Effect of integrated application of bio-fertilizer and soil amendments on Growth parameters of Groundnut (*Arachis hypogaea* L.)

Abstract

The pot experiment entitled "Effect of integrated application of bio-fertilizer and soil amendments on Growth parameters of Groundnut (*Arachis hypogaea* L.)'' was conducted at the Research Farm of School of Agriculture, ITM University, during kharif season 2022. The soil of the experimental field was sandy loam, having a pH of 8.13, EC of 54 ds m^{-1}, organic carbon 0.40%, available N, P, K of 180, 11.09 and 283.40 kg ha^{-1} respectively and exchangeable Ca+Mg of 1.5 me 100 g^{-1}soil. The pot experiment was laid out in CRD (Completely Randomized Design) with six treatments and six replications. The treatment combinations were: T1- Control, T2- Recommended Dose of Fertilizer (N, P_2O_5 and K_2O @ 20, 40 and 20 kg ha^{-1} respectively), T3- FYM (10 t ha^{-1}), T4- Rhizobium (*Bradyrhizobium japonicum*) @ 200 gm 10 kg^{-1} seeds, T5- RDF + Rhizobium, T6- Rhizobium + FYM. The nodulation (number of nodules and nodule dry weight) was increased with the combined application of rhizobium inoculation and FYM over ~~the~~ time (30 and 60 DAS) followed by RDF and rhizobium inoculation. The growth attributes *viz.* plant biomass, shoot length,and root length, weresignificantly improved with the integration of bio-fertilizer, FYM and inorganic fertilizers. The highest result for plant biomass (22.34 gm $plant^{-1}$) and shoot length (21.78 cm) wasrecorded in rhizobium inoculation and FYM treatment combination, but root length (8.87 cm) was recorded highest in combinedapplication of RDF with rhizobium. Application of rhizobium with FYM (25.74 gm pot^{-1}) producesthe highest pod yield, followed by RDF and rhizobium (23.65 gm pot^{-1}) combination.

Keywords: FYM, Biofertilizer, Growth Parameter, Groundnut, Pot experiment

I. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important legume crop in India, and it's known by many other local names such as earthnuts, monkey nuts, goober peas, pygmy nuts, and pig nuts.

Worldwide, China ranks first with the production of 17.57 million tonnes followed by India with 6.73 million tonnes in Groundnut. India has the largest groundnut area (32% of the world). In India, the groundnut is grown mostly in rainfed dry lands, well-drained sandy soils in low (750 mm) and medium (750-1000 mm) annual rainfall areas. Inan agricultural economy like India, oilseeds are important next only to food grains in terms of area, production and value. The diverse agroecological conditions in the country are favourable for growing major oilseeds, including groundnut (Meena *et al.* 2014). Groundnut

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the premier oilseed in the country grown in area of 6 million ha. and production of about 7.5 million ton according to AICRP-Groundnut.

Peanut seeds make an important contribution to the diet in many countries. In general, groundnuts contain 50-55% fat, of which approximately 30% is linoleic acid and 45% is oleic acid, and these two fatty acids can account for up to 80% of the total fatty acids. Groundnuts with high oleic acid content have more self-life than normal groundnuts and thus improve the oxidative stability of peanut products (Isleib *et al.* 2006). The seed of groundnut contains44-56% oil and 22-30% protein content on a dry seed basis and is a rich source of minerals (phosphorus, potassium, calcium and magnesium) and vitamins (E, K and B group) (Savage and Keenan, 1994).

Groundnut is cultivated in both rainfed and irrigated conditions. The effectiveness of crop management techniques like irrigation, nitrogen application, and weed control, among others, is highly dependent on the land configuration (Saravanan *et al*. 2022), which affects crop production and productivity.

The increasing human population has led to fragmentation and intensive use of agriculturally prolific lands, leading to the exhaustion of available soil nutrients. Limited soil nitrogen has been pointed out as one of the restraining factors in production (Shamseldin*et al.,* 2012). Organic manure, bio-fertilizers, and inorganic nitrogen fertilizers are used to counter soil nitrogen limitation. However, smallholder farmers rarely have organic manure (Gichangi*et al.,* 2012). On the other hand, inorganic nitrogen fertilizers, which boost production, are costly and unaffordable to resource-poor smallholder farmers. In addition, the use of inorganic fertilizers has drawn several reactions, creating negative environmental effects, especially on soil biodiversity and aquatic ecosystems (Hester and Harrison, 2012; Mutuma *et al.,* 2014).

In modern agriculture, undoubtedly 'Green Revolution' takesa great place, but ~~it~~ allows more application of chemical fertilizers and pesticides to maximize the yield. The chemicals cause soil and animal health hazards by accumulating toxic chemicals. Biological nitrogen fixation has been widely used to replace nitrogenous fertilizers in legume crop production because of its economic efficiency in providing sustainable agroecosystem services (Ouma *et al.,* 2016). Rhizobia are the nitrogen-fixing bacteria that live in the soil either freely or form a symbiotic association with the roots of legumes (Martínez-Romero, 2003). Rhizobia are used as bio-fertilizers in legume crop production and have been reported to increase nitrogen availability through biological nitrogen fixation in different agroecosystems, hence improving plant growth and yields (Chabot *et al.,*1998). *Bradyrhizobium* spp. is an agronomically significant gram-negative bacterium that can form root nodules on groundnuts roots and fix atmospheric nitrogen (Isawa*et al*. 1999).

II. Material and Methods

A field experiment entitled "Effect of integrated application of bio-fertilizer and soil amendments on soil fertility parameters of Groundnut (*Arachis hypogaea* L.)''was conducted at the Research Farm of School of Agriculture, ITM University, during kharif season 2022. The details of materials used and procedures followed during the course of investigation are presented in this chapter.

3.1 Description of the experiment site

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Madhya Pradesh is primarily a state in central India and is known regionally as the "Central Region". ITM University Gwalior's College of School of Agriculture (M.P.). Gwalior district has a subtropical climate with warm summers from late March to early July, a wet monsoon climate from late June to early October, and a cold, dry winter from early November to late February. The maximum and lowest temperatures at the research site are 48 °C and 1 °C, respectively. Only approximately 90% of the total annual rainfall of 900 mm is obtained by the southwest monsoon from July to September, with the remainder falling throughout the winter.Mostof the time, the relative humidity is between 40 and 60%.

Gwalior district soils are Alluvial, with Entisols being the major soil order (USDA Taxonomy). Soils are primarily loamy sand in consistency, somewhat alkaline in response, low in organic carbon, and medium in N, P, and K content. Alkaline soils cover andover 79% of the geographical area.

Table 1. Physico-Chemical properties of the soil of the experimental site

Soil Property	Value
Electrical Conductivity (EC) (ds m^{-1})	54.0
pH (1:2.5)	8.13
Organic C (%)	0.40
Available N (kg ha^{-1})	180
Available phosphorus (kg ha^{-1})	11.09
Available potassium (kg ha^{-1})	283.4
Exchangeable Ca & Mg (meq 100^{-1} g soil)	1.5
Porosity (%)	49.1
Bulk density (mg m^{-3})	32.4
Sand (%)	67.8
Silt (%)	14
Clay (%)	18.2

2.1 Pot experiment for determination best nutrient source for Groundnut production

In the pot experiment, Groundnut (variety: TG-37A) was cultivated. The trial began in July of 2022. The soil was gathered from ITM farm and well mixed. The soil mixture was sieved using a 2 mm sieve. 36 plastic pots (each 30 cm in diameter) were set and each pot was topped with 6.0 kg of sieved soil. The soil was compressed so that the bulk density of the pottingsoil remained constant at 1.25 Mg m^{-3}. In these pots, 6 treatments were imposed,each with3 duplicated pots. The treatment combinations were: 1. Control, 2. RDF (N, P_2O_5 and K_2O @ 20, 40 and 20 kg/ha, respectively)3. FYM (10 ton/ha) 4. Rhizobium (*Bradyrhizobium japonicum*) @ 200 gm/10 kg seeds 5. RDF + Rhizobium 6. Rhizobium + FYM. In RDF, Urea (9.78 gm.), DAP (87 gm.) and MOP (33.3 gm.) were used as the nutrient sources for N, P_2O_5 and K_2O. The control treatment got no nutrient input, whereas FYM was used 26.5 gm.

2.2 Collection of experimental data

2.2.1Plant parameters in the pot experiment

Three pots of every treatment were used to take the root nodules parameters at 30 and 60 days after sowing (DAS), while the others were left to grow for maturity, and the other plant parameters were taken.One plant from each pot of the first three replications was used for 30 DAS, and the remaining were used at 60 DAS.

2.2.2 Shoot length (cm)

The shoot length of each treatment wasmeasured from ground level to the tip of the main stem at harvest. The average shoot length of the plants was computed and expressed in centimeters.

2.2.3 Root length (cm)

Plants of every treatment were uprooted carefully without damaging the root system and measured theroot length at harvest. The root length was measured from the collar region to the tip of the seedling's primary root and expressed in centimeters. The average length of two roots was computed and expressed in centimeters.

2.2.4 Plant biomass (gm plant^{-1})

Plants were carefully uprooted from each pot at harvest and their fresh weight was taken ~~by~~using electronic weighing balance and expressed in grams.

2.2.5 Number of nodules and dry weight of nodules (gm)

Plants of every treatment were uprooted carefully without damaging the root system at 30 and 60 DAS. Roots were washed with water to remove the adhered soil particles, and nodules were separated from the plant; numbers of nodules were recorded, and their dry weight was taken using electronic weighing balance and expressed in grams.

2.2.6 Number of pod pot^{-1}

Groundnut plants were carefully harvested from pots so that the pods did not get any harm, then washed with water and counted the pods of every pot.

2.2.7 Yield of pod (gm) pot^{-1}

The pods were dried in sun and pod weight was recorded which expressed as yield of pods in gm pot^{-1}.

III. Experimental Findings

3.1 Plant Biomass

~~In~~ Table 2 provides ~~the~~ information on the impact of Biofertilizer, FYM and inorganic fertilizers on the biomass of groundnut at the harvesting stage and is depicted graphically in Fig. 1. Data clearly showed that different treatments had a significant impact on the biomass of groundnut plants. The

highest plant biomass was recorded in the treatment combination of RHZ and FYM (22.34 gm plant^{-1}). However, this treatment is on per with the treatment combination of RDF and RHZ (21.41 gm plant^{-1}) and sole application of RDF (20.10 gm plant^{-1}). The lowest plant biomass has been recorded in the control (12.05 gm plant^{-1}).

Table 2. The information on the impact of Biofertilizer, FYM and inorganic fertilizers on the biomass of groundnut at harvesting stage

Treatments	Plant biomass (gm plant^{-1})	Shoot length (cm)	Root length (cm)
Control	12.05	14.54	3.43
RDF	20.10	18.59	7.75
FYM	17.69	17.49	5.93
RHZ	16.72	16.28	4.74
RDF + RHZ	21.41	20.26	8.87
RHZ + FYM	22.34	21.78	8.47
C.D.	2.956	2.686	1.174
SE(m)	0.949	0.862	0.377

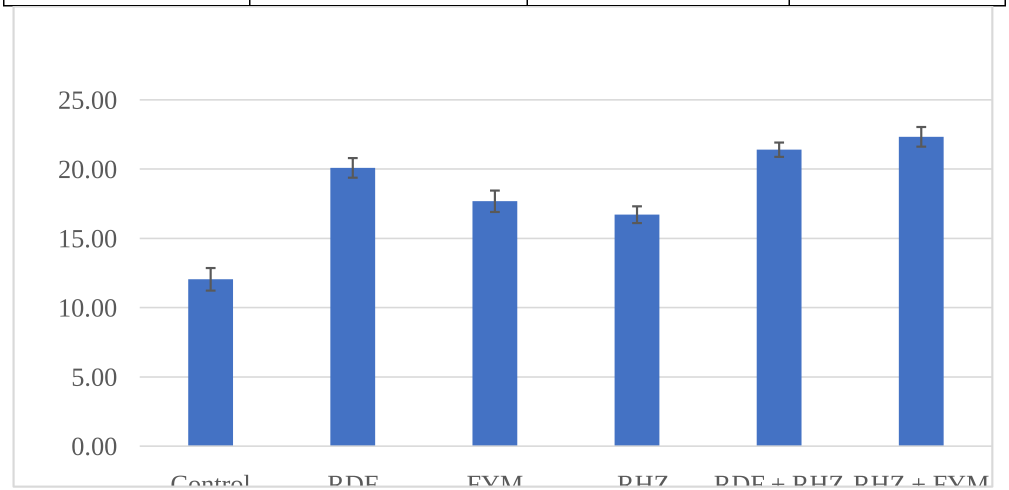

Fig 1: Effect of Bio-fertilizer, FYM and inorganic fertilizers on plant biomass

3.2 Shoot Length

The influence of different treatments on the shoot length is presented in table 3 and depicted graphically in Fig.2. From the statistically analysed data, significant differences existed across the treatments regarding shoot length.Seed inoculation with rhizobium with combination of FYM (21.78 cm) has significantly increased the shoot length over the sole application of RDF (7.75 cm), FYM (5.93 cm), RHZ (4.74 cm) and control (3.43 cm) except the RDF + RHZ treatment combination. This treatment found at per with RDF and seed inoculation with rhizobium (20.26 cm) treatment combination. Shoot length recorded lowest in the control (14.54 cm).

3.3 Root Length

The root length was greatly influenced over the cropping period by the treatments (Table 3) and depicted graphically in Fig. 3. It was discovered that combine application of RDF and RHZ (8.87 cm) statistically significant effect on the root length over the sole application of RDF (7.75 cm), FYM (5.93 cm), RHZ (4.74 cm) and control (3.43 cm) treatment. The effect of RHZ + FYM (8.47 cm) was significant over a single application of RHZ and FYM. It was also found that the RDF + RHZ treatment combination was statistically at per with the treatment combination of RHZ and FYM and sole application of RDF treatment.

Table 3 Effect of rhizobium and soil amendments on Plant biomass (g plant^{-1}), Shoot length(cm), Root length(cm)

Treatments	Plant biomass (gm plant^{-1})	Shoot length (cm)	Root length (cm)
Control	12.05	14.54	3.43
RDF	20.10	18.59	7.75
FYM	17.69	17.49	5.93
RHZ	16.72	16.28	4.74

RDF + RHZ	21.41	20.26	8.87
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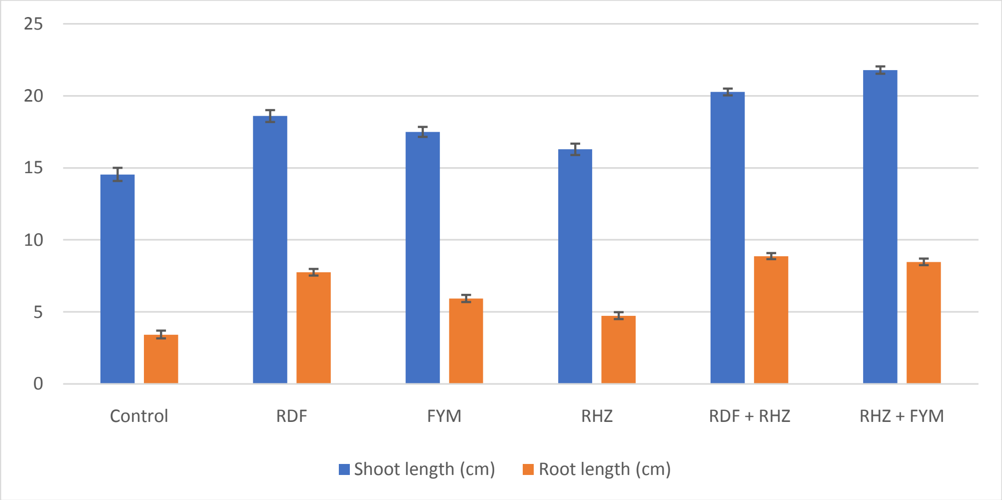

Fig 2: Effect of Bio-fertilizer, FYM and inorganic fertilizers on shoot and root length

3.4 Nodule Number Plant^{-1}

According to data, the root nodules plant^{-1}wereinfluenced significantly due to the application of various treatments during all the growth stages are presented in Table 4 and depicted graphically in Fig. 4. At 30 and 60 DAS data showed that the effect of combineduse of RHZ and FYM (17.30 and 23.60 for 30 and 60 DAS respectively) was found significant over the sole application of RHZ, FYM, RDF and the control treatment. It was also observed that RDF and RHZ (15.25 and 18.92 for 30 and 60 DAS, respectively) treatment combination significantly increased the nodule numbers over all the treatments but the RHZ and FYM treatment combination. Among all the treatments application, the combination of rhizobium inoculation and FYM has given higher root

nodulation followed by the RDF + RHZ treatment combination, the sole application of RHZ for both 30 and 60 DAS.

Table 4 Effect of rhizobium and soil amendments on Nodule numbers plant^{-1} and Nodule dry weight (gm) plant^{-1}

Treatments	Nodule numbers plant^{-1}		Nodule dry weight (gm plant^{-1})	
	30 DAS	60 DAS	30 DAS	60 DAS
Control	5.40	6.77	0.09	0.11
RDF	7.40	10.45	0.11	0.15
FYM	9.22	13.55	0.12	0.18
RHZ	12.57	16.03	0.14	0.20
RDF + RHZ	15.25	18.92	0.16	0.23
RHZ + FYM	17.30	23.60	0.19	0.29
C.D.	1.662	2.02	0.039	0.044
SE(m)	0.533	0.648	0.013	0.11

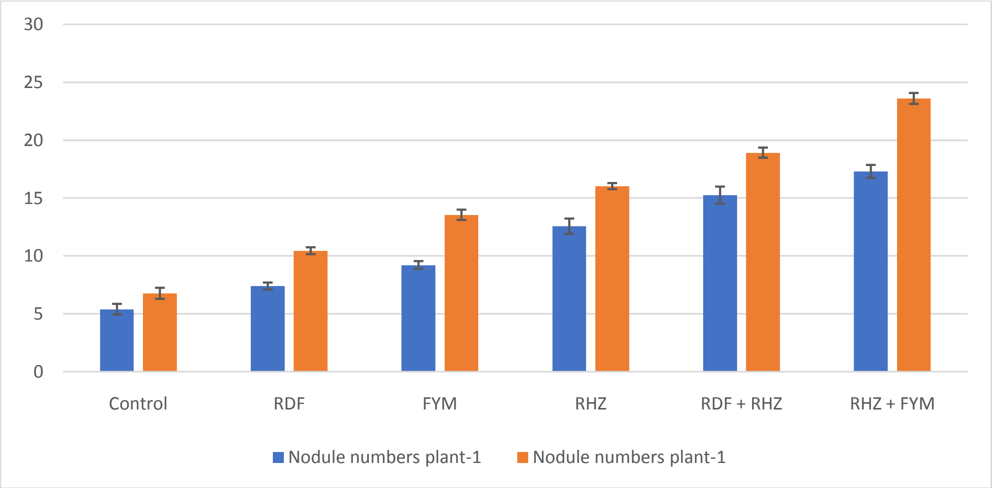

Fig 3: Effect of Bio-fertilizer, FYM and inorganic fertilizers on nodules number

3.5 Nodule Dry Weight Plant^{-1}

The dry weight of nodules plant^{-1} were affected by various treatments are presented in the table 5and depicted graphically in Fig. 4. The analysed data showed that different treatments significantly influenced the dry weight of nodules in plant^{-1} at 30 and 60 DAS. The findings clearly shown that combine effect of inoculation with rhizobium and FYM (0.29 gm ha^{-1}) significantly achieved the highest dry weight of nodules plant^{-1} above all other treatments at 60 DAS, but there is no significant differencebetween RHZ + FYM (0.19 gm ha^{-1}) and RDF + RHZ (0.16 gm ha^{-1}) at 30 DAS. Sole application of RHZ and FYM significantly increased the nodule dry weight ~~as~~ compared to the control.

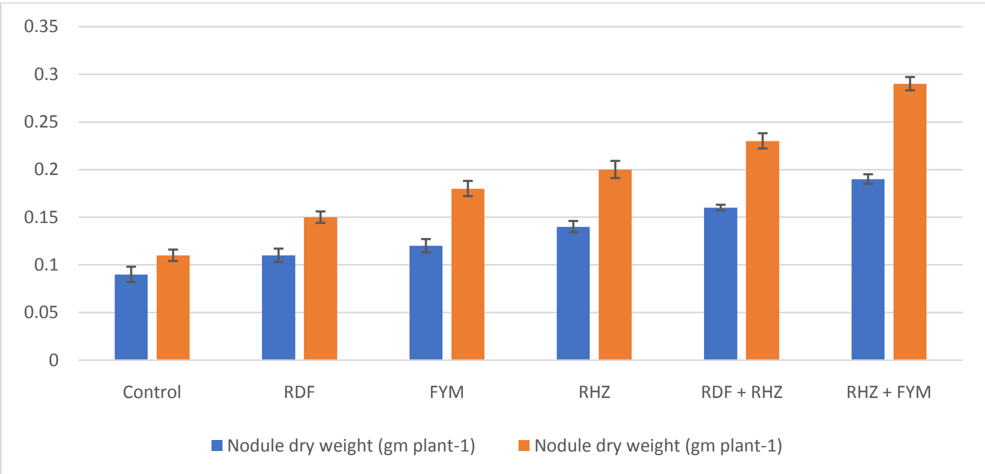

Fig 4: Effect of Bio-fertilizer, FYM and inorganic fertilizers on nodules of dry weight

3.6 Yield Attributes

3.6.1 No. of Pods Pot^{-1}

No. of pod pot^{-1} was significantly affected by the integrated application of different treatments; the results are shown in ~~the~~ table 5 and depicted graphically in Fig 4. The maximum pod number was noticedin the rhizobium inoculation and FYM treatment (21.76) combination,followed by RDF and rhizobium inoculation combination (18.22) treatment, while the minimum was recorded in the control (9.05) treatment.

Table 5Effect of rhizobium and soil amendments on No. of pod pot^{-1} and Yield of pods (gm)

Treatments	No. of pods pot^{-1}	Yield of pods (gm) pot^{-1}
Control	9.05	8.35
RDF	16.83	17.71
FYM	13.28	13.26
RHZ	12.32	11.77
RDF + RHZ	18.22	23.65
RHZ + FYM	21.76	25.74
C.D.	0.518	0.585
SE(m)	0.166	0.188

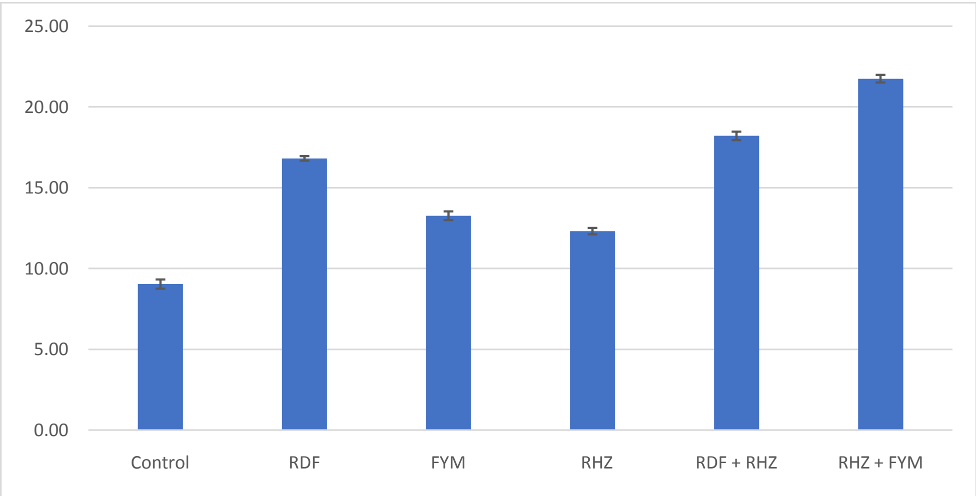

Fig 5: Effect of Bio-fertilizer, FYM and inorganic fertilizers on no. of pods

3.6.2 Yield of Pod Pot^{-1}

Information about the effect of application of rhizobium inoculation, FYM and inorganic fertilizers on pod weight pot^{-1} in groundnut are represented in the table 5 and depicted graphically in Fig. 5. Data indicated that weight of

pods pot^{-1}under various treatments varied greatly from one another. Data clearly showed that seed inoculation with rhizobium and FYM combination (25.74 gm) had significantly increasing the pod weight plant-1than all other treatments. Combine application of RDF and RHZ (23.65 gm) was also increased the pod yield per pot in comparison to sole application of RHZ (11.77 gm), FYM (13.26 gm) and RDF (17.71 gm). The lowest pod yield was observed in the control (8.35 gm) treatment.

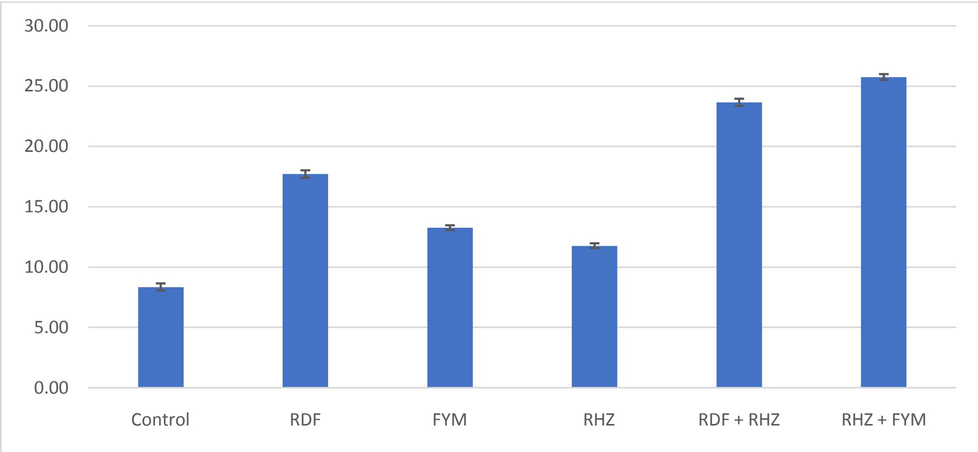

Fig 6: Effect of Bio-fertilizer, FYM and inorganic fertilizers on pod yield

V. DISCUSSION

The results of the current study, "Effect of integrated application of bio-fertilizer and soil amendments on soil fertility parameters of Groundnut (*Arachis hypogaea* L.)''have been discussed in the previous chapter regarding soil chemical properties, growth parameters and yield. This chapter aims to evaluate the findings in the context of cause-and-effect relationships critically. While discussing the outcomes of the current analysis, the conclusions of prior researchers on the subject have also been taken into account.

An important leguminous food crop, groundnut has a lot of high-quality protein and unsaturated fatty acids. Groundnut is an essential leguminous food crop with high-quality protein and unsaturated fatty acids. The environment in which crops are cultivated directly or indirectly impacts the soil properties, growth, and seed yield. Additionally, genotypes, fertilizer management, soil, cultural practices, and their interactions significantly impact crop output.

Plant biomass and Shoot length:

Data showed that plant growth parameters weresignificantly affected by the different treatments. The plant biomass data was in the range of 12.05 to 22.34 gm plant^{-1}. The highest plant biomass was recorded in a combination of seed inoculation with rhizobium and FYM;however, it was at per with RDF with a combination of rhizobium and sole application of RDF treatment. While the lowest biomass was observed in the control treatment. More biomass increase recorded might be due to more availability of soil nitrogen and soil organic carbon. More soil nutrient availability fulfilled the plant's nutrient demand and improved the plant biomass.

Shoot length was recorded as highest under the influence of rhizobium seed inoculated FYM treatment combination, which was at per with RDF with rhizobium inoculated treatment combination, while the lowest plant height was observed in control. According to Pandey *et al.* (2015),supplying nutrients through the combination of FYM and seed inoculation of biofertilizers performed better than using an inorganic or organic source alone. This may be because integrated nutrient management treatments balance the availability of nutrients and moisture throughout the growth period. According to Satpute*et al.* (2020) the increase in plant height with higher levels of nitrogen and phosphorus application resulted from enhanced activities of the plant's meristematic tissues, an increase in thethe number and size of the cell and the efficient utilization of nutrients uptake. Plant height significantly increased by FYM and rhizobium inoculation (Qureshi*et al.,* 2015). The combined application of FYM, RDF and seed inoculation of biofertilizers improvesall growth and yield components and it could be ascribed tothe extended period of available moisture and nutrients and hence improved photosynthetic activity (Sharma *et al.,* 2012).

5.2.2 Root length:

Different treatments were significantly increased the root length of groundnut. Root length data coming in the range of 3.43 to 8.87 cm. Maximum root length was observed in combination of RDF and seed inoculation with rhizobium and it was on per with rhizobium and FYM treatment combination while, the minimum root length was observed in control treatment. Fertilizers provide essential nutrient like nitrogen, phosphorus and potassium in available form. Phosphorus is an important nutrient for root development and rhizobium fixed the nitrogen from atmosphere which is a critical element for plant growth. NPK levels with bio-inoculants fulfil the demand of nutrient due to the reasons the more root development was observed. FYM is rich in organic carbon and source of all plant nutrients and having synergistic effect on microbes that helps to mineralized the organic matter and release the nutrients quickly. Combine application of RDF with rhizobium and rhizobium with FYM proved significantly superior to sole application and over control. Pal *et al.* (2016) also reported the similar result. Qureshi*et al.* (2015) reported that root length was significantly increased with FYM and rhizobium inoculation over control.

5.3 Root nodulation

Number of root nodules plant^{-1} were significantly improved by rhizobium, FYM and NPK fertilizers. Nodules plant^{-1} recorded maximum in rhizobium inoculation with FYM followed by RDF and rhizobium inoculation and sole application of rhizobium at both 30 and 60 DAS. The increase in nodule number mainly dure to rhizobium inoculation which is a host specific bacterium. On the other side FYM is a rich source of organic matter content and organic carbon this might be increased the microbial activity as well as soil enzymatic activity thus increased the nutrient availability ultimately it results in more nodule formation. Results for nodule dry weight lying in the range of 0.09 to 0.19 gm at 30 DAS and 0.11 to 0.29 gm at 60 DAS. The highest result at 60 DAS was recorded in the rhizobium seed inoculation with FYM treatment while at the 30 DAS there was no significant difference between RHZ + FYM and RDF + RHZ treatment in contrast of nodule dry weight. The nodule dry weight increased due to a greater number of nodules recorded in that treatment. Significantly increased in nodule number by *Bradyrhizobium* inoculation as compared to the uninoculated plants but the reduction of nodule number was found due to inorganic application Argaw (2018). In contrast, Konthoujam*et al.* (2013) and Pal *et al*. (2016) reported the similar results in root nodulation improvement with biofertilizer and organic source application.

IV Conclusion

Rhizobium, FYM and fertilizers significantly influenced the no. of pods pot^{-1} and pod yield pot^{-1} in groundnut. Data of the no. of pod and pod yield were coming in the range of 9.05 to 21.76 and 8.35 to 25.74 gm respectively and among all the treatments the highest pod yield (no. of pod as well as pod weight) was recorded in rhizobium inoculated with FYM applied pot. The application of organic manure and biofertilizer together lead the soil organic matter, organic carbon, soil microbial activity and supply balance nutrient might be due to the reasons the yield of groundnut increased. Akbari*et al.* (2011) reported that bio-fertilizer with organic manure enhanced the yield of groundnut. The symbiotic association between rhizobium (bacteria) and the roots of leguminous crops, which fixes the atmospheric nitrogen into the roots of groundnut, may be the cause of the maximum number of pods leads to higher yield in inoculated plants (Sajid *et al.,* 2011).

Plant biomass 22.34 gm plant^{-1}) and shoot length (21.78 cm) were recorded highest in rhizobium seed inoculation and FYM application and also gave batter result as comparison to sole application of rhizobium and FYM. For plant biomass it was at per with RDF with rhizobium treatment combination and single application of RDF. In case of shoot length rhizobium with FYM was at per with RDF + rhizobium treatment. Different nutrient application along with rhizobium significantly improved the root length of groundnut. The highest result was obtained in RDF with rhizobium inoculation (8.87 cm) it was also at per with combine application of rhizobium and FYM and sole application of RDF. The sole application of rhizobium and FYM also significantly increased the root length. Nodulation (nodules number and nodule dry weight) were significantly improved by different fertilizers application. In the treatment combination of rhizobium inoculation and FYM maximum nodule number plant^{-1}(17.30 and 23.60 at 30 and 60 DAS respectively) and nodule dry weight

plant^{-1} (0.19 and 0.29 gm at 30 and 60 DAS respectively) was recorded, while the minimum was recorded for both the parameters in control having no application of fertilizer. Pod yield was significantly influenced with different nutrient fertilizers application. Highest pod yield was recorded in rhizobium inoculation with FYM treatment (25.74 gm) combination followed by combine application od RDF with rhizobium inoculation (23.65 gm) while the lowest was recorded in control.

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