associated crops at the 2 lower tree densities, nor was its yield affected by them at any density. Data on soil water content in cropped and uncropped plots confirmed the lack of competition, but also showed differences between crops in their effect on soil water. However, when the trees were older, and at higher tree densities, crop yield was reduced, and there was a decrease in soil water in the upper 75 cm layer, indicating competition between trees and crops for water. After 4-year, 417 stems/ha (4x6 m spacing) was the optimum density for both tree growth and crop yield, higher stem densities adversely affected both tree growth and crop yield. The pulses were better suited than *Pennisetum glaucum* as intercrops.

Mishra *et al.* (2001) investigated the productivity of soybean under *Populus deltoides* based agrisilviculture system at Raipur (Chhattisgarh). The system comprised of five poplar clones (G3, G48, 65/27, D121 and S7C1). Soybean was intercropped under these clones during *kharif* season. Grain yield was highest (14.5 q/ha) in sole crop but decreased under poplar clones. It reduced from 2.06 to 33.1 per cent under different clones.

Thakur *et al*. (2002) found that the effects of different canopy management treatments in 5-year-old *Morus Alba* trees on yield potential of urdbean and pea. Results showed that yield attributes, number of pods/plant, number of grains/pod, size of pod, grain yield and harvest index were found to have maximum magnitude in the control (without tree) followed by plants under least shade (75per cent crown removal). The values decreased with increasing shade (less transmission) in both urdbean and pea. Better yield was observed on northern aspect than southern aspect. Yield increased with increasing light transmission through tree canopy.

Mohanty *et al*. (2004) studied four tree sp. *(Casuarina equisetifolia, Eucalyptus* hybrid*, Dalbergia sissoo* and *Tectona grandis)* planted in rows at with row spacing of 5 m to study the effect of crops (ragi, sesame, blackgram, and cowpea) sown inthe alleys with recommended fertilizer application. *Eucalyptus* hybrid attained the maximum plant height (14 m) and collar girth (58 cm) recorded highest cumulative growth after 7 years o fplanting. Association of tree adversely affected the grain production of crops. Among the field crops, ragi with a mean grain yields of 6.85 q/ha emerged as the most stable crop with least reduction in yield (21 per cent). It is revealed that the overall performance of intercrops was 31 per cent lower than the sole crop yield.

Lal and Sharma (2004) reported that litchi (*Litchi chinensis,* cv. Rose scented) plantation-based agri-horti system can be raised on degraded gravelly riverbed land in Doon valley, erstwhile Uttar Pradesh with cowpea, okra, sesame, blackgram and pigeonpea, as intercrops during the *kharif* season and toria during the *rabi* season. On an average, during the *kharif* season, cowpea and okra produced 20.24 and 29.16 q/ha of pods while sesame, blackgram and pigeonpea produced 2.41, 5.27 and 3.80q/ha of grains, respectively. However, toria grown in sequence with cowpea, okra, sesame and blackgram produced 5.00, 3.85,4.26 and 5.19 q/ha grains and 18.75, 21.92, 16.70 and 19.25q/ha stover yield, respectively during the *rabi* season. The plant growth characters of litchi were not influenced by any intercrop.

Handa (2007) investigated that the pruning intensity and its effect on the growth performance of tree species [(*Hardwickiabinata*, *Anogeissus pendula* (*A. acuminata*) and *A. latifolia*] and yield of blackgram. The pruning was initiated for the first time after 8 years of establishment of the tree species. There were four pruning treatments (10, 25, 50 and 75per cent) with 10 per cent pruning as control. Blackgram was used as intercrop during the *kharif* season. Crop data revealed that maximum grain (141 kg/ha) and straw yield (233 kg/ha) were recorded with *H. binata* at 75 per cent pruning intensity. No adverse effect was observed even 75 per cent pruning on tree growth while intercrop yield was maximum.

Shukla *et al*. (2008) reported that fruit species, *Annona squamosal* were not for growing in horti-pastural system in rangelands because of their poor establishment and survival.

Mohanty *et al.* (1992). Observed that tree association affected the crop yield negatively and *Eucalyptus* hybrid reduced the alley crop yield by 17.2 to 41 per cent. On sandy loam soil at Indian Grassland and Fodder Research Institute, Jhansi, Ram and Kumar (2009). reported that the fruit yield of annona was not significantly influenced with two legumes intercropping *Stylosanthes hamata* (L.) Taub and *Stylosanthes scabra* (L.) Vog. However, significant increase in fruit yield (7.14 kg/tree) was recorded with application of 60 kg P2O5 + 45 kg K2O/ha than the control and lower levels. The positive yield response with phosphorus and potash application was also reported in Kinnow (Monga *et al*., 2004).

Rangasamy (1997) and Chittapur (1998) the maximum DMP was produced by the treatment 100% RDF with FC+VC fallowed by 100% RDF with FC+PM, 33% RDF with FC + PM and 100% RDF alone, all of which were comparable with each other and proved significantly better than the treatment FC + PM alone. The interaction between the three factors, viz, fertilizer levels, manorial forms and biofertilizer and/or organic spray was noted to be positive for dry weight in comparison to zero level combinations. This indicated that the legume species in a cropping system with INM has a potential to produce larger dry weight.

2.3.3 Nutrient Contents and Their Uptake

Ong *et al.* (1999) concluded from their study that competition between neighbouring roots occurred when the nutrient depletion zones around the roots overlap, which was caused by the uptake of nutrient into the roots.

Suresh and Rao (1999). witnessed similar results in semiarid areas for intercrop with sorghum and nitrogen fixing trees such as *Acacia ferruginea* and

Albizia lebbeck. Benjamin *et al.* (2000) and Jose *et al.* (2000) observed that root-pruning was not only beneficial for maize growth in alley cropping with black walnut (*Juglansnigra*) and red oak (*Quercus rubra*) but such agroforestry system was much more attractive economically than traditional agriculture or forestry.

Costa *et al*. (2000) observed the inter-species differences in root competition exerted by six tree species (*Calliandracalothyrsus, Desmodium rensonii, Flemingia congesta {F.macrophylla}, Gliricidia sepium, Cassia spectabilis and Tithoniadiversifolia*) on mungbean grown as hedgerow intercrops in Sri Lanka. All intercrops had significantly lower plant nutrient (N, P, and K) contents than sole mungbean indicating significant competition by hedges for nutrients. All intercrops showed increases of exchangeable soil K and available P (except with *Gliricidia*) during the cropping season. It is concluded that tree roots of hedgerow intercrops exerted significant competition with the annual crop for absorption of nutrients and water. In this study, out of the tree species tested, *Gliricidia* exerted the least competition for nutrients while *Tithonia* exerted the least competition for water.

Pandey *et al*. (2000) and Pirmoradian *et al.*, (2004) observed reduction in nitrogen uptake by maize and rice, respectively during drought periods. Similar finding observed by Celette *et al* (2008) that in the presence of a cover crop, the nitrogen content in soil layers beneath the inter-row decreased rapidly. This is because nitrogen mobility is reduced as well as water stress decreases nitrate reductase activity Larsson (1992), Azedo-Silva *et al*., 2004 and Correia *et al*., 2005.

Ram and Kumar (2007) reported that the introduction of *S. hamata* in natural pasture under *Annona* trees resulted insignificantly higher total crude protein yields (255.9, 311.7 and305.1 kg/ha) than *S. scabra* in first, second and third years, respectively.

2.4 Interaction Between Crops and Trees Components

Wannawong *et al.* (1991) revealed after 3-year experimentation that early supplementary and complementary relationships between some system components can simply synergistic in financial gains. Although these biological interactions turn competitive over time. Accordingly, the gains should be sufficient enough to make early adopters to consider the Agro forestry systems financially preferable to traditional Monocrops.

2.4.1 Competition for Light

Investigation on light interception and competition in Agro forestry systems are generally, scare. An additional problem is the difficulty to compare the available results because of the differences in methodologies used in the investigations.

2.4.2 Root and Water Competition and Their Effect in Alley Cropping

Singh *et al.* (1989) reported that under alley-cropping trial of *leucaena* with cowpea, castor, and sorghum in semiarid condition of India, competition for water appeared more important than shading effects.

Jonsson *et al.* (1999) concluded that microclimate amelioration and enhanced soil fertility may exceed the potentially detrimental influence of shade in the Sahel. By contrast, studies using root barriers to segregate tree and crop roots suggested that shading is less important than belowground competition. Corlett *et al.* (1992) and Odhiambo *et al.* (1999) found that root length density of tree roots within the crop rooting zone may be important in determining the intensity of competition between trees crops.

2.5 Relative Economics

Ram and Kumar (2009) observed the maximum net returns (Rs 13710 per hectare) as well as B:C ratio investigated (1.52) were obtained by intercropping of *S. hamata* with *baffale* grass under Annona tress mainly due to higher forage yield.

Beg and Singh (2009) reported that the interaction of dual inoculation with *Rhizobium* and PSB under moderate fertility level (20 kg N and 45 kg phosphorus per hectare) proved beneficial for boosting seed yield (11820 kg per hectare) and recorded maximum net income (Rs. 21941 per hectare) and benefit: cost ratio (2:10).

Lal and Sharma (2004) concluded that litchi (*Litchi chinensis*) plantation-based agri-horti system can be raised on degraded gravelly riverbed land in Doon valley of erstwhile Uttar Pradesh with cowpea, okra, sesame, blackgram and pigeonpea, as intercrops during the *kharif* season and toria during the *rabi* season. The highest net profit of Rs. 4554 was obtained fromokra-toria cropping system followed by cowpea-toria (Rs. 1270) and blackgram-toria (Rs. 779) cropping systems with benefit: cost ratio of 1.27, 1.08 and 1.05, respectively. The plant growth character of litchi was not influenced by any intercrop.

Pir *et al*. (2009) reported that the highest net profit (Rs18,320/ha) and B: C ratio (1.34) was realised with the treatment of 5 t FYM ha-1 + 30, 50, 30 kg NPK ha-1 + *Rhizobium* + PSB.

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MATERIALS AND METHODS

The field experiment was conducted to ascertain the impact of **"Comparative effect of organic manure and inorganic manure on growth and yield of blackgram (*Vigna mungo* L, Hepper) under guava based agri-horti system"** during *kharif* season 2016 at Agricultural Research Farm Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur, Uttar Pradesh. The edaphic and climatic condition under which the experiment crop was carried out and material and techniques employed in conducting the experiment are being described in this chapter.

3.1 Experimental site

The experiment was carried out at the agricultural research farm, Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur (U.P.) which is situated in Vindhyan region of district Mirzapur. The research farm is situated at a distance of about 10 km in south-east from Mirzapur on Mirzapur-Robertasgunj road. Geographically, experimental site falls under the agro-climatic zone III A (semi-arid eastern plain zone) and located on 25^0 10' N latitude 82^0 37' E longitudes and an altitude of 427 meters above mean sea level. The experiment was laid on fairly uniform topography and well-drained soil which had invariably poor fertility status.

3.2 Climate and Weather

Mirzapur falls in a belt of semi-arid to sub-humid climate. The normal period for the onset of monsoon in this region is the third week of June and it lasts up to end of September or sometimes extends to the first week of October. Winter showers are often experienced in between the month of December to mid of February. However, March to May is generally dry. On an average, out of the total annual rainfall major fraction (75 per cent) are received from June to September. The winter months are cool whereas summers are hot and dry. The coldest and hottest month is January and May, respectively. The temperature begins to rise from the month of February and reaches its maximum in May.

During the crop season, total rainfall received was 513.70 mm. Out of total rainfall more than 88 per cent received between 32 to 35 standard meteorological weeks (SMW). Data showed that there were very less fluctuations in maximum temperature. The mean maximum temperature during the crop growth season was recorded 34.95^{0}C whereas; mean minimum temperature remained 25.30^{0}C. The average weekly temperature was lowest (32.23^{0}C) in 40 meteorological weeks and maximum (34.95^{0}C) in 40 meteorological weeks. The relative humidity varied between 92.10 per cent and 96.57 per cent.

Table: 3.1: Mean week-wise meteorological data during crop season *kharif*, 2016.

Standard week No.	Months	Rainfall (mm)	Temperature (˚C)		Relative humidity (%)
			Max.	Min.	
36	September	18.1	34.11	26.55	95.50ss
37		29.1	33.35	26.23	94.14
38		37.9	33.34	26.21	96.57
39		76.7	32.92	26.02	92.57
40		18.07	34.34	25.67	92.10
41	October	00	34.58	25.91	94.56
42		00	34.95	25.30	92.35
43		00	32.23	26.35	93.62
44		00	32.65	26.40	92.36
45	November	00	-	-	-

SOURCE: OBSERVATORY, KRISHI BHAWAN, MIRZAPUR.

3.3 Soil and Soil Analysis

Soil samples were taken before actually conducting the experiment from a depth of 0-15 cm, taking all the possible precautions prescribed for soil sampling. The samples were brought to the laboratory, air dried and crushed to pass through 2.0 mm mesh sieve. The processed samples were subjected to appropriate mechanical and chemical analyses.

The soil of the experimental field was sandy loam in texture with low drainage. It was acidic in reaction, poor in nitrogen as well as phosphorus and moderate in potash. Composite soil samples prior to commencement of the experiment were collected to determine mechanical composition and physic-chemical properties of the soil and the data are presented in Table 3.2.

Table 3.2 Mechanical and physico-chemical properties of experimental field

Soil properties		Value	Method employed
a. Physical			
Course sand	(%)	10.34	International Pipette Method (Piper, 1966)
Fine sand	(%)	48.31	
Silt	(%)	19.40	
Clay	(%)	21.95	
Textural class		Sandy clay loam (Typic Us ochrept)	
Bulk density	(Mg m^{-3})	1.43	
Particle density	(Mg m^{-3})	2.47	
b. Chemical			
pH (1:2.5, soil and water ratio)		5.9	Beckman's glass electrode method (Jackson, 1958)
Electrical conductivity	(dSm^{-1} at $25^{0}C$)	0.28	Systronics Electrical Conductivity Meter (Chopra and Kanwar, 1976)
Organic carbon	(%)	0.26	Walkley and Black rapid titration method (Piper, 1966)
Available nitrogen	(kg ha^{-1})	179.60	Modified alkaline permanganate method (Subbiah and Asija, 1956)
Available phosphorous	(kg ha^{-1})	13.10	0.5M $NaHCO_3$ extractable (Olsen *et al.*, 1954)
Available potassium	(kg ha^{-1})	183.25	1N neutral ammonium acetate method (Piper, 1966)

3.4 Cropping History of the Experimental Field

The crop sequences followed in the experimental field during the past eight years have been presented in Table 3.3. The cropping history of the experimental site clearly indicates that the field was not cropped continuously and kept fallow during three consecutives rainy (*kharif)* seasons (2009-2010) followed by fallow in winter (*rabi)* during 2009-11 to 2011-12. During 2012-13 green gram-mustard sequence was taken and during 2011-12 black gram fallow sequence was taken and during 2013-14 green gram fallow sequence was taken and during 2014-15 green gram fallow sequence was taken and during 2015 -16 sesame fallow sequence also thus, the fertility set up has not been disturbed. Hence, as such the field is ideally suitable for the experiment.

Table 3.3: Cropping History of the Experimental Field

Year	Season	
	Rainy	Winter
2009-10	Fallow	Fallow
2010-11	Green gram	Fallow
2011-12	Black gram	Fallow
2012-13	Green gram	Mustard
2013-14	Green gram	Fallow
2014-15	Green gram	Pearl millet
2015-16	Green gram	Fallow
2016-17	Experimental crop	....

*** Black gram**

3.4.1 Selection of Variety Black Gram

The variety ku-300 was selected for the experimental work. Resistant variety of blackgram ku-300 was taken as test crop. It matured within 65 to 70 days with average yield of 10 to 12 q/ha.

3.5 Experiment Details

The experiment was laid out during rainy (kharif) season of 2016 in 10 years old guava which was planted in August, 2007 at the spacing of 7.0x7.0 meter. Black gram crop was sown as an alley crop under guava based agri-horti system. The experiment was conducted in randomized block design with three level of organic manure treatments (FYM, vermicompost and rhizobium) and two fertilizer doses were allocated as treatments such as (20:40:20 kg ha^{-1} and 30:50:30 kg ha^{-1}) NPK respectively. Experiment consists total (12) treatment combinations replicated thrice have been presented in table (Table 3.4).

Table 3.4: Details of Treatments Combination and Abbreviation Use

Serial No.	Treatment	Symbol Used
T_1	No inorganic or organic fertilizer (control)	I_0 O_0
T_2	Farmyard manure	I_0 O_1
T_3	Vermicompost	I_0 O_2
T_4	Rhizobium	I_0 O_3
T_5	N (20 kg ha^{-1}) + P_2O_5(40 kg ha^{-1}) + K_2O (20 Kg ha^{-1})	I_1 O_0
T_6	N (20 kg ha^{-1}) + P_2O_5(40 kg ha^{-1}) + K_2O (20 Kg ha^{-1}) + Farmyard Manure	I_1 O_1
T_7	N (20kg ha^{-1}) + P_2O_5(40 kg ha^{-1}) + K_2O (20 Kg ha^{-1}) + Vermicompost	I_1 O_2
T_8	N (20kg ha^{-1}) + P_2O_5(40 kg ha^{-1}) + K_2O (20 Kg ha^{-1}) +Rhizobium	I_1 O_3
T_9	N (30 kg ha^{-1}) + P_2O_5(50 kg ha^{-1}) + K_2O (30 Kg ha^{-1})	I_2 O_0
T_{10}	N (30 kg ha^{-1}) + P_2O_5(50 kg ha^{-1}) + K_2O (30 Kg ha^{-1}) + Farmyard Manure	I_2 O_1
T_{11}	N (30kg ha^{-1}) + P_2O_5(50 kg ha^{-1}) + K_2O (30 Kg ha^{-1}) + Vermicompost	I_2 O_2
T_{12}	N (30kg ha^{-1}) + P_2O_5(50 kg ha^{-1}) + K_2O (30 Kg ha^{-1}) + Rhizobium	I_2 O_3

Table 3.5 : Layout Plan

The Layout Plan of Experiment Field is as Follows

Experimental design	:	Randomized block design
No. of treatment	:	12
No. of replication	:	3
Total number of plots	:	12x3 = 36
Block border	:	1,0 m
Gross plot size	:	4.5x 3.5m
Net plot size	:	4m x 3 m
Plot border	:	0.5 m
Row to row distance	:	30 cm
Plant to plant distance	:	10 cm

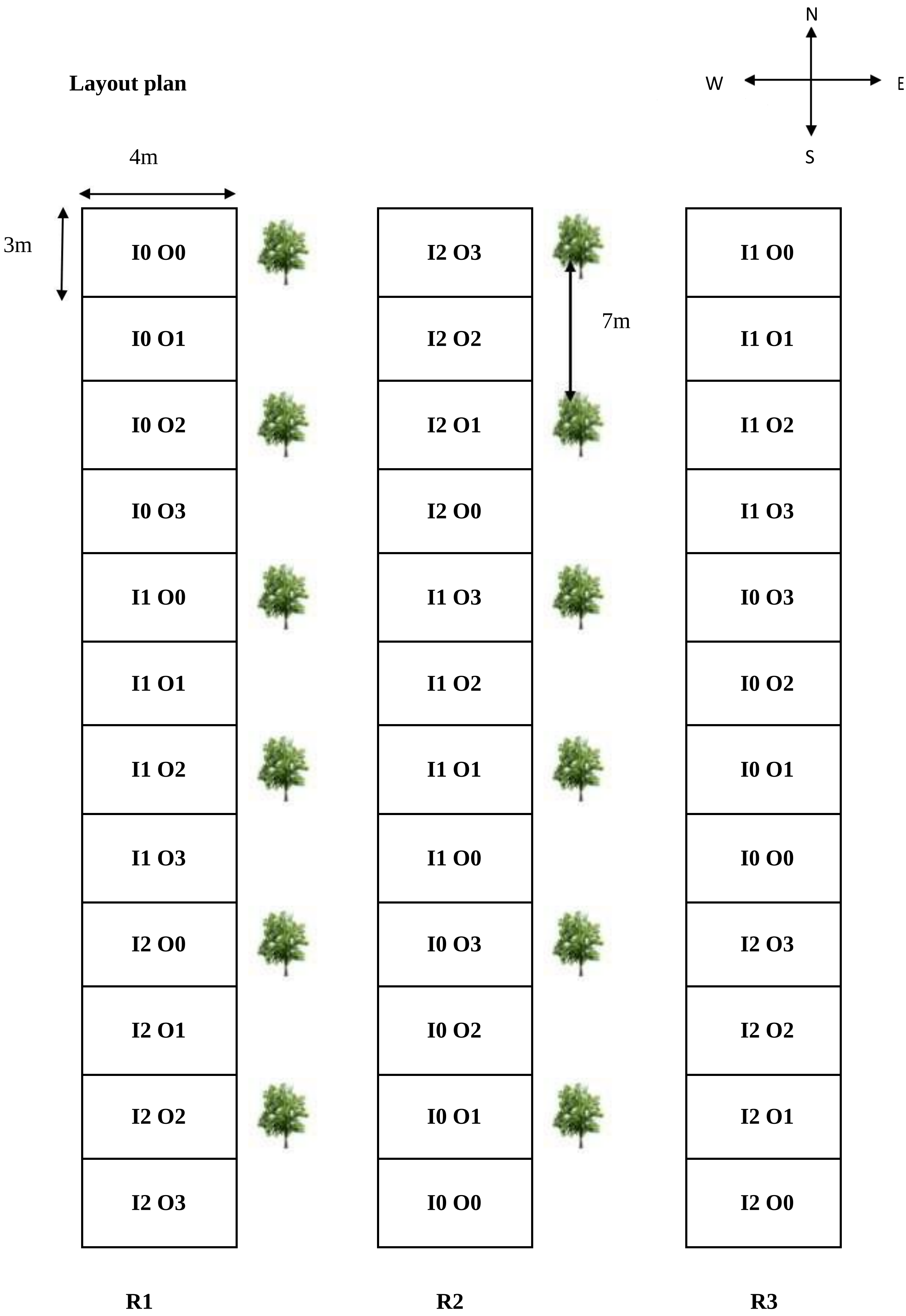

Figure 3.3. Layout Plan of Experimental Field

3.7. Agronomic Practices

The details of cultural operations done starting from field preparation to harvesting of the crops are given in Table 3.6.

Table 3.6 Scheduling of Field Operation

S. No.	Operation	Date
(A)	**Pre-sowing operation**	
1.	Land preparation • First plough • Second plough	 03.09.2016 04.09.2016
2.	Layout and experiment	08.09.2016
3.	Farm yard manure	08.09.2016
(B)	**Sowing operations**	
1.	Fertilizer application and sowing	09.09.2016
(C)	**Post sowing operations**	
1.	Thinning of crop	25.09.2016
2.	Weeding and hoeing	30.10.2016
3.	Harvesting	17.11.2016
4.	Threshing	19.11.2016
5.	Cleaning	22.11.2016

3.7.1 Land Preparation

At workable condition, field was ploughed with the help of disc plough and harrowing was done followed by planking. Thereafter, the experiment was laid out as per plan and design.

3.7.2.2 Fertilizer Application

The fertilizer application was done with doses of (20:40:20 NPK), and (30:50:30 NPK), Kg ha-1 respectively. Fertilizer application was done according to the treatments. All the nutrients were applied as basal and the sources of N, P and K were Urea, DAP and MOP.

3.7.3 Seed Rate and Sowing

The seeds of variety **ku-300** were sown manually in the row by *kudal* at a row distance of 30 cm as per treatment. Relatively higher seed rate (15 kg ha^{-1}) was used for proper maintenance of plant population. A plant spacing of 10 cm within the row was maintained by thinning operation at 15 days after sowing.

3.7.4 Thinning and Intercultural Operation

Extra plants were thinned to maintain the desired plant population at 15 days after sowing. One weeding was done manually by *khurpi* at 18 days after sowing to control weeds.

3.7.5 Plant Protection

To protect the crops, mainly from leaf caterpillar, kranti (carpet hydrochloride 50%SP@ 250 ml per hectare was sprayed at 19days after sawing.

3.7.6 Harvesting and Threshing

Crop was harvested at complete maturity as judged by visual observations. The border rows were harvested first and kept aside. Thereafter, the net plots were harvested by hand picking of the pods when nearly 80 percent pods were matured and harvested crop left in the field for drying for a period of 3-4 days. Thereafter, small bundles were made and taken to the threshing floor.

3.8 Observation on Black Gram (Alley Cropping)

Five plants of each plot were randomly selected and tagged for recording the biometric observations at different stages of growth. The observations on growth and yield attributes were recorded at an interval of 20, 45 days after sowing and at maturity.

Yield attributes and yield were studied before and after harvesting as per investigation required.

3.8.1 Growth Parameters

3.8.1.1 Plant Height (cm)

Height of randomly selected and marked plants from each plot was measured from base of the plants up to growing tip of main stem. The average plant height was calculated by taking the mean of five observations and expressed in cm.

3.8.1.2 Trifoliate Leaves Plant^{-1} (No.)

The number of green trifoliate leaves plant^{-1} of Blackgram was counted at different stages of the crop growth from the selected tagged plants per plots and mean of observation of five plants was computed.

3.8.1.3 Leaf Area Index

Five plants were randomly selected from sampling zone in each plot, cut and leaf area was measured at 60 DAS and harvest with the help of leaf area meter (laser area meter, CID Inc.-USA) and leaf area index was calculated with the following relationship:

$$\textbf{Leaf area index (LAI)} = \frac{\textbf{Total leaf area per plant (cm}^{-1}\textbf{)}}{\textbf{Ground area occupied each plant (cm}^{2}\textbf{)}}$$

3.8.1.4 Primary Branches Plant^{-1} (No.)

Primary branches having at least two fully developed trifoliate leaves were considered for recording of number of primary branch.

3.8.1.4 Secondary Branches Plant^{-1} (No.)

The number of secondary branches of five randomly representative plants in each plot were counted and average number of secondary branches plant^{-1} were worked out.

3.8.1.5 Dry Matter Accumulation (g Plant^{-1})

For recording dry matter accumulation in leave, stem and root, 5 plants from each plot were cut from the ground level of border rows. Sampled plants were sun dried first then dried in an oven at 70^0C for 24 hours to get constant dry weight. Thereafter, the average dry weight was recorded in gram plant^{-1}.

3.7.1.6 Root Nodules Plant^{-1} (No.)

Five plants were randomly uprooted along with soil from the penultimate rows from each plot. These plants were kept in water to remove the adhered soil from roots of the plants. Nodules excised from the roots with a scalpel were counted, weight and expressed as number per plants.

3.8.2 Yield Attributing Characters

The following observations on yield attributes and yield studies for Blackgram were recorded during the experimentation:

3.8.2.1 Pods Plant^{-1} (No.)

Total number of pods on the tagged plants was counted and average number of pods plant was recorded.

3.8.2.2 Pod Length (cm)

Length of five randomly selected pods was measured from five tagged plants and average was worked out to get the pod length of crop.

3.8.2.5 Grains Pod^{-1} (No.)

The ten randomly selected pods from each five tagged plants per plot were taken out and total number of grain was counted. Average number of grain pod^{-1} was then calculated and recorded.

3.8.2.4 Test Weight (g)

Randomly selected 1000 grains from the grain yield sample of crop were counted from each plot and their combined weight was recorded to get the test weight of 1000 grains.

3.8.2.3 Seed Yield (Kg ha^{-1})

The seed yield obtained from net plot was thoroughly cleaned; sun dried and weighed treatment wise. The net plot yield was then converted and expressed as kg ha^{-1}

3.8.2.7 Straw Yield (Kg ha^{-1}.)

The straw yield of each net plot was sun dried and then weighed treatment wise and expressed in kg ha^{-1}

3.8.2.8 Harvest Index (%)

It was calculated by dividing economic yield i.e. seed yield with biological yield (seed and Stover and expressed as percentage).

Harvest Index	=	**Economic yield (kg ha^{-1})** / **Biological yield (kg ha^{-1})**	**100**

3.8 Observation on Guava (Fruit Trees)

3.8.1.1 Growth Parameters of Guava

The following growth parameters of custard apple, suitable at border of the plot, were recorded at the scheduled dates.

3.8.1.1 Height

	Height (m)	
At sowing	**45 DAS**	**At Harvest**
5.35	5.57	5.72

The height of guava was measured from base of the plants up to growing tip of main stem. The plant height was measured and expressed in meter.

3.8.1.2 Canopy

The canopy area of guava was recorded with the help of meter tape and it was recorded from the highest canopy diameter in meter.

	Canopy diameter (m)	
At sowing	**45 DAS**	**At Harvest**
6.10	6.22	6.32

3.8.1.3 Stem Girth

The stem girth of guava was recorded from base of the plants in inches which was situated at the plot of the crops.

	Stem girth (inch)	
At sowing	**45 DAS**	**At Harvest**
25.17	26.30	26.62

3.8.1.4 Shading

The shading area of the guava was recorded with the help of meter tape and measured as width and length in meter.

		SHADING AREA (m)			
At sowing		45 DAS		At Harvest	
Length	Width	Length	Width	Length	Width
6.83	5.78	6.90	6.05	7.35	6.12

3.8.1.5 Yield (kg ha^{-1})

The guava has the advantage of cropping in late winter and spring when the preferred members of the genus are not in season. It is picked when it is completely matured and slightly yellow in colour, so that it is readily sold in local market. Inferior quality is not picked if in touch hard in nature. The tree is naturally a fairly heavy bearer. The average yield was noticed 700 to 1000 kg ha^{-1} at Agricultural Research, Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur.

3.9 Relative Economics

The cost of cultivation including weeding and harvesting of the fruit tree were considered common in all treatments while cost of various practices varied due to their requirement as per treatment. Gross income was worked out by multiplying grain and stalk yields of the crop and yield of fruit trees with their prevailing market prices. Calculations were made as per normal rates prevalent at the Agriculture Research Farm, R.G.S.C. (B.H.U.), Barkachha, Mirzapur. The cost of farm yard manure, fertilizers, and seed etc. were taken as per prevailing market prices. Net return (R ha^{-1}) and benefit: cost ratio was calculated with the help of the following formula:

Net return (R ha^{-1}) = Gross return (R ha^{-1}) – Cost of cultivation (R ha^{-1})

3.10 Benefit: Cost Ratio

Benefit: cost ratio of various treatments was worked with the help of following formula.

$$\text{BCR} = \frac{\text{Net return (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

3.11 Statistical Analysis

For determining the significance between the treatment means and to draw valid conclusions, statistical analyses were done. Data obtained from various observations were subjected to statistical analysis by adopting appropriate method of "Analysis of Variance". The significance of the treatment effects was judged with the help of F test (Variance ratio). Standard error of mean was computed in all cases. The differences of the treatments mean were tested against critical difference (C.D.) at 5 % level of probability (Gomez and Gomez, 1976).

If the variance ratio (F test) was found significant at 5 % level of significance, the standard error of mean (SEm) and critical difference (C.D.) were calculated for further comparison.

$$\text{SEm}\pm = \sqrt{\frac{\text{Error sum of square}}{\text{n}}}$$

C.D. at 5 % = SEmt $\sqrt{2}$ value at value at 5 % of error degree of freedom.

The results have been presented in tabular form as well as in figure wherever necessary.

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EXPERIMENTAL FINDINGS

The summary of experimental findings recorded during the course of study is presented in this chapter. Data recorded during the conduct of experiment were statistically analyzed and significant variations have been discussed. While representing the response trend, suitable illustrations have been adopted as and where was necessary.

4.1 Growth Parameters

4.1.1 Plant Height (cm)

The data on plant height as affected by different treatments recorded at 20, 45**,** days after sowing (DAS) and at harvest are presented in table 4.1. The mean maximum plant height of black gram recorded under combination of Vermicompost + NPK (30:50:30 kg ha-1) at 20, 45 and at harvest was 19.75, 41.52, and 51.70 cm respectively. The lowest plant height was recorded at all stages of crop growth in the control treatment.

Increasing level of NPK (30:50:30 kg ha^{-1}) increased the plant height at each level of nutrient application at all stages of crop growth except where organic manure are not used, i.e**.,** T_1 treatment. The fertility treatment with T_{11} and T_{10} were at par with control treatment at 45 days after sowing (DAS) similarly T_{11} and T_{10} treatment also remained at par at harvest stage. The increasing rate of N, P, and K in combination with vermicompost significantly increased the plant height. Subsequent rate of elongation remained slower particularly between 45 DAS and at harvest. Further analysis of data indicated that at 20,45, and at harvest stage, T_{11}, T_{10} were at par and, lowest height observed under T_1 in which no organic and inorganic fertilizer were applied.

TABLE: 4.1 EFFECTS OF ORGANIC FERTILIZER AND INORGANIC FERILIZER ON PLANT HEIGHT PLANT^{-1} (cm) OF BLACKGRAM UNDER AGRI-HORTI SYSTEM.

TREATMENT	PLANT HEIGHT PLANT^{-1}(cm) DAYS AFTER SOWING		
	20	45	AT HARVEST
T_1 (I_0 O_0)	14.51	30.35	37.79
T_2 (I_0 O_1)	16.73	35.00	43.58
T_3 (I_0 O_2)	17.78	37.20	46.31
T_4 (I_0 O_3)	15.66	32.76	40.79
T_5 (I_1 O_0)	17.19	36.14	45.00
T_6 (I_1 O_1)	18.42	38.72	48.22
T_7 (I_1 O_2)	18.79	39.50	49.19
T_8 (I_1 O_3)	18.93	39.80	49.56
T_9 (I_2 O_0)	17.48	36.75	45.76
T_{10} (I_2 O_1)	19.69	41.39	51.53
T_{11} (I_2 O_2)	19.75	41.52	51.70
T_{12} (I_2 O_3)	19.25	40.47	50.38
SEm±	0.27	0.57	0.74
CD (P=0.05)	0.80	1.68	2.09
C.V	5.18	5.48	5.54

GENERAL VIEW OF EXPERIMENTAL FIELD SHOWING BLACKGRAM CROP UNDER GUAVA BASED AGRI-HORTICULTURE SYSTEM (R.G.S.C, B.H.U, MIRZAPUR)

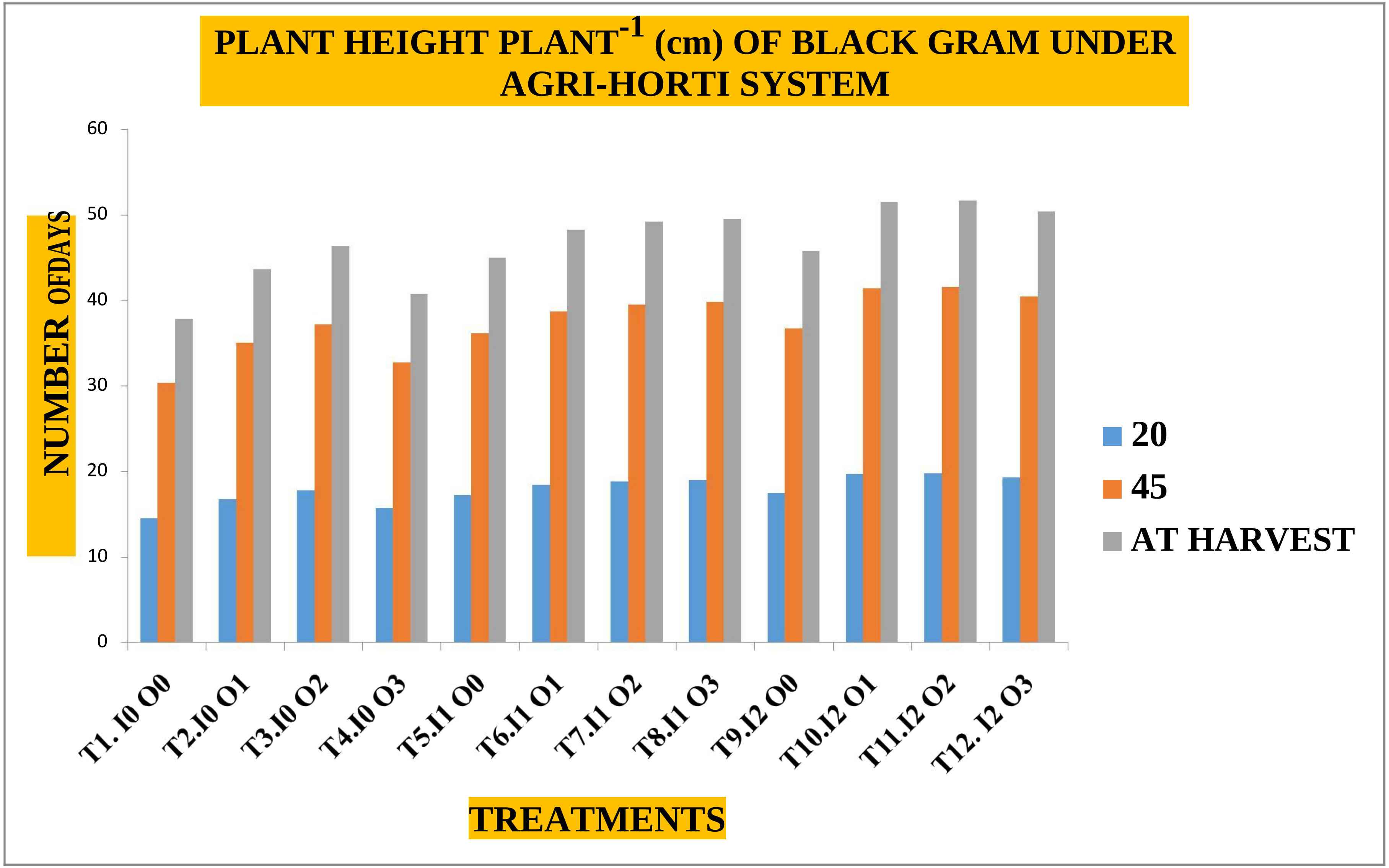

FIGURE : 4.1 EFFECTS OF ORGANIC FERTILIZER AND INORGANIC FERILIZER ON PLANT HEIGHT PLANT^{-1} (cm) OF BLACKGRAM UNDER AGRI-HORTI SYSTEM.

4.1.2 Root Nodules Plant^{-1}

The data presented in table (4.2) revealed that root nodules plant^{-1} increased with the advancement of crop growth from 20 to 45 DAS irrespective of the effect treatment.

Data in the table 4.2 revealed that application of varying inorganic and organic fertilizer significantly enhanced the number of root nodules plant over control treatment at 20 and 45 DAS of the crop. Application of vermicompost with combination NPK doses (30:50:30 kg ha^{-1}) significantly increased the highest number of root nodules plant over control and other treatments

4.1.3 Trifoliate Leaves Plant^{-1} (No.)

It is evident from the data presented in table 4.3 that number of functional trifoliate leaves per plant increased with the advancement of crop growth up to harvest, Maximum rate of increase was observed between 20 to 45 DAS whereas decrease in functional trifoliate per plant was noticed at harvest stage.

An analysis of data indicated that there was significant variation in number of functional trifoliate leaves per plant was due to different combination of treatment i.e**.** NPK (30:50:30 kg ha^{-1}) with vermicompost (T_{11}) and with farmyard manure. The maximum trifoliate leaves were recorded at 20, 45 and at harvest stage of the crop growth. In corporation of NPK with vermicompost proved significantly superior over the control at all the stages of observations. However, maximum trifoliate leaves were recorded under T_{11} in comparison to control treatment.

4.1.4. Primary Branches Plant^{-1}(No.)

Data on primary branches per plant showed significant variation as influenced by different organic levels with inorganic levels and presented in, Table 4.4 scanning of data showed the value of extreme and low both and depicted graphically also in Fig.4.4.1.

Marked effect of different organic levels i.e. farmyard manure and vermicompost with NPK (30:50:30 kg ha^{-1}) fertilizer was recorded on the primary branches per plant at 45 DAS, and at harvest. Increasing fertility levels with organic manures significantly increased the number of primary branches $plant^{-1}$ at both the above stages of crop growth. The maximum values were recorded with the application of NPK (30:50:30 kg ha^{-1}) with vermicompost and farmyard manure at all the stages of observation. Further analysis of data clearly indicated that the treatment NPK (30:50:30 kg ha^{-1}) with vermicompost and treatment NPK (30:50:30) kg ha^{-1} with farm yard manure was at par at 45 DAS**.**

The result clearly revealed that the number of primary branches per plant of blackgram were significantly increased under dual treatment of NPK (30:50:30 kg ha^{-1}) with vermicompost over the control and over remaining treatments respectively. The lowest value of primary branches per plant of urdbean was recorded under control. Separate treatment of Inorganic and organic fertilizer are also presented in Fig.4.4.1 indicating better response of organic manure.

TABLE: 4.2 EFFECTS OF ORGANIC FERTILIZER AND INORGANIC FERILIZER ON NUMBER OF ROOT NODULES PER PLANT OF BLACK GRAM UNDER AGRI-HORTI SYSTEM.

TREATMENT	ROOT NODULES PLANT^{-1}	
	DAYS AFTER SOWING	
	30	50
T_1 (I_0 O_0)	16.83	30.53
T_2 (I_0 O_1)	19.41	35.21
T_3 (I_0 O_2)	20.63	37.42
T_4 (I_0 O_3)	18.17	32.96
T_5 (I_1 O_0)	19.14	72.73
T_6 (I_1 O_1)	20.50	77.92
T_7 (I_1 O_2)	20.92	79.49
T_8 (I_1 O_3)	21.08	80.09
T_9 (I_2 O_0)	19.46	73.94
T_{10} (I_2 O_1)	22.33	83.27
T_{11} (I_2 O_2)	24.00	83.55
T_{12} (I_2 O_3)	21.43	81.42
SEm±	0.27	1.03
CD (P=0.05)	0.80	3.02
C.V	4.65	5.58

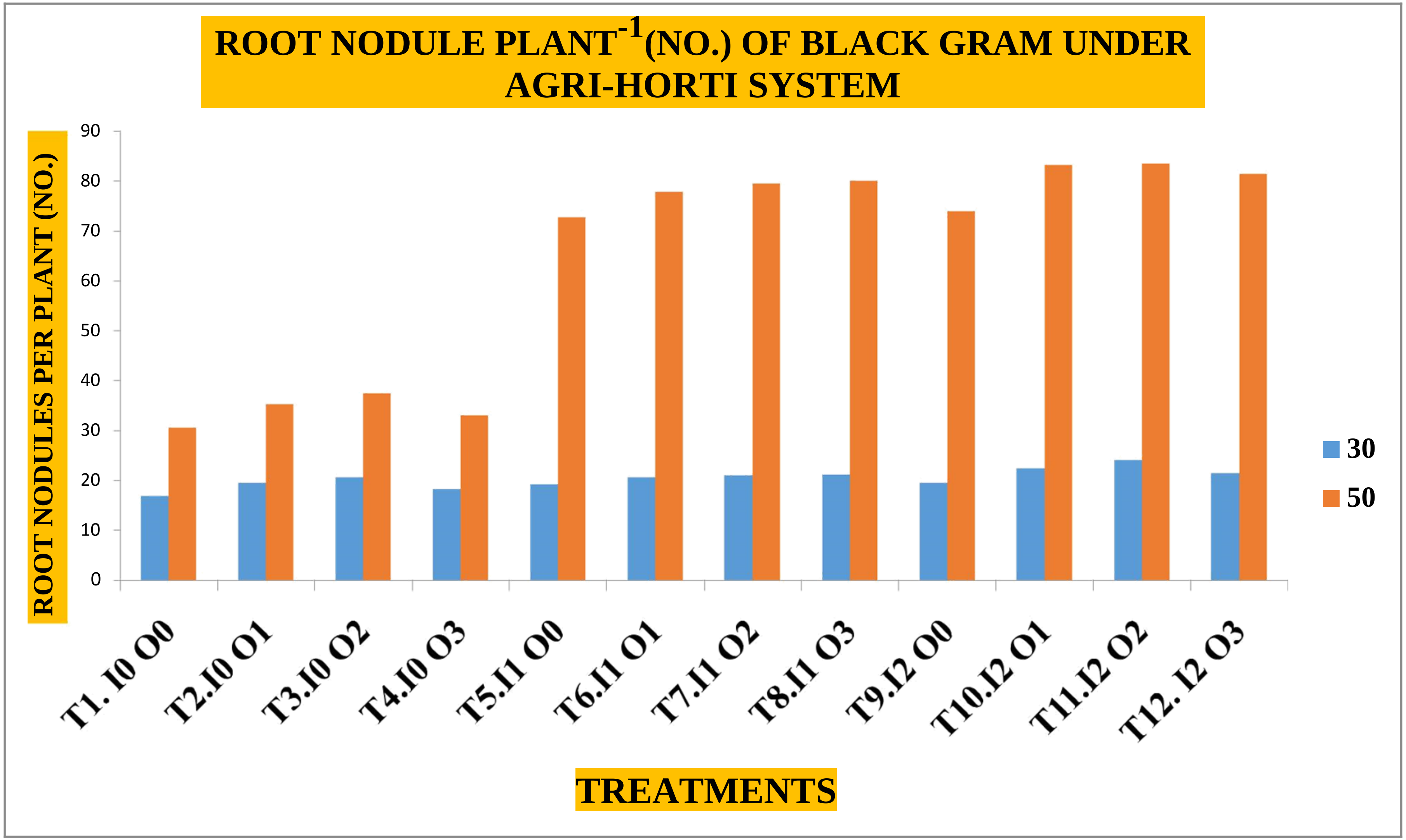

FIGURE: 4.2 EFFECTS OF ORGANIC FERTILIZER AND INORGANIC FERILIZER ON NUMBER OF ROOT NODULES PER PLANT OF BLACK GRAM UNDER AGRI-HORTI SYSTEM.

TABLE: 4.3 EFFECTS OF ORGANIC FERTILIZER AND INORGANIC FERILIZER ON NUMBER OF TRIFOLIATE LEAVES PER PLANT OF BLACK GRAM UNDER AGRI-HORTI SYSTEM.

Treatment	TRIFOLIATE LEAVES PLANT^{-1}(cm)		
	DAYS AFTER SOWING		
	20	45	AT HARVEST
T_1 (I_0 O_0)	2.29	9.59	12.77
T_2 (I_0 O_1)	2.65	11.06	14.72
T_3 (I_0 O_2)	2.81	11.76	15.65
T_4 (I_0 O_3)	2.48	10.36	13.78
T_5 (I_1 O_0)	2.74	11.43	15.21
T_6 (I_1 O_1)	2.93	12.25	16.30
T_7 (I_1 O_2)	2.99	12.49	16.63
T_8 (I_1 O_3)	3.01	12.59	16.75
T_9 (I_2 O_0)	2.78	11.62	15.47
T_{10} (I_2 O_1)	3.13	13.09	17.42
T_{11} (I_2 O_2)	3.14	13.13	17.47
T_{12} (I_2 O_3)	3.06	12.80	17.03
SEm±	0.04	0.18	0.24
CD (P=0.05)	0.14	0.54	0.70
C.V	5.86	5.40	5.30

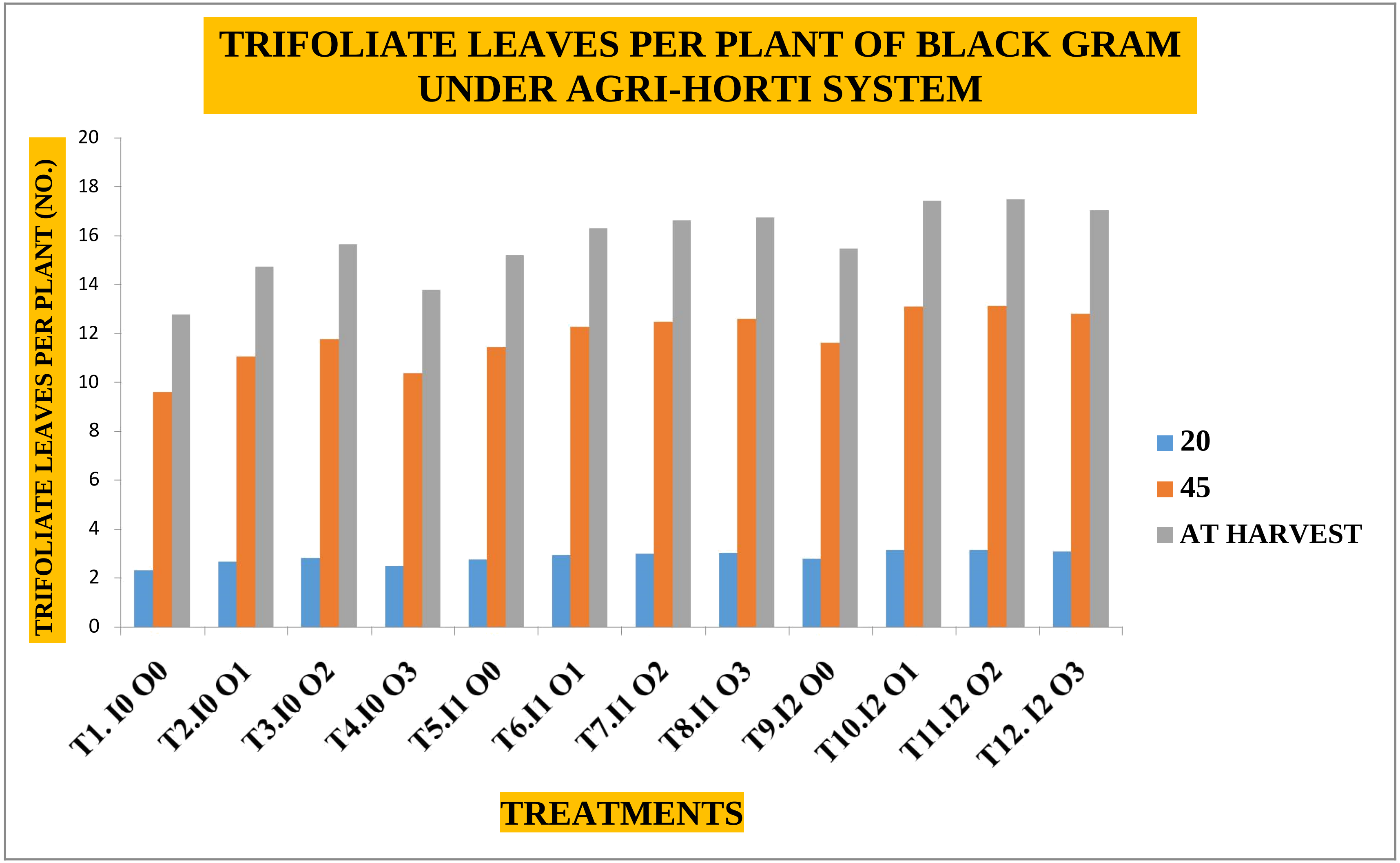

FIGURE: 4.3 EFFECTS OF ORGANIC FERTILIZER AND INORGANIC FERILIZER ON NUMBER OF TRIFOLIATE LEAVES PER PLANT OF BLACK GRAM UNDER AGRI-HORTI SYSTEM.

TABLE: 4.4 EFFECTS OF ORGANIC FERTILIZER AND INORGANIC FERILIZER ON NUMBER OF PRIMARY BRANCHES PER PLANT OF BLACK GRAM UNDER AGRI-HORTI SYSTEM

TREATMENT	PRIMARY BRANCHES PLANT-1 (cm)	
	DAYS AFTER SOWING	
	45	AT HARVEST
T_1 (I_0 O_0)	2.39	3.88
T_2 (I_0 O_1)	2.75	4.48
T_3 (I_0 O_2)	2.93	4.76
T_4 (I_0 O_3)	2.58	4.19
T_5 (I_1 O_0)	3.09	5.03
T_6 (I_1 O_1)	3.31	5.39
T_7 (I_1 O_2)	3.38	5.49
T_8 (I_1 O_3)	3.23	5.26
T_9 (I_2 O_0)	3.14	5.11
T_{10} (I_2 O_1)	3.54	5.76
T_{11} (I_2 O_2)	3.55	5.78
T_{12} (I_2 O_3)	3.46	5.63
SEm±	0.04	0.07
CD (P=0.05)	0.13	0.22
C.V	5.11	5.11

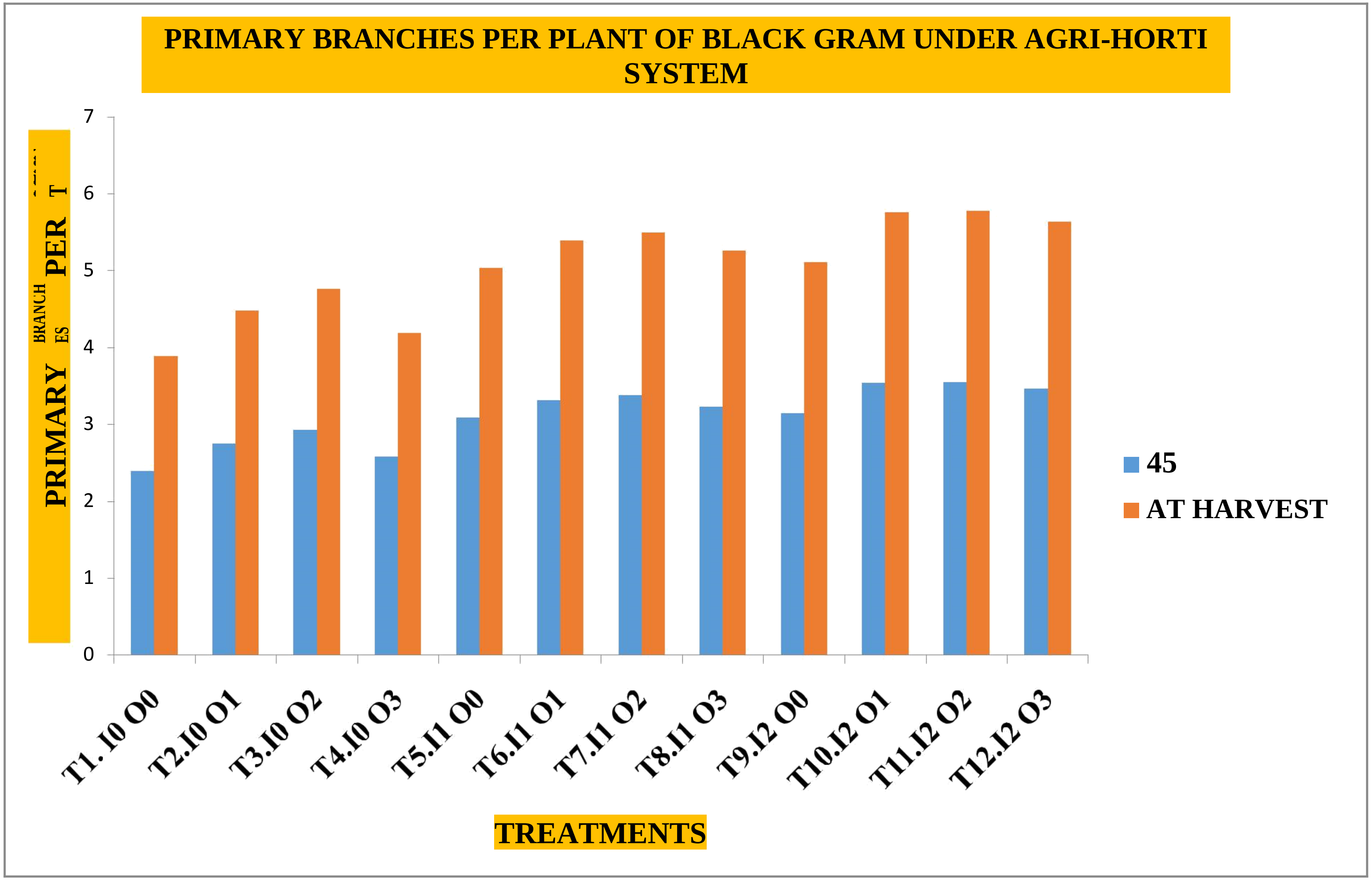

FIGURE: 4.4 EFFECTS OF ORGANIC FERTILIZER AND INORGANIC FERILIZER ON NUMBER OF PRIMARY BRANCHES PER PLANT OF BLACK GRAM UNDER AGRI-HORTI SYSTEM

4.1.5 Secondary Branches Plant^{-1} (No.)

It is quite evident from the data presented in table 4.5 and depicted graphically in fig.4.5. Data revealed that the number of secondary branches per plant were increased with the advancement of crop growth however the maximum rate of increase were observed during 45 DAS to harvest stage of the crop growth, Critical examination of data clearly indicated marked variation in the number of secondary branches per plant due to combination of NPK (30:50:30 kg ha^{-1}) with vermicompost.

The highest number of secondary branches per plant were recorded under NPK (30:50:30 kg ha^{-1}) with vermicompost (T11) treatment which proved significantly superior over the control and other treatments at all the dates of observations.

The number of secondary branches per plant was recorded more in the treatment NPK (30:50:30 kg ha^{-1}) with vermicompost over the control at 45 DAS and at the harvest stage, respectively.

4.1.6. Dry Matter Accumulation (g Plant^{-1})

The data on dry matter accumulation (DMA) in crop plant as influenced by treatment combination NPK (30:50:30 kg ha^{-1}) with vermicompost application are presented in table 4.6 and depicted graphically in fig. 4.6.

It is clear from the data that dry matter accumulation significantly influenced by combined treatment of NPK (30:50:30 kg ha^{-1}) with vermicompost at 20, 45 DAS and at harvest stages, and proved significantly superior to control treatment.

TABLE: 4.5 EFFECTS OF ORGANIC FERTILIZER AND INORGANIC FERILIZER ON SECONDARY BRANCHES PER PLANT OF BLACK GRAM UNDER AGRI-HORTI SYSTEM

TREATMENT	SECONDARY BRANCHES PLANT^{-1} (cm)	
	DAYS AFTER SOWING	
	45	AT HARVEST
T_1 (I_0 O_0)	2.16	4.43
T_2 (I_0 O_1)	2.50	5.11
T_3 (I_0 O_2)	2.65	5.43
T_4 (I_0 O_3)	2.34	4.79
T_5 (I_1 O_0)	2.57	5.26
T_6 (I_1 O_1)	2.75	5.63
T_7 (I_1 O_2)	2.81	5.75
T_8 (I_1 O_3)	2.83	5.79
T_9 (I_2 O_0)	2.61	5.35
T_{10} (I_2 O_1)	2.94	6.02
T_{11} (I_2 O_2)	2.95	6.04
T_{12} (I_2 O_3)	2.88	5.89
SEm±	0.04	0.08
CD (P=0.05)	0.12	0.24
C.V	5.30	5.30

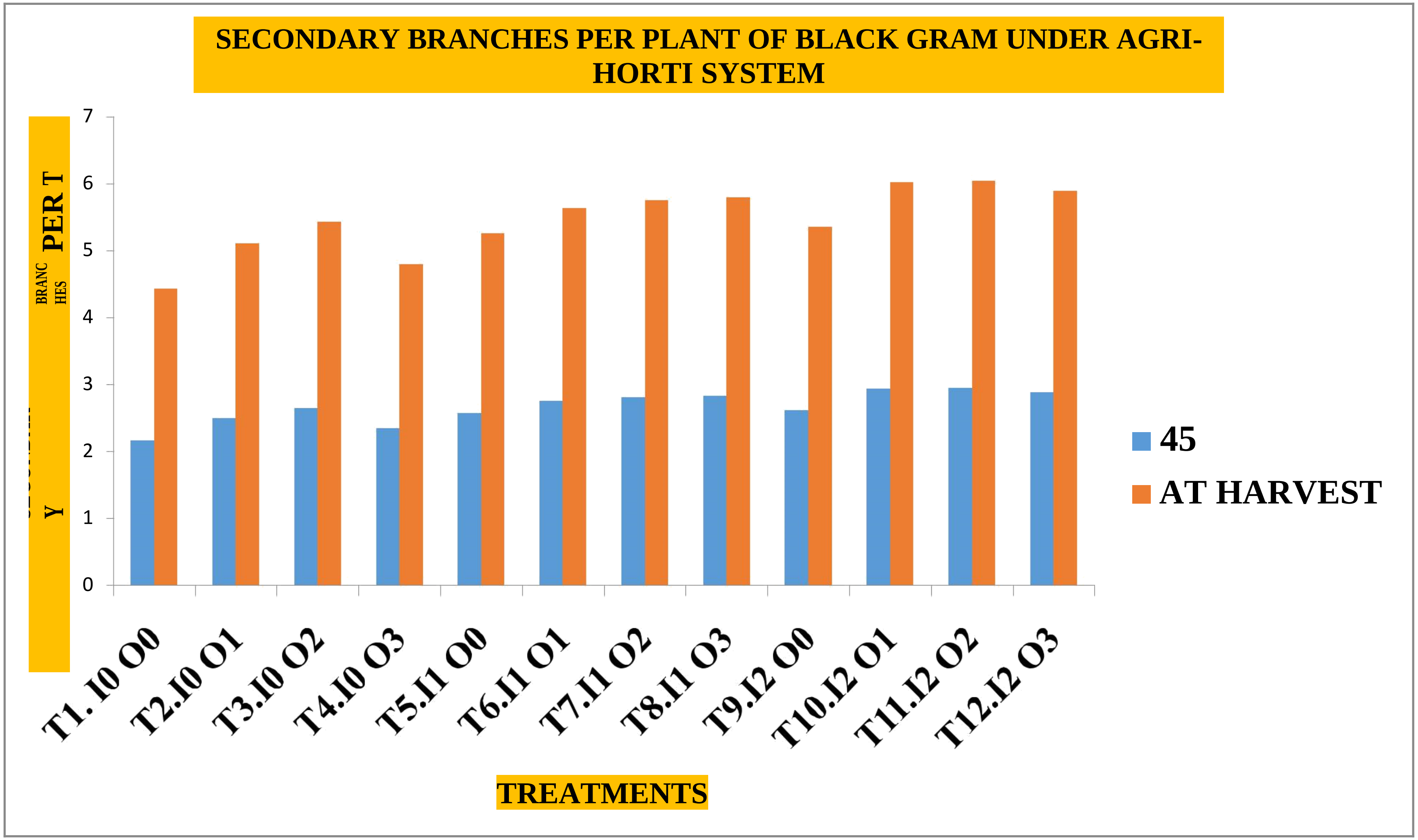

FIGURE: 4.5 EFFECTS OF ORGANIC FERTILIZER AND INORGANIC FERILIZER ON SECONDARY BRANCHES PER PLANT OF BLACK GRAM UNDER AGRI-HORTI SYSTEM

TABLE: 4.6 EFFECTS OF ORGANIC FERTILIZER AND INORGANIC FERILIZER ON DRY MATTER ACCUMULATION PER PLANT OF BLACK GRAM UNDER AGRI-HORTI SYSTEM.

TREATMENT	DRY MATTER ACCUMULATION^{-1} (g)		
	DAYS AFTER SOWING		
	20	45	AT HARVEST
T_1 (I_0 O_0)	0.35	2.63	3.30
T_2 (I_0 O_1)	0.40	3.04	3.80
T_3 (I_0 O_2)	0.42	3.23	4.04
T_4 (I_0 O_3)	0.37	2.84	3.56
T_5 (I_1 O_0)	0.41	3.02	4.80
T_6 (I_1 O_1)	0.44	3.24	5.15
T_7 (I_1 O_2)	0.45	3.30	5.25
T_8 (I_1 O_3)	0.45	3.33	5.29
T_9 (I_2 O_0)	0.42	3.07	4.89
T_{10} (I_2 O_1)	0.47	3.60	5.50
T_{11} (I_2 O_2)	0.47	3.73	5.52
T_{12} (I_2 O_3)	0.46	3.38	5.38
SEm±	0.006	0.04	0.07
CD (P=0.05)	0.019	0.13	0.21
C.V	5.30	4.84	5.35

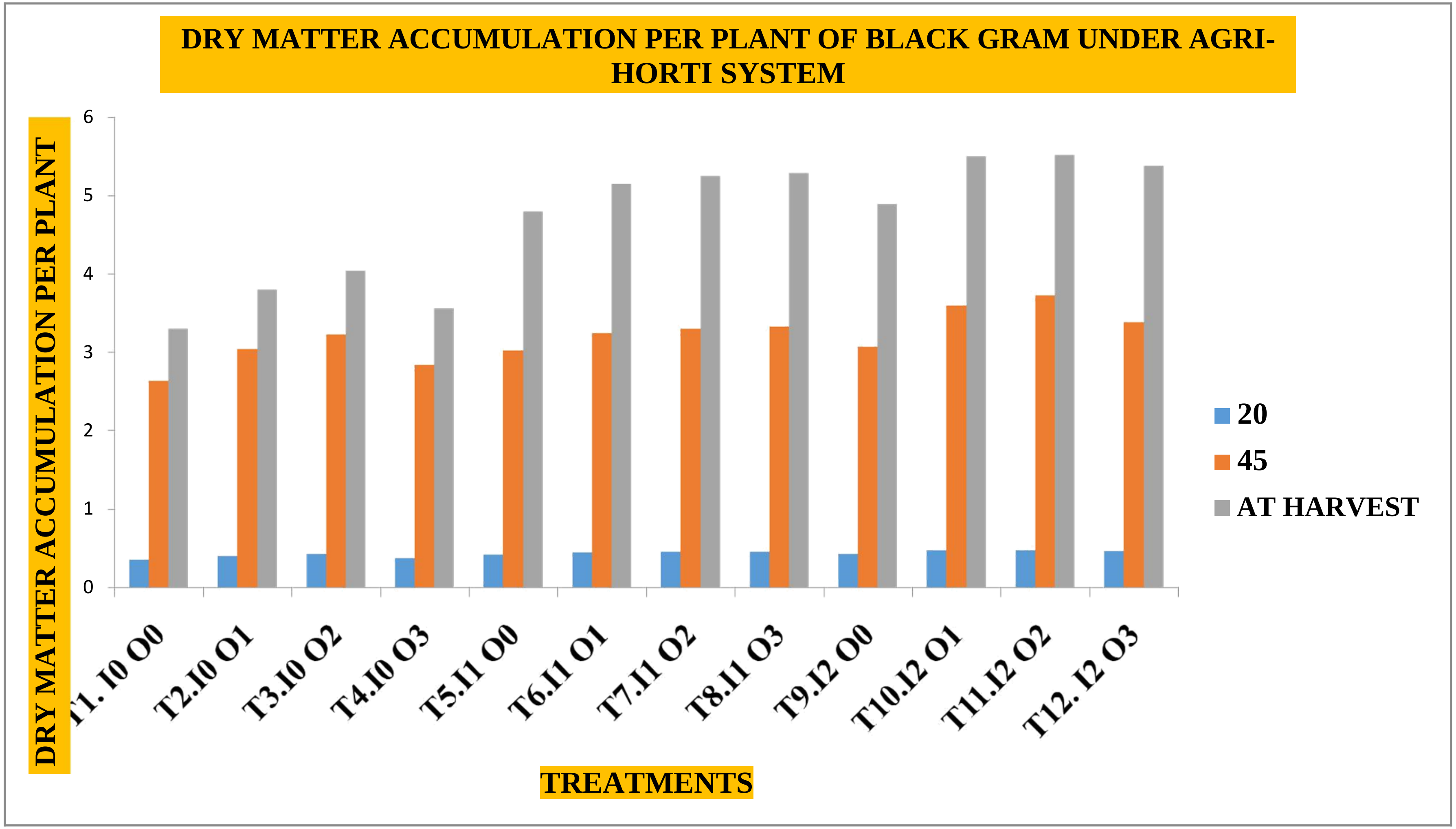

FIGURE: 4.6 EFFECTS OF ORGANIC FERTILIZER AND INORGANIC FERILIZER ON DRY MATTER ACCUMULATION PER PLANT OF BLACK GRAM UNDER AGRI-HORTI SYSTEM

4.2 Yield Attributes

The data pertaining to yield attributes, viz. number of pods per plant, number of grains per pod, pod length (cm) and 1000 grain weight (g) as influenced by different treatment of combination NPK (30:50:30 kg ha^{-1}) with vermicompost and farm yard manure were presented in table 4.7 and depicted graphically in fig.4.7.

4.2.1. Pods $Plant^{-1}$ (No.)

A critical analysis of the data clearly indicated (table 4.7) significant variation in pod per plant due to the combination of NPK (30:50:30 kg ha^{-1}) with vermicompost and farm yard manure and registered significant improvement over the control treatment. However, the maximum number of pods per plant were recorded with the application of NPK (30:50:30) kg ha^{-1} combined with vermicompost.

Lowest number of pods per plant were recorded under control treatment. The fertility levels of NPK (30:50:30 kg ha^{-1}) with vermicompost recorded more percent of (50-60%) enhancement in number of pods per plant as compared to control treatment.

4.2.2. Length of Pods (cm)

The data on variation in pod length (cm) are presented in table 4.7 and depicted graphically in fig. 4.7 combined treatment of NPK (30:50:30 kg ha^{-1}) with vermicompost and NPK (30:50:30 Kg ha^{-1}) with farm yard manure produced maximum pod length (cm). Fertility levels with organic manure also proved significant over control.

4.2.3 Grain Pod^{-1} (No.)

Close examination of the data on no. of grains pod^{-1} as affected by different organic levels with inorganic levels are presented in table 4.7

The variation in number of grain per pod due to different organic manure, bio fertilizer with inorganic levels were found to be significant.

The maximum number of grains per pod were recorded due to NPK (30:50:30) kg ha^{-1} with vermicompost level followed by treatment NPK (30:50:30) kg ha^{-1} with farm yard manure. However, the minimum of grains per pod were registered under control treatment.

Further, examination of the data revealed that the number of per pod production proved significant superior due to varying combination treatment of organic over inorganic levels and significantly increased the grain per pod compared to all the treatment combination.

4.2.4 1000 Grain Weight (g)

A critical analysis of data clearly indicated significant variation in 1000 grains weight due to different combination of organic manure with inorganic levels.

The maximum 1000 grains weight were recorded under NPK (30:50:30 kg ha^{-1}) with vermicompost which proved significantly superior over the control and other treatments. The data indicated that the test weight increased significantly due to the application of graded level of NPK (30:50:30 kg ha^{-1}) with vermicompost over the control treatment and the magnitude of increase over the control was around 20-30 percent.

TABLE 4.7 EFFECT OF INORGANIC AND ORGANIC FERTILIZER ON YEILD ATTRIBUTES OF BLACK GRAM UNDER GUAVA BASED AGRI HORTICULTURE SYSTEM.

TREATMENT	PODS PLANT^{-1} (No.)	POD LENGTH (cm)	GRAINS POD^{-1} (No.)	TEST WEIGHT (gm)
T_1 (I_0 O_0)	12.73	5.63	6.82	27.52
T_2 (I_0 O_1)	14.68	6.49	7.87	31.74
T_3 (I_0 O_2)	15.60	6.89	8.36	33.73
T_4 (I_0 O_3)	13.74	6.07	7.36	29.71
T_5 (I_1 O_0)	16.48	7.28	8.83	35.63
T_6 (I_1 O_1)	17.65	7.80	9.46	38.17
T_7 (I_1 O_2)	18.01	7.96	9.65	38.94
T_8 (I_1 O_3)	17.24	7.62	9.24	37.27
T_9 (I_2 O_0)	16.75	7.40	8.98	36.22
T_{10} (I_2 O_1)	18.86	8.34	10.11	40.79
T_{11} (I_2 O_2)	18.93	8.37	10.14	40.93
T_{12} (I_2 O_3)	18.45	8.15	9.89	39.89
SEm±	0.24	0.10	0.13	0.52
CD (P=0.05)	0.71	0.31	0.38	1.55
C.V	5.11	5.11	5.11	5.24

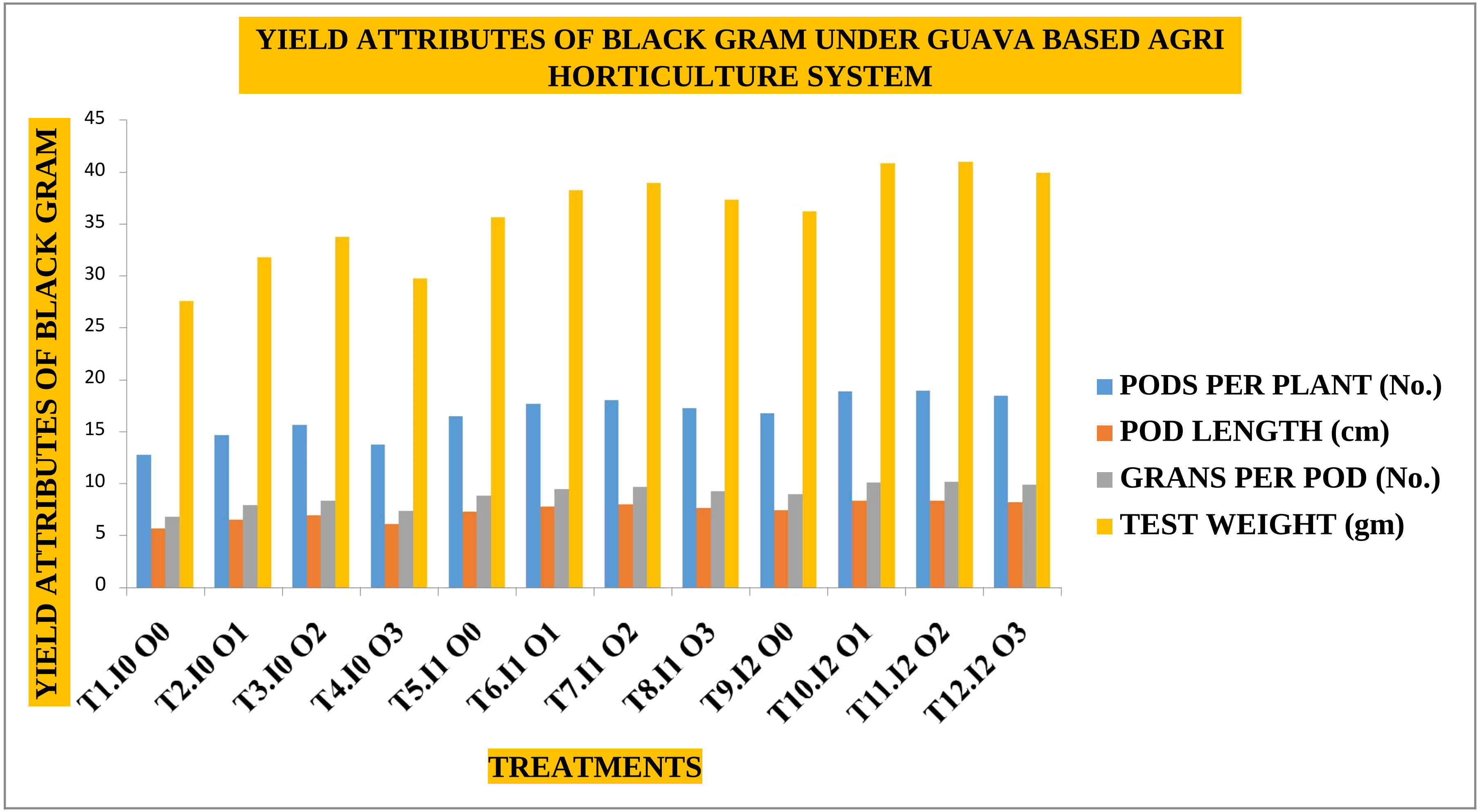

FIGURE 4.7 EFFECT OF INORGANIC AND ORGANIC FERTILIZER ON YEILD ATTRIBUTES OF BLACK GRAM UNDER GUAVA BASED AGRI HORTICULTURE SYSTEM.

4.3 Yield Studies

The mean data on grain yield, straw yield (kg ha^{-1}) and harvest index (%) as influenced by inorganic level combined with organic manure have been depicted graphically in the figure 4.8.

4.3.1 Grain Yield (kg ha^{-1})

It is quite clear from the data presented in Table 4.8, that treatment (I_2O_2), *i.e.*, NPK (30:50:30 Kg ha^{-1}) with vermicompost and farm yard manure, (I_2O_1) proved equally effective on production of grain yield.

An examination of data revealed a significant variation in grain yield due to different combination of organic and inorganic levels. The combined treatment of NPK (30:50:30 kg ha^{-1}) with vermicompost recorded the maximum grain yield, followed by NPK (30:50:30 kg per hectare) farmyard manure. The data indicated that the grain yield increased significantly due to the application of different levels of inorganic and organic levels i.e. NPK (30:50:30 kg ha^{-1}) with vermicompost and the magnitude increase over the control was 45- 50 percent.

4.3.2 Straw Yield (Kg ha^{-1})

The data on straw yield of green gram as influenced by different levels of N, P, K and organic manure and biofertilizer are presented in Table 4.8 The data revealed treatment NPK (30:50:30 kg ha^{-1}) with vermicompost brought about significant improvement in straw yield followed by NPK (30:50:30 kg per hectare) with farm yard manure**.** Increase in the straw yield was up to 30- 40 percent in comparison to the control.

4.3.3 Harvest Index (%)

A critical analysis of data clearly indicates that there was no significant variation in harvest index due to different organic and inorganic levels. However, the maximum harvest index was recorded under NPK (30:50:30 kg per hectare) i.e., T_{11} treatment.

TABLE 4.8: EFFECT OF INORGANIC AND ORGANIC FERTILIZER ON GRAIN, STRAW YEILD (Kg ha^{-1}) AND HARVEST INDEX (%) OF BLACK GRAM UNDER GUAVA BASED AGRI HORTICULTURE SYSTEM

TREATMENT	YIELD (Kg ha^{-1})		HARVEST INDEX (%)
	GRAIN	STRAW	
T_1 (I_0 O_0)	461	1497.60	23.56
T_2 (I_0 O_1)	531.67	1684.32	24.04
T_3 (I_0 O_2)	565	1726.65	24.67
T_4 (I_0 O_3)	497.67	1587.53	23.90
T_5 (I_1 O_0)	596.73	1746.33	25.47
T_6 (I_1 O_1)	639.33	1820.00	26.01
T_7 (I_1 O_2)	652.20	1845.00	26.10
T_8 (I_1 O_3)	624.33	1837.33	25.38
T_9 (I_2 O_0)	606.73	1857.67	24.67
T_{10} (I_2 O_1)	683.27	1932.33	26.10
T_{11} (I_2 O_2)	685.53	1933.67	26.17
T_{12} (I_2 O_3)	668.10	1921.67	25.80
SEm±	8.86	25.37	0.34
CD (P=0.05)	26.01	74.42	1.02
C.V	5.52	5.35	4.82

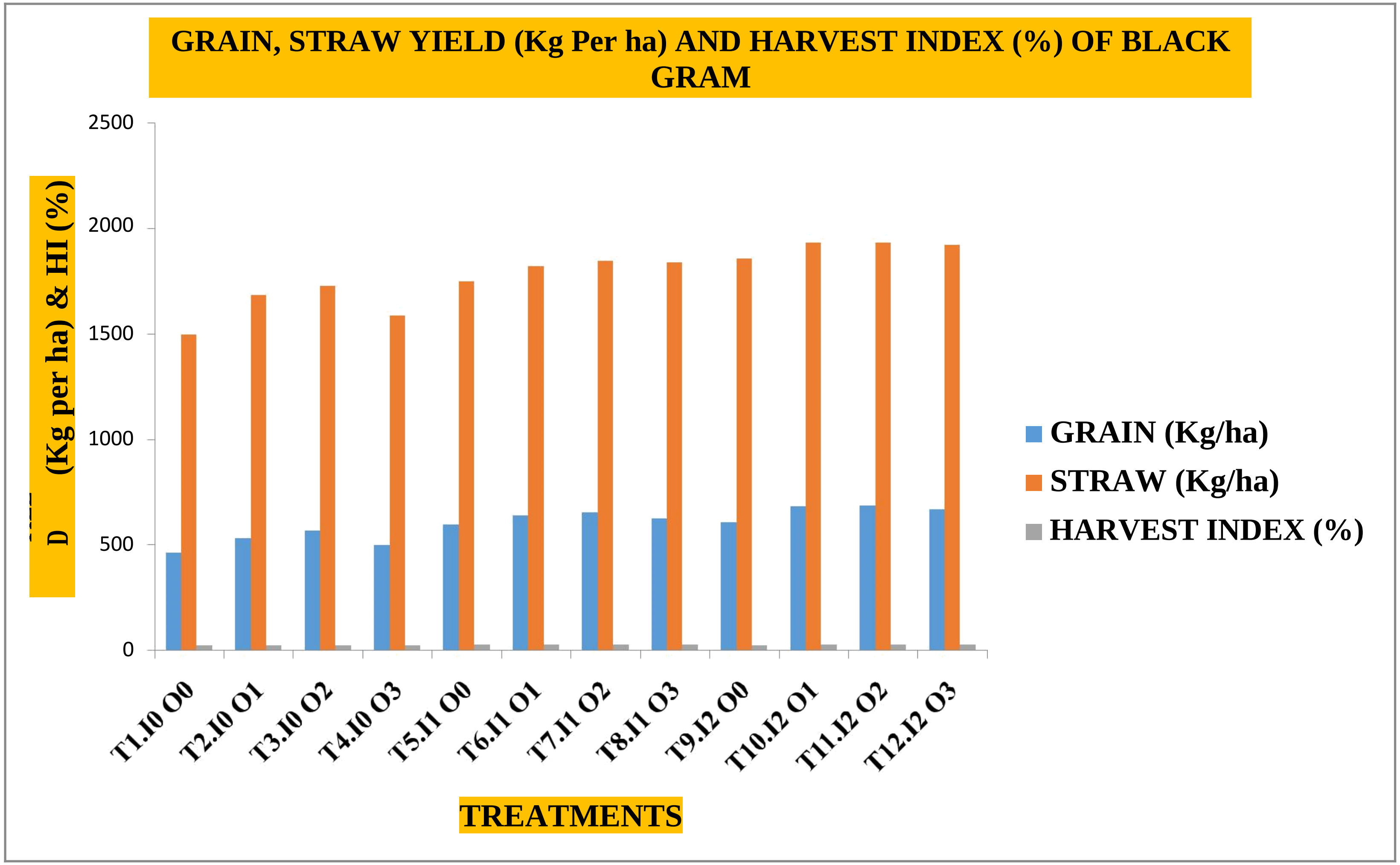

FIGURE 4.8: EFFECT OF INORGANIC AND ORGANIC FERTILIZER ON GRAIN, STRAW YEILD (Kg ha^{-1}) AND HARVEST INDEX (%) OF BLACK GRAM UNDER GUAVA BASED AGRI HORTICULTURE SYSTEM

4.4. Available Nitrogen, Phosphorus and Potassium (Kg ha^{-1}) in Soil

Data regarding residual soil fertility status after harvest as influenced by different treatments are presented in table 4.9. Available nitrogen and phosphorus showed significant variation due to different fertility levels with organic manure and without organic manure and separate treatment. However, significantly higher in NPK (30:50:30) kg ha^{-1} with vermicompost was recorded over the control (I_0 O_0) and other treatments.

4.5 Relative Economics

Research finding may be useful from academic point of view but would not be useful to the farmers unless these findings are economically feasible from the point of its adoption by beneficiaries. The economic analysis includes the cost of cultivation, gross return, net Return, and benefit: cost ratio for different treatment combination, and the data in respect of economics have been summarized in table 4.10.

TABLE 4.9: EFFECT OF INORGANIC AND ORGANIC FERTILIZER ON AVAILABLE N P K AFTER POST HARVEST IN SOIL OF BLACK GRAM UNDER GUAVA BASED AGRI HORTICULTURE SYSTEM.

TREATMENT	AVAILABLE NITROGEN (Kg ha^{-1})	AVAILABLE PHOSPHORUS (Kg ha^{-1})	AVAILABLE POTASSIUM (Kg ha^{-1})
T_1 (I_0 O_0)	142.28	13.80	147.76
T_2 (I_0 O_1)	164.09	15.92	170.41
T_3 (I_0 O_2)	174.38	16.92	181.09
T_4 (I_0 O_3)	153.60	14.90	159.51
T_5 (I_1 O_0)	184.18	17.87	191.26
T_6 (I_1 O_1)	197.33	19.14	204.91
T_7 (I_1 O_2)	201.30	19.53	209.04
T_8 (I_1 O_3)	192.70	18.69	200.11
T_9 (I_2 O_0)	187.26	18.17	194.47
T_{10} (I_2 O_1)	210.88	20.46	219.00
T_{11} (I_2 O_2)	211.58	20.52	219.72
T_{12} (I_2 O_3)	206.20	20.00	214.13
SEm±	2.73	0.26	2.84
CD (P=0.05)	8.02	0.77	8.33
C.V	5.48	4.97	5.84

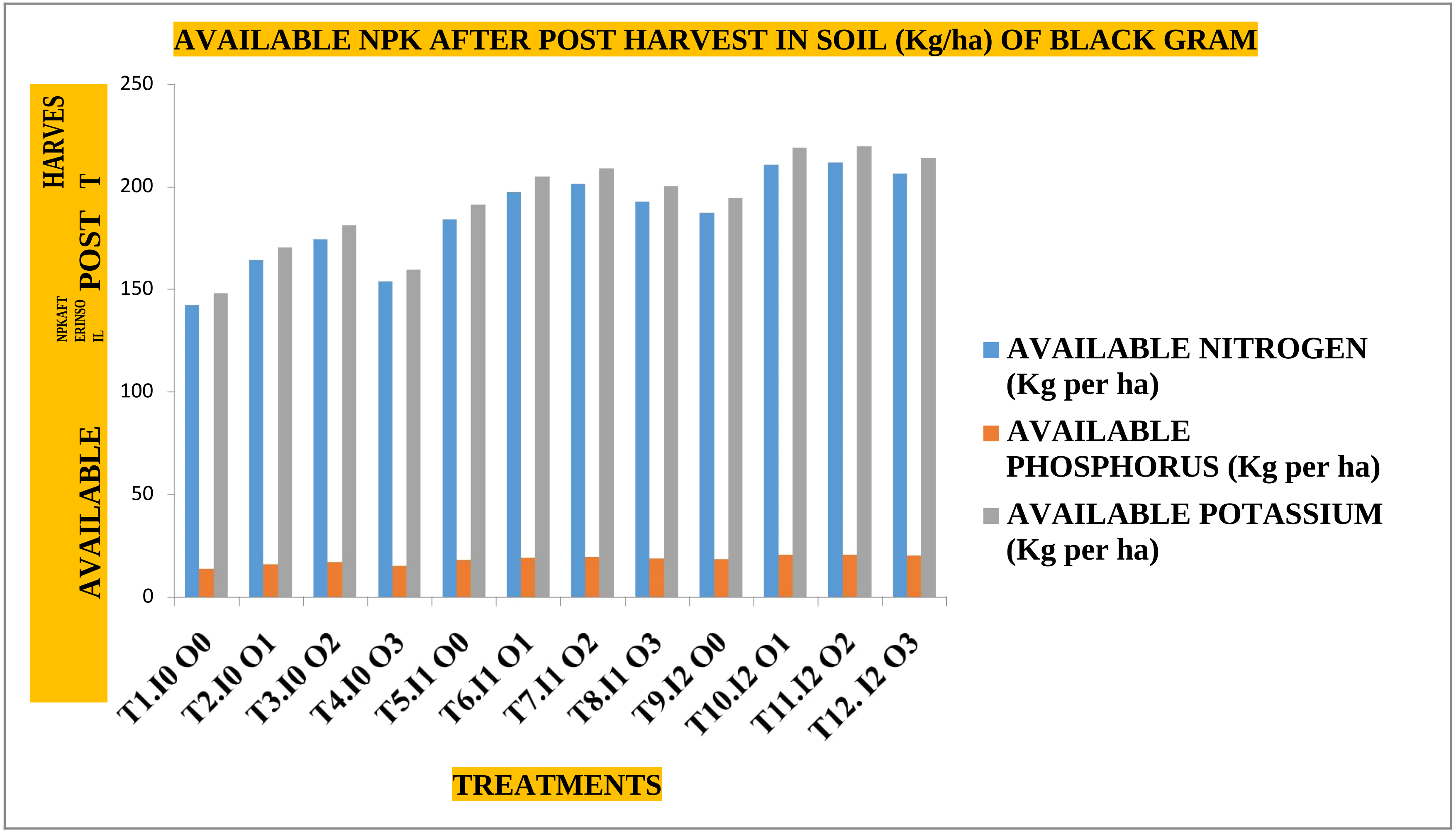

FIGURE 4.9: EFFECT OF INORGANIC AND ORGANIC FERTILIZER ON AVAILABLE N P K AFTER POST HARVEST IN SOIL OF BLACK GRAM UNDERGUAVA BASED AGRI HORTICULTURE SYSTEM.

4.5.1 Cost of Cultivation (Rs. ha^{-1})

The common cost of cultivation of different treatment combination were work out, considering all operation from land preparation to harvesting and input used. The treatment cost was calculated separately and it was combined with common cost of cultivation to find out the total cost of cultivation. Data revealed that the cost of cultivation was maximum of Rs.26706.29 ha^{-1} for NPK (30:50:30 kg ha^{-1}) with farmyard manure, over the control and the rest of the treatment. The total costs of cultivation were minimum of Rs.19149.2 under the control treatment (I_0 O_0).

4.5.2 Gross Return (Rs. ha^{-1})

It is evident from the data that among different fertility levels and dual treatment of organic fertilizer recorded maximum gross return in alley cropping was Rs. 56332.32 ha^{-1} due to NPK (30:50:30kg ha^{-1}) with vermicompost. The minimum gross return of Rs. 45514.75 per hectare was recorded in guava based cropping system under control treatment respectively.

4.5.3 Net Return (Rs. ha^{-1})

The net return was markedly influenced due to different cost incurred and yield (grain and straw) obtained under various treatments. The maximum and minimum net return was recorded under application of NPK (30:50:30 kg ha^{-1}) with vermicompost (I_2 O_2) and minimum under control treatment i.e., (I_0 O_0) treatment, respectively.

4.5.4 Benefit: Cost Ratio

The data on benefit: cost ratio indicated that the maximum benefit: cost ratio (1.47) was recorded in combined application of NPK (30:50:30 kg ha^{-1}) with I_1 O_3. However, the treatment under I_0 O_1 guava based agri- horti system incurred the minimum benefit: cost ratio (1.09).

TABLE : 4.10 EFFECT OF INORGANIC AND ORGANIC FERTILIZER ON AVAILABLE N P K ON RELATIVE ECONOMMICS OF BLACKGRAM UNDER GUAVA BASED AGRI HORTICULTURE SYSTEM.

TREATMENT	COST OF CULTIVATION	GRAIN (Rs/ ha)	STRAW (Rs/ ha)	GUAVA (FRUIT) (Rs/ ha)	TOTAL (Rs/ ha)	NET RETURN (Rs/ ha)	BENEFIT: COST RATIO
T_1 (I_0 O_0)	19149.2	21090.75	1872.00	22552.2	45514.75	26365.55	1.37
T_2 (I_0 O_1)	23349.2	24323.75	2105.40	22552.2	48981.15	25631.95	1.09
T_3 (I_0 O_2)	21349.2	25848.75	2158.31	22552.2	50559.06	29209.86	1.36
T_4 (I_0 O_3)	19164.2	22768.25	1984.41	22552.2	47304.66	28140.46	1.46
T_5 (I_1 O_0)	21588.21	27300.55	2182.92	22552.2	52035.47	30447.26	1.41
T_6 (I_1 O_1)	25788.21	29249.50	2275.00	22552.2	54076.52	28288.29	1.09
T_7 (I_1 O_2)	23788.21	29838.15	2306.25	22552.2	54696.4	30908.19	1.29
T_8 (I_1 O_3)	21603.21	28563.25	2296.67	22552.2	53411.92	31808.71	1.47
T_9 (I_2 O_0)	22506.29	27758.05	2322.08	22552.2	52632.13	30125.84	1.33
T_{10} (I_2 O_1)	26706.29	31259.45	2415.42	22552.2	56226.87	29520.58	1.10
T_{11} (I_2 O_2)	24706.29	31363.15	2417.08	22552.2	56332.32	31625.94	1.28
T_{12} (I_2 O_3)	22521.29	30565.58	2402.08	22552.2	55519.66	32998.37	1.46
SEm±	391.38	405.77	31.71	00	589.02	367.39	0.02
CD (P=0.05)	1147.86	1190.07	93.05	NS	1727.53	1077.53	0.07
C.V	17.35	5.54	5.35	00	11.71	12.90	19.10

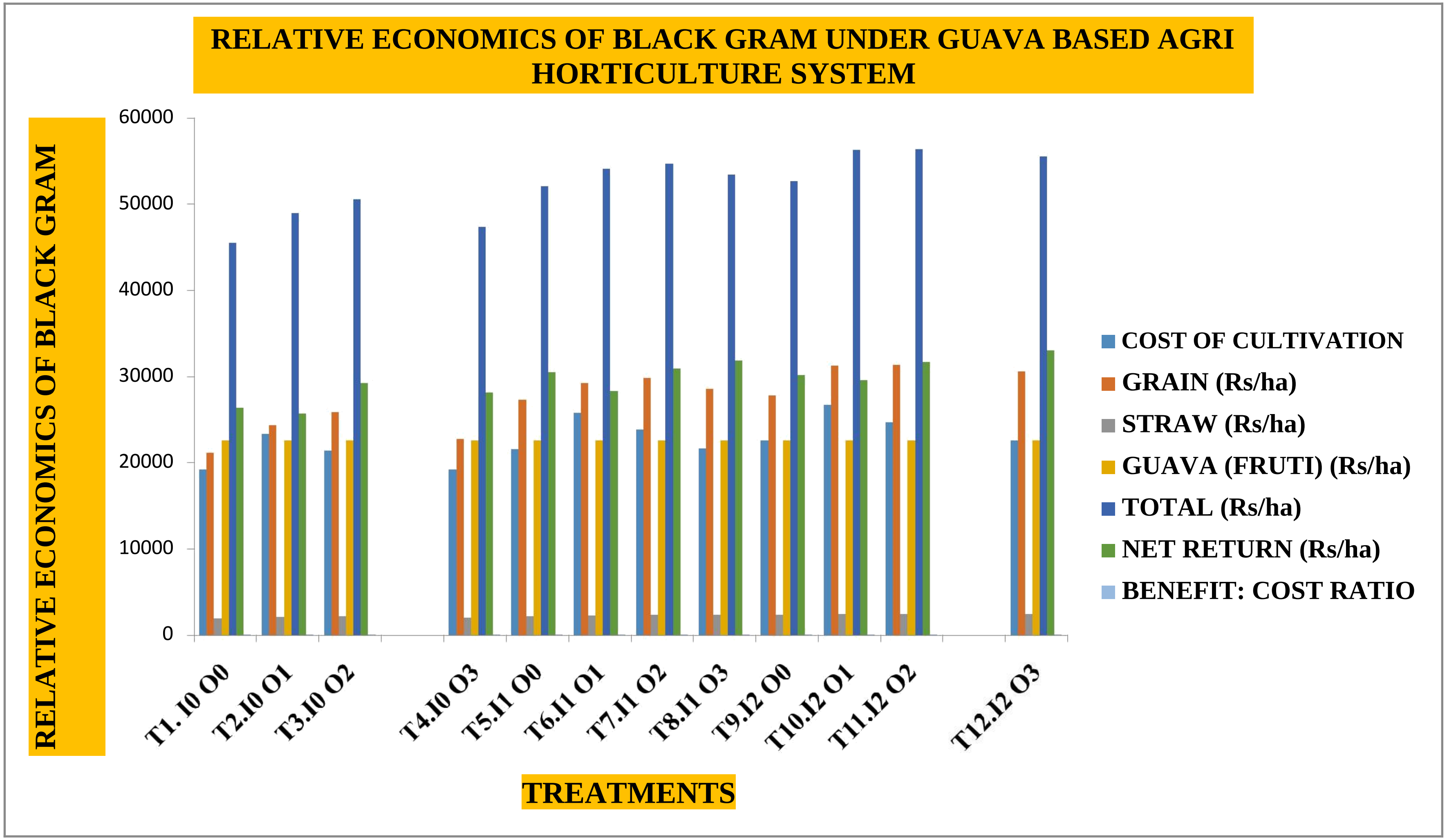

FIGURE 4.10 EFFECT OF INORGANIC AND ORGANIC FERTILIZER ON AVAILABLE N P K ON RELATIVE ECONOMMICS OF BLACKGRAM UNDER GUAVA BASED AGRI HORTICULTURE SYSTEM.

CHAPTER - 5

RESULT AND DISCUSSION

The present investigation entitled "**Effect of different levels of inorganic and organic fertilizer on growth and yield of black gram *(Vigna mungo* L.Hepper) under guava based agri-horti system**'' was conducted during rainy (kharif) season of 2016 at agricultural research farm of Rajiv Gandhi south campus, Barkachha (BHU), Mirzapur, Uttar Pradesh. The experimental findings have been described in the preceding chapter. An attempt has been made to analyze the results critically in the light of causes of variation in this chapter. Various impacts due to the variation in treatment combination and their influence on soil as well as crops have been described in this chapter.

The growth and yield potentiality of crop heavily depends upon its genetic characters as well as the environmental factors to some extent. Physical and chemical nature of along with some cultural practices also affects the performance of crop plant, the proper growth and development of crops is also greatly influenced by the alley cropping system and have shown fluctuation of indirect or direct effect on growth and development. The findings have been discussed considering the weather situation during the crop period. The weather data shows ample soil moisture supplementation at periodic intervals. The crop witnessed a normal weather in terms of temperature, relative humidity sun shine hour's etc., are concerned. In alley cropping system, apart from all factors, fertility levels and bio fertilizer combination as well as organic manure of the respective components crop and their competitive relationship are of paramount important.

The findings of earlier workers on the subject have also been taken in to consideration while discussing the result of present investigation. The discussion is presented under various heads.

5.1 Effect of Weather Conditions on Growth and Yield of Black Gram

Every crop requires a set of definite suitable environmental condition for its proper growth and development. In addition to alley cropping and weather parameters such as temperature, rainfall, sun-shine duration, relative humidity and evaporation are the main factor, which influenced crop growth and development. Black gram is generally grown as summer and rainy season crop in northern India. Heavy rainfall during the flowering stage is harmful and adversely affects the production. Such crops require hot and humid climate, but it is susceptible to hail damage at all stages of growth. Frost is also harmful to this crop.

Temperature is known to have strong effect on vegetative and reproductive phases. The sub- optimal or supra-optimal temperature severely affects germination and plant stand.

The meteorological data (**Table 3.1)** recorded during the crop season showed that the average temperature remained 34.95^{O}C (September) to 25.30^{O}C (October) respectively, which was within the optimum range for growth of green gram.

5.2 Effect on Crop

5.2.1 Effect on Growth Parameters

Result of the experiment revealed that growth parameters of black gram **(Table 4.1 to 4.10)** showed marked variation due to the combined treatment of organic with inorganic and due to bio fertilizer. Individual response of organic manure over inorganic was recorded higher. The combined treatment of NPK (30:50:30 Kg ha^{-1}) with vermicompost showed greater enhancement in increasing maximum parameters of plant growth, followed by farm yard manure and also bio fertilizer. Due to the use of bio fertilizer in some treatment, it showed remarkable growth and increased the production of new leaves as well as roots which promoted enough nitrogen, phosphorus and potassium level to the crops. Due to the combined treatment of inorganic and organic levels i.e., NPK (30:50:30 Kg ha^{-1}) with vermicompost synthesis of protein and yield recorded higher with good vegetative as well as yield attributes.

Vermicompost are the products of the degraded organic matter through interactions between earthworms and microorganisms. Vermicompost are finely transformed into peat -like materials with high porosity, aeration, drainage, and water-holding capacity and usually contain most nutrients in the available forms such as nitrates, phosphates, exchangeable calcium and soluble potassium. Phosphate solubilising microorganisms such as; bacteria and fungi, are effective in releasing P from inorganic and organic pools of total soil P through solubilisation and mineralization (Chen *et al.,* 2006). Vermicompost in combination with NPK (30:50:30 kg per hectare) enhanced the plant height and also caused positive changes in the primary and secondary branches of the plant.

Vermicompost, with high water-holding capacity and proper supply of macro- and micro- nutrients has a positive effect on biomass production and subsequently the enhanced plant height. Improved growth, development and height of crops have previously been reported in the presence of optimal amounts of vermicompost (Vadiraj *etal.,* 1998; Arguello *et al.,* 2006; Darzi *et al.,* 2007; Azizi *et al.,* 2008). Vermicompost has significantly influenced the flowering, increasing trifoliate leaves, secondary branches per plant and primary branches per plant. On the other hand, vermicompost application responsible for the improvement of biological activities of soil and mineral element absorption (Arancon *et al.,* 2004), caused more biomass production along with grain yield.

These earlier findings are in accordance with the results of present experiment, and the observations on the *Fragaria ananasa* (Arancon *et al.,* 2004). Similar, results were also obtained for several other plants such as *Artemisia pallens, Foeniculum vulgare* (Pandey 2005; Roy and Singh 2006; Darzi *et al.,* 2007). Roy and Singh (2006) reported a large number of productive tillers of barley in response to vermicompost application. They have suggested that vermicompost affected the productive tillering through microbial stimulation and gradual mineralization of soil. According to the present analysis, vermicompost with NPK (30:50:30 kg per hectare) that is T_{11} treatment promoted flowering and increased grain yield per plant by enhancing the phosphorus content and the rate of photosynthesis (Ratti *et al.,* 2001). The present result was derived from the improvement of phosphate solubilizing microorganisms' activities in soil at the third treatment level (inoculated seed +

spraying on plant base at stem elongation stage), which are in agreement with the previous studies carried out on the borage plant (Shaalan, 2005a).

The results clearly demonstrated the effectiveness of vermicompost in combination with NPK level for increased biological yield. Vermicompost with NPK (30:50:30) kg per hectare has increased the growth rate, because of water and mineral uptake such as; nitrogen and phosphorus, which lead to the proper biological yield improvement (Atiyeh *et al.,* 2002; Arancon et al., 2004). This finding is in accordance with the previous observations (Anwar *etal.,* 2005; Darzi *et al.,* 2008). Effect of phosphate solubilising bacteria on the biological yield attributed due to increased phosphorus uptake (Ratti *et al.,* 2001; Shaalan, 2005a, b). The result of the present work is in agreement with the reports of Omar (1998) on *Triticum aestivum*, Ratti *et al.* (2001) on *Cymbopogon martini*, Rashmi *et al.* (2008) on *Ocimum gratissimum* and Darzi *et al.* (2011) on *Pimpinella anisum*. All the earlier reports and present results supported the fact of positive and synergistic effect on interaction between two factors which highly dependent on the effect of organic matter, containing vermicompost, on the activity of phosphate solubilising bacteria. Many reports have shown that the interaction between bio fertilizers can be beneficial for plant growth and yield (Hazarika *et al.,* 2000; Ratti *et al.,* 2001; Kumar *et al*., 2002; Darzi *et al.,* 2008; Padmapriya and Chezhiyan, 2009).

Increased seed yield due to vermicompost treatments could be attributed due to the improvement of yield components such as; plant height, trifoliate leaves per plant, secondary branches per plant, primary brancher per plant and biomass/biological yield. Findings are in accordance with the observations of earlier researchers (Mba 1996; Vadiraj *et al.,* 1998; Darzi *et al.,*2007; Chand *et al*., 2007; Sanchez *et al.,* 2008). Whilst, Roy and Singh (2006) demonstrated that increased supply of mineral elements, through vermicompost application, resulted in greater absorption and utilization of these elements, which resulted in better growth of barley having direct effect on the yield attributes as well as the grain yield. Arguello *et al.* (2006) have shown that the application of vermicompost on *Allium sativum* caused greater yield as compared to the experimental plants with no vermicompost application due to an earlier start of bulbification and lengthening of the bulb filling period. Phosphatic biofertilizer promoted seed yield through the enhancement of yield attributes. These results are in agreement with the earlier investigation on *Vigna radiata*, *Borago officinalis, Nigella sativa* and *P. anisum* (Singh and Kapoor, 1998; Shaalan 2005a, b; Darzi *et al.*, 2011)

Due to combination of inorganic level that is NPK (30:50:30) kg ha^{-1} with vermicompost produced highest yield due to vermicompost composition and also due to the application of phosphorus which improved the nutrient availability status, resulting into greater grain yield which might have increased the photosynthetic and then translocated the synthate to different parts for promoting meristematic development in potential apical buds and intercalary meristems and hence increased growth parameters of the crop.

Potassium is one of the greatest investments in protecting a crop against disease. It has ability to strengthen stalks and stems against disease and protecting the plant from lodging. It has the ability to make plant cells thicker, making it more difficult for certain diseases to invade the plant after heavy rain or other unfavourable conditions.

5.2.2 Effect on Yield Attributes and Yield

The results have indicated that biological yields affected by the application of vermicompost Significant increase in biological yield was observed in two treatments i.e., combination with NPK level or as separate component as compared to the control experiment (non-vermicompost). The highest biological yields were obtained with applying vermicompost and NPK level (30:50:30 kg per hectare). Vermicompost showed significant effect on biological yield. The present results showed that the interaction of vermicompost and NPK level also proved significant. The use of vermicompost and phosphatic bio fertilizer, on the biological yield, revealed that the application of 6 ton/ha vermicompost successively increased the levels of phosphatic bio fertilizer, which resulted in a significant increase in biological yield.

The results presented revealed that vermicompost in combination with NPK level (30:50:30 kg per hectare) significantly affected the seed yield. It increased the root nodulation and better root development and more nutrient availability, resulting in vigorous plant growth and dry matter accumulation which resulted in better flowering, fruiting, and pod formation and helped in reducing in p fixation by its effect and also solubilised the unavailable form of P leading to more removal of nutrients by the crop which reflected in better growth parameters *viz.*, pods plant^{-1} and grains pod^{-1}, the increased the grain, straw and biological yield due to the cumulative effect of increased growth and yield parameters.

Enhanced vegetative growth in term of dry matter production and branches plant $^{-1}$ provided more sites for the translocation of photosynthates and ultimately resulted in increased number of pods plant^{-1}, grain pod^{-1}, pod length and test weight and significantly benefitted with the availability of nutrients.

As stated earlier, the adequate supply of nitrogen, phosphorus and potassium play a vital role in metabolic process of photosynthesis that resulted in increased flowering and fruiting, thereby improving number of pods plant^{-1} grains pod^{-1} and test weight. The increase in above parameters with the application of nitrogen and phosphorus in appropriate level proved instrumental for effective removal and translocation of nutrients, especially phosphorus, resulting in bold seed formation by increasing the size and weight of grains, there results are in close accordance with findings of Kumar *et al*. (2003).

The better growth of plant in terms of height and dry matter accumulation are most important factor in improving yield parameters and yield of black gram through better translocation of food reserves to sink. The levels of phosphorus during this period regulate the starch/sucrose ratio in the source leaves and the reproductive organs. It also influences the stomatal resistance and activity of ribilose bi- phosphate partitioning of photosynthates to sink development has led to increased number of pods plant^{-1}, grains pod^{-1} and test weight. It also helped in stimulating the cell division and root elongation in meristematic tissues and constitute ADP and ATP in plant, which plays an important role in energy storage.

Due to increased dry matter and photosynthetic products with efficient translocation, plant produced more pods plant^{-1} with more number of grains pods^{-1} and higher test weight and it is due to the combination of NPK (30:50:30 kg ha^{-}1) with vermicompost. Rashmi KR, Earanna N, Vasundhara M (2008). Influence of biofertilizers on growth, biomass and biochemical constituents of *Ocimum gratissimum*. L. Biomed., 3(2): 123-130, also observe the effect explained.

5.2.3 Effect on Tree and its Fruit

Experiment laid out in guava based agri-hoticulture system has increased the fruit yield, canopy, girth, stem and height of the plant. It showed positive response on guava. It is highly perishable in nature. Shelf life under ambient conditions is 2 to 3 days on an average, therefore, it should be marketed immediately after harvest. The yield is of about 751.74 kg per hectare and gross income from fruit tree was Rs 22552 Kg per hectare.

5.2.4 Available NPK in the Soil

Combination of inorganic level of NPK (30:50:30 kg ha^{-1}) with vermicompost significantly increased the residual available nitrogen, phosphorus, and potassium in the soil over the control after harvest of crop. This can be attributed to higher level of fertility. Due to this combination, it brought about better aeration of soil moisturizer maintained on the soil and also it increased the good transportation of necessary minerals and water. Vermicompost, with high water-holding capacity and proper supply of macro- and micro-nutrients has a positive effect on biomass production and subsequently enhanced plant height. Improved growth, development and height of medicinal plants and other crops have previously been reported in the presence of optimal amounts of vermicompost.

5.2.5 Relative Economics

The maximum economy obtained from treatment that is **T_{11}(N_2VC).** The practical utility of any measure can be judged on the basis of net returns. In present study, all the treatment with organic manure got more net returns than that of inorganic fertilizer.

Among fertilizer, application of NPK (30:50:30 kg ha^{-1}) with vermicompost showed highest value. Highest grain and straw yield of black gram were in great number in **T_{11}** treatment. Similar result was also reported by Kohli *et al*. (2006), Deore *et al.* (2007) and Yadav *et al.* (2009).

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SUMMARY AND CONCLUSION

In this chapter, an attempt has been made to summarize the results presented in the chapter of experimental findings, and also to draw valid conclusion based on the significant variation in the present investigation entitled “Effect of different levels of inorganic and organic fertilizer on growth and yield of black gram *(Vigna mungo* L. Hepper) under guava based agri-horti system.’’ Experiment was conducted during rainy (kharif) season of 2016 at agricultural research farm of Rajiv Gandhi south campus, barkachha (BHU), Mirzapur, Uttar Pradesh

The soil of the experimental field was sandy loam-silt in texture with low drainage having pH 5.9. It was moderately fertile, being low in available organic carbon (0.26%) available nitrogen (179.60.51 kg ha^{-1}), and medium in available phosphorus (13.10 kg ha^{-1}), potassium (183.25 kg ha^{-1}). The experiment is laid out in factorial randomized block design with three replications under agri-horti system. Treatments were replicated three times. The experiment consist of 12 treatments viz. having two levels of inorganic fertilizer i.e, N+P+K, first level is N,P,K(20:40:20 kg ha^{-1}) & second level is N,P.K (30:50:30 kg ha^{-1}) along with three levels of Organic fertilizer i.e, farmyard manure (6 t ha^{-1}), vermicompost (8 to 10 kg ha^{-1}), biofertilizer i.e Seed inoculated by strain *rhizobium (*MOR-1) 8 gram per kg of seed *of* black gram *(Vigna mungo* L. Hepper) 18 gram for each plot spreadwith soil in seed sowing area with 3 replication including control treatment. The inoculants were obtained from the Institute of Agricultural Sciences, Banaras Hindu University. The treatments were randomized as per statistical procedure. The seed were sown with the help of kudal directly in rows 30×10 cm apart. The experiment was carried out with 10 yrs old guava tree planted at 7.0×7.0 meter spacing.

Various observations were recorded during the course of investigation including morphological and yield attributes as affected by biofertilizer, farm yard manure, vermicompost and inorganic fertility levels. Morphological studies particularly the growth parameters were recorded at various phonological stages starting from 20 DAS followed by 45 DAS and at harvest. Crop response to the treatments were measured in term of various quantative indices, viz. plant height, root nodules plant^{-1}, Number of trifoliate leaf plant^{-1} (No.), Primary branches plant^{-1} (No.), 4 Secondary branches plant^{-1} (No.), Dry matter accumulation^{-1} (g), Number of root nodules plant^{-1} (No.), Yield attributing characters, like Number of pods plant^{-1}, Pod length (cm), Number of grains pod^{-1} (No.), Test weight (g), Grain and straw yield were recorded. Soil were analyzed for available nitrogen and phosphorus at initiation of the experiment and after harvest of the black gram.

The data collected during the course of the experimentation were subjected to statistical analysis to drawn valid conclusion. Finally, the different treatments were analyzed for their gross return, net return and benefit: cost ratio. The important findings and broad conclusion emerging from the study are summarized here under:

CONCLUSION

1. Plant height of black gram under guava based agri-horticulture system was significantly increased at 20, 45 DAS with combined application of inorganic NPK (30:50:30 kg ha^{-1}) with vermicompost followed with same level of NPK with farm yard manure. This combination increased the plant height and up to its harvest. Minimum growth was observed under control treatment.

2. The maximum root nodules were recorded under combined inoculation of seed with *Rhizobium* culture along with NPK level (30:50:30 kg ha^{-1})

3. In alley cropping system, maximum dry weight accumulation was obtained Under combined application of inorganic NPK (30:50:30 kg ha^{1}) with vermicompost followed by the same level of NPK with farm yard manure.

4. Combined application of inorganic NPK (30:50:30) kg ha^{1} with vermicompost and also with farm yard manure showed significantly maximum number of primary and secondary branches plant^{-1}.

5. Highest number of trifoliate leaves of black gram were recorded in combined application of inorganic NPK (30:50:30 kg ha^{1}) with vermicompost and also in

combined application of NPK (30:50:30) kg ha^{1} with rhizobium culture. Lowest value recorded under control.

6. The number of pods per plant was also recorded high in combined application of inorganic NPK (30:50:30) kg ha^{1} with vermicompost.

7. The 1000-grains weight of green gram under guava based Agri-horticulture system was varied significantly and maximum weight was recorded with combined application of inorganic NPK (30:50:30 kg ha^{1}) with vermicompost in comparison with other treatments and control.

8. The Combined application of inorganic NPK (30:50:30 kg ha^{1}) with vermicompost and then farm yard manure with NPK level (30:50:30 kg ha^{1}) recorded significantly more grain and straw yield of black gram over other treatment combination i.e. Rs. (31363.15 kg per hectare). However, the harvest index was not significantly influenced due to treatment.

9. The available nitrogen, phosphorus, potassium in soil after the harvest of the crop was improved markedly under combined application of inorganic N, P, K (30:50:30 kg ha^{1}) with vermicompost.

10. The highest net return of Rs. Ha^{-1} was Rs. 56332.32 per hectare was recorded under combined application of inorganic N, P, K (30:50:30 kg ha^{1}) with vermicompost, and minimum Rs.45514.75 ha^{-1} under control.

11. The higher benefit: cost ratio 1.46 was observed with combined application of inorganic N, P, K (30:50:30 kg ha^{1}) with rhzobium as compared to control (1.37).

RECOMMENDATION

Based on the experimental findings, the combined application of inorganic N, P, K (30:50:30 kg ha^{1}) with vermicompost and same level of nutrients with farm yard manure showed best response in respect of grain yield and maximum B:C ratio with variety ku-300 of urad bean in red loamy soil of vindhyan region of Mirzapur district. Same level of nutrients N, P, K (30:50:30) Kg ha^{-1} with *Rhizobium* (MOR-1) also showed the marked effect on black gram. Over all from the all data calculated the response of organic manure with inorganic fertilizer showed great or enhancement in production of primary branches per plant, secondary branches per plant, trifoliate leaves per plant, root nodules per plant and also dry matter accumulation per plant, followed by application of biofertilizers with inorganic fertilizer. Separate application of organic and inorganic, also showed improved productivity of black gram. Thus, to maintain the sustainability and good soil health and fertility, organic should be encouraged and it will be profitable to the farmers residing under the Vindhyan region of Mirzapur.

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Appendix - I. Common cost of cultivation (Rs. ha^{-1})

S. No.	Operations	Input	Rate (Rs.)	Cost (Rs.)
1	Land preparation			
	(i) One deep ploughing by soil turning plough	One tractor (35 HP) for 2.5 hrs	300 ha^{-1}	750
	(ii) Harrowing and Planking	One tractor (35 HP) for 4 hrs	300 ha^{-1}	1200
2	Layout	4 labour day^{-1}	180 $labour^{-1}$	720
3	Seed sowing	8 labour day^{-1}	180 $labour^{-1}$	1440
4	Seed (cultivar: Ku-300)	15 kg ha^{-1}	160 kg^{-1}	2400
5	Thinning and weeding (Urdbean)	10 labour day^{-1}	180 $labour^{-1}$	1800
6	Weeding (Guava)	6 labour day^{-1}	180 $labour^{-1}$	1080
7	Harvesting and threshing	25 labour day^{-1}	180 $labour^{-1}$	4500
8	Harvesting of fruit(Guava)	20 labour day^{-1}	180 $labour^{-1}$	3600
9	Land revenue	For 6 months	140 $annum^{-1}$	70
10	Interest on working Capital	For 6 months	14% $annum^{-1}$	1229.2
Total				**18789.2**

Appendix II: Cost of Cultivation Treatment Wise

Treatment	Labour required (No.)	Labour cost 180 labour^{-1}	Fertilizer dose (kg ha^{1})			Amount of Organic Manure (kg ha^{-1})			Cost of fertilizer (Rs. ha^{-1})			Cost of Organic manure (Rs. ha^{-1})			Treatment cost (Rs. ha$^{-1)}$	Total cost$^{\#\#}$ (Rs. ha^{-1})
			Urea	DAP	MOP	*Rh.*	FYM	V.C.	Urea	DAP	MOP	Rhizobium	FYM	V.C.		18789.2
T_1	2	360	-	-	-	-	-	-	-	-	-	-	-	-	360	19149.2
T_2	2	360	-	-	-	-	6 tonne	-	-	-	-	-	4200	-	4560	23349.2
T_3	2	360	-	-	-	-	-	8 tonne	-	-	-	-	-	2200	2560	21349.2
T_4	2	360	-	-	-	300gm	-	-	-	-	-	15	-	-	375	19164.2
T_5	2	360	9.21	86.80	33.33	-	-	-	57.10	2152.64	589.27	-	-	-	2799.01	21588.21
T_6	2	360	9.21	86.80	33.33	-	6 tonne	-	57.10	2152.64	589.27	-	4200	-	6999.01	25788.21
T_7	2	360	9.21	86.80	33.33	-	-	8 tonne	57.10	2152.64	589.27	-	-	2200	4999.01	23788.21
T_8	2	360	9.21	86.80	33.33	300gm	-	-	57.10	2152.64	589.27	15	-	-	2814.01	21603.21
T_9	2	360	22.95	108.5	50.00	-	-	-	142.29	2690.80	884	-	-	-	3717.09	22506.29
T_{10}	2	360	22.95	108.5	50.00	-	6 tonne	-	142.29	2690.80	884	-	4200	-	7917.09	26706.29
T_{11}	2	360	22.95	108.5	50.00	-	-	8 tonne	142.29	2690.80	884	-	-	2200	5917.09	24706.29
T_{12}	2	360	22.95	108.5	50.00	300gm	-	-	142.29	2690.80	884	15	-	-	3732.09	22521.29

***T_1:No inorganic or organic fertilizer (control),T_2: Farmyard manure,T_3:Vermicompost, T_4:Rhizobium, T_5: N (20 kg ha^{-1}) + P2O5(40 kg ha^{-1}) + K2O (20 Kg ha^{-1}), T_6: N (20 kg ha^{-1}) + P2O5(40 kg ha^{-1}) + K2O (20 Kg ha^{-1}) + Farmyard Manure, T_7: N (20kg ha^{-1}) + P2O5(40 kg ha^{-1}) + K2O (20 Kg ha^{-1}) +Vermicompost, T_8: N (20kg ha^{-1}) + P2O5(40 kg ha^{-1}) + K2O (20 Kg ha^{-1}) +Rhizobium, T_9:N (30 kg ha^{-1}) + P2O5(50 kg ha^{-1}) + K2O (30 Kg ha^{-1}), T_{10}:N (30 kg ha^{-1}) + P2O5(50 kg ha^{-1}) + K2O (30 Kg ha^{-1}) + Farmyard Manure, T_{11}:N (30kg ha^{-1}) + P2O5(50 kg ha^{-1}) + K2O (30 Kg ha^{-1}) +Vermicompost, T_{12}:N (30kg ha^{-1}) + P2O5(50 kg ha^{-1}) + K2O (30 Kg ha^{-1}) +Rhizobium**

FYM - Farmyard manure, V.C. - Vermicompost, Rh. -Rhizobium

APPENDIX III: Yield Attributes Yield and Economic of Guava Tree

FRUIT TREES	NUMBER OF AVERAGE FRUIT PER TREES	AVERAGE WEIGHT OF FRUIT(g)	NUMBER OF FRUIT TREES (per hectare)	FRUIT YIELD (Kg per hectare)	RATE OF FRUIT (Rs. per kg)	GROSS INCOME FROM FRUIT TREE
GUAVA	55	67	204	751.74	30	22552