



Effect of Integrated Application of Bio-Fertilizer and Soil Amendments on Growth Parameters of Groundnut (*Arachis hypogaea* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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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 0.54 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⁻¹soil. 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, P₂O₅ and K₂O @ 20, 40 and 20 kg ha⁻¹ respectively), T3- FYM (10 t ha⁻¹), T4- Rhizobium

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(*Bradyrhizobium japonicum*) @ 200 gm 10 kg⁻¹ seeds, T5- RDF + Rhizobium, T6- Rhizobium + FYM. The nodulation (number of nodules and nodules dry weight) was increased with combine 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, root length was significantly 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) were recorded in rhizobium inoculation and FYM treatment combination but root length (8.87 cm) was recorded highest in combine application of RDF with rhizobium. Application of rhizobium with FYM (25.74 gm pot⁻¹) produce the highest pod yield followed by RDF and rhizobium (23.65 gm pot⁻¹) combination. The combination of RHZ + FYM has much more favorable results on growth and yield of groundnut and it also enhance the nodulation.

Keywords: FYM; biofertilizer; growth parameter; groundnut; pot experiment.

1. 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.

World-wide, China ranks first with the production of 17.57 million tonnes followed by India 6.73 million tonnes in Groundnut. Presently, 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. As agricultural economy like India, oilseeds are important next only to food grains in terms of area, production and value. The diverse agro-ecological conditions in the country are favourable for growing major oilseeds, in which groundnut is also included [1]. Groundnut 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 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 having high oleic acid content have more self-life rather than normal groundnuts and thus improve the oxidative stability of peanut products [2]. The seed of groundnut contain 44-56% 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) [3].

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 [4] which effects crop production and productivity.

The increasing human population has led to fragmentation and intensive use of agriculturally prolific lands, leading to exhaustion of available soil nutrients. Limited soil nitrogen has been pointed out as one of the restraining factors in production [5]. To counter soil nitrogen limitation, organic manure, bio-fertilizers and inorganic nitrogen fertilizers are used. However, organic manure is rarely available for smallholder farmers [6]. On the other hand, inorganic nitrogen fertilizers, which boost production, are costly and unaffordable to the resource poor smallholder farmers. In addition, use of inorganic fertilizers has drawn a number of reactions which creates negative environmental effects especially on soil biodiversity and aquatic ecosystems [7,8].

In modern agriculture, undoubtedly 'Green Revolution' take a great place but it allows more application of chemical fertilizers and pesticides to maximize the yield. The chemicals cause health hazards of soil and animals by accumulation of toxic chemicals. Biological nitrogen fixation has been widely used as a replacement of nitrogenous fertilizers in legume crop production because of its economic efficiency in the provision of sustainable agroecosystem services [9]. Rhizobia are the nitrogen-fixing bacteria that live in the soil either freely or form a symbiotic association with the roots of legumes [10]. Rhizobia are used as bio-fertilizers in legume crop production and reported to increase the availability of nitrogen through biological nitrogen fixation in different agroecosystems, hence improving plant growth and yields [11]. *Bradyrhizobium* spp. is an agronomically significant gram-negative bacterium with the ability of forming root nodules on groundnuts roots and fixing atmospheric nitrogen (Isawa et al. 1999).

2. MATERIALS 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.

2.1 Description of the Experiment Site

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 having warm summers from late March to early July, a wet monsoon climate from late June to early October, as well as 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. During the majority of 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 and over 79% of the geographical area.

2.2 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 pot soil remained constant. In these pots, 6 treatments were imposed, with each treatment having 6 duplicated pots. The treatment combinations were: 1. Control, 2. RDF (N, P₂O₅ and K₂O @ 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, P₂O₅ and K₂O. The control treatment got no nutrient input, whereas FYM was used 26.5 gm.

2.3 Collection of Experimental Data

2.3.1 Plant parameters in the pot experiment

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

2.3.2 Shoot length (cm)

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

2.3.3 Root length (cm)

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

2.3.4 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.

2.3.5 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 and numbers of nodules were recorded and their dry weight was taken by using electronic weighing balance and expressed in grams.

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

Soil Property	Value
Electrical Conductivity (EC) (ds m ⁻¹)	0.54
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 (me 100 ⁻¹ g soil)	1.5
Porosity (%)	49.1
Bulk density (gm cm ⁻³)	1.29
Sand (%)	67.8
Silt (%)	14
Clay (%)	18.2

2.3.6 Number of pod pot⁻¹

Groundnut plants were harvested from pots very carefully that pods did not get any harm then wash it with water and count the pods of every pot.

2.3.7 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.

3. RESULTS

3.1 Plant Biomass

In Table 2 provides the information on the impact of Biofertilizer, FYM and inorganic fertilizers on the biomass production of groundnut at harvesting stage and depicted graphically in Fig. 1. Data clearly showed that different treatments had a significant impact on the biomass of groundnut plant. The highest plant biomass was recorded in the treatment combination of RHZ and FYM (22.34 gm plant⁻¹). However, this treatment is on par 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).

3.2 Shoot Length

Influence of different treatments on the shoot length are presented in table 3 and depicted graphically in Fig. 2. From the statistically analysed data it is clear that significant differences existed across the treatments in terms of 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 (18.59 cm), FYM (17.49 cm), RHZ (16.28 cm) and control (14.54 cm) except the RDF + RHZ treatment combination. This treatment found at par with RDF and seed inoculation with rhizobium (20.26 cm) treatment combination.

3.3 Root Length

The root length was greatly influenced over the cropping period by the treatments (Table 3) and depicted graphically in Fig. 2. It was discovered that combine application of RDF and RHZ (8.87 cm) statistically significant effect on the root

Table 2. Effect of Biofertilizer, FYM and inorganic fertilizers on the biomass (gm plant⁻¹), shoot and root length (cm) of groundnut

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
CD (P=0.05)	2.956	2.686	1.174
SE±(m)	0.949	0.862	0.377

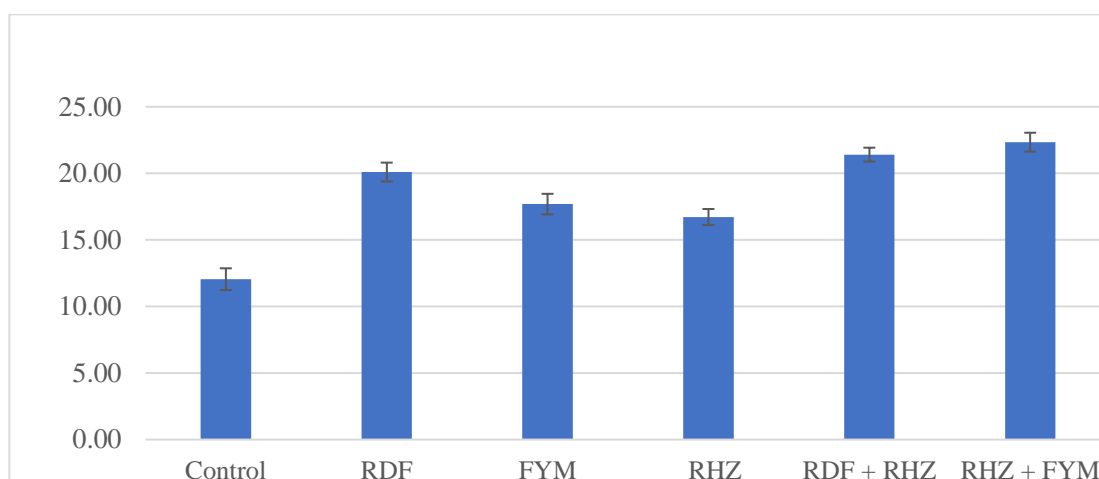


Fig. 1. Effect of Bio-fertilizer, FYM and inorganic fertilizers on plant biomass

length over the sole application of RDF (7.75 cm), FYM (5.93 cm), RHZ (4.74 cm) and control (3.43 cm) treatment. Effect of RHZ + FYM (8.47 cm) was found significant over single application of RHZ and FYM. It was also found that RDF + RHZ treatment combination statistically at par with the treatment combination of RHZ and FYM and sole application of RDF treatment.

3.4 Number of Nodules Plant⁻¹

According to data the root nodules plant⁻¹ was influenced significantly due to application of various treatments during all the growth stages are presented in Table 3 and depicted graphically in Fig. 3. At 30 and 60 DAS data showed that effect of combine use 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 nodules number 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 RDF + RHZ treatment combination and sole application of RHZ for both 30 and 60 DAS.

3.5 Nodules Dry Weight Plant⁻¹

The dry weight of nodules plant⁻¹ were affected by various treatments are presented in the Table 3 and 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 different between 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 nodules dry weight as compared to control.

Table 3. Effect of Bio-fertilizer, FYM and inorganic fertilizers on number of nodules plant⁻¹ and nodules dry weight (gm) plant⁻¹

Treatments	Number of Nodules plant ⁻¹		Nodules 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
CD (P=0.05)	1.662	2.02	0.039	0.044
SE±(m)	0.533	0.648	0.013	0.014

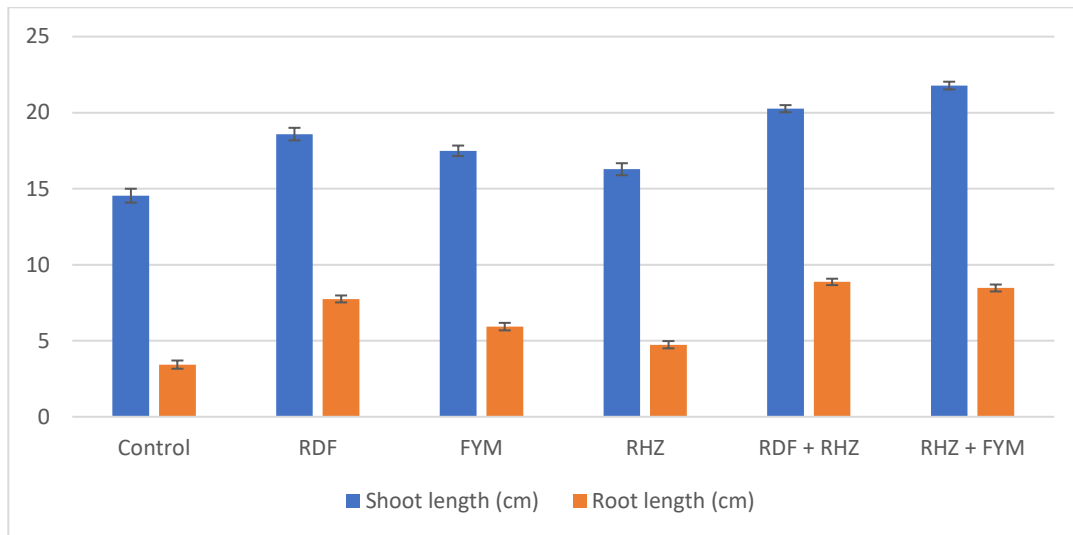


Fig. 2. Effect of Bio-fertilizer, FYM and inorganic fertilizers on shoot and root length

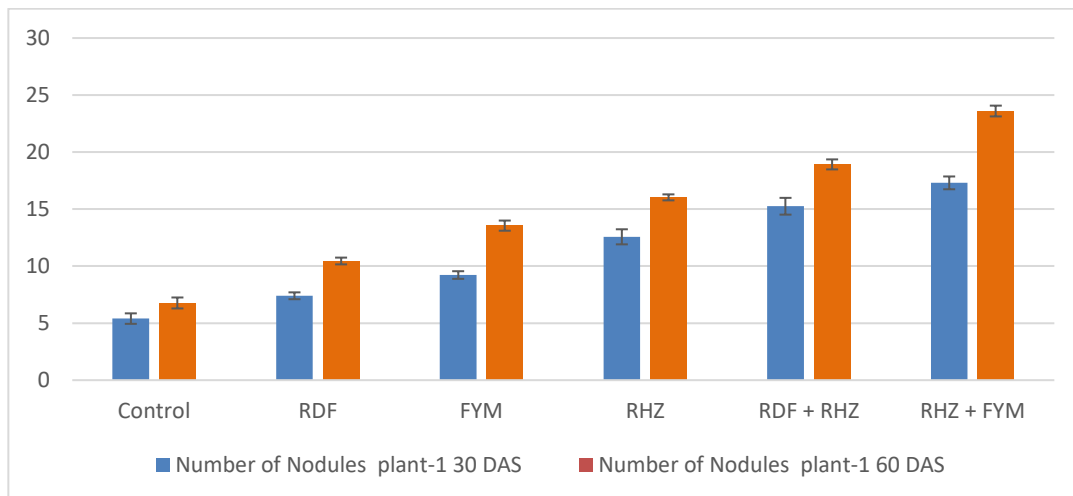


Fig. 3. Effect of Bio-fertilizer, FYM and inorganic fertilizers on number of nodules Plant⁻¹

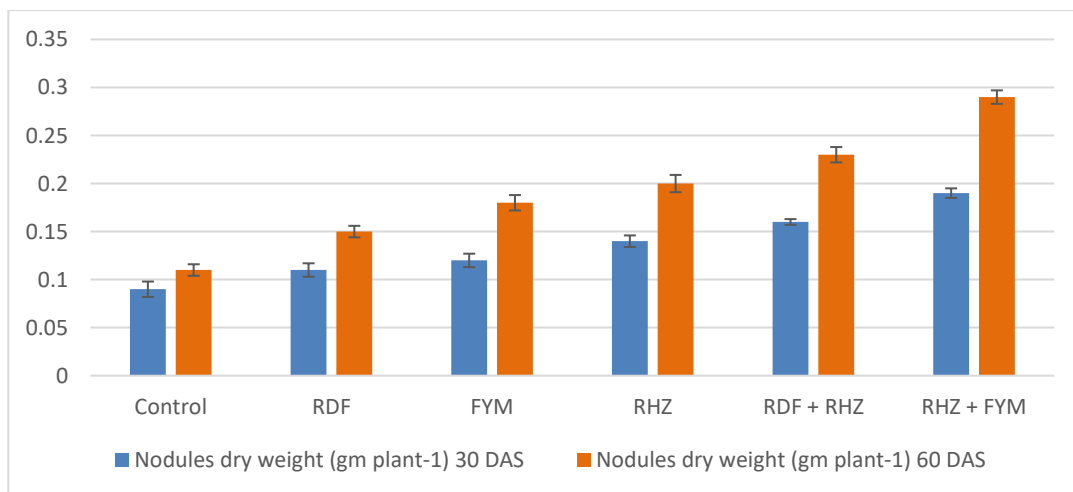


Fig. 4. Effect of Bio-fertilizer, FYM and inorganic fertilizers on nodules dry weight Plant⁻¹

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 were shown in the Table 4 and depicted graphically in Fig. 5. The maximum pod number was notice in rhizobium inoculation and FYM treatment (21.76) combination followed by RDF and rhizobium inoculation combination (18.22) treatment while the minimum was recorded in control (9.05) treatment.

3.6.2 Yield of pod pot⁻¹

Information about the effect of application of rhizobium inoculation, FYM and inorganic fertilizers on pod yield pot⁻¹ in groundnut are represented in the Table 4 and depicted graphically in Fig. 6. 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 yield plant⁻¹ than all other treatments. Combine application of RDF and RHZ (23.65 gm) was also increased the pod

yield pot⁻¹ in comparison to sole application of RDF (17.71 gm), FYM (13.26 gm) and RHZ (11.77 gm). The lowest pod yield was observed in the control (8.35 gm) treatment.

4. DISCUSSION

The results of the current study revealed that chemical and physical parameter was affected by the using treatment. This chapter aims to critically evaluate the findings in the context of cause-and-effect relationships. 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. An essential leguminous food crop, groundnut has a lot of high-quality protein and unsaturated fatty acids. The environment in which crops are cultivated has a direct or indirect impact on the soil properties, growth and seed yield. Additionally, genotypes, fertilizer management, soil, cultural practices, and their interactions all have a significant impact on crop output.

Table 4. Effect 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
CD (P=0.05)	0.518	0.585
SE±(m)	0.166	0.188

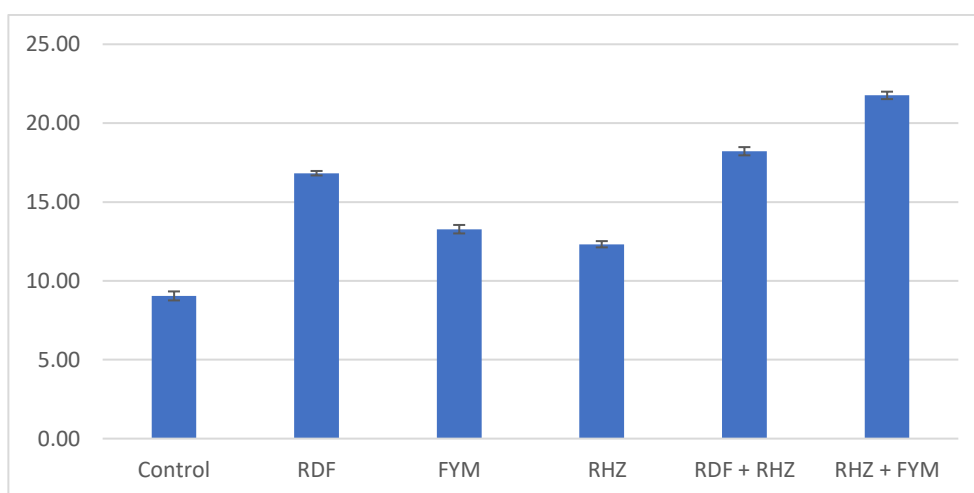


Fig. 5. Effect of Bio-fertilizer, FYM and inorganic fertilizers on number of pods pot⁻¹

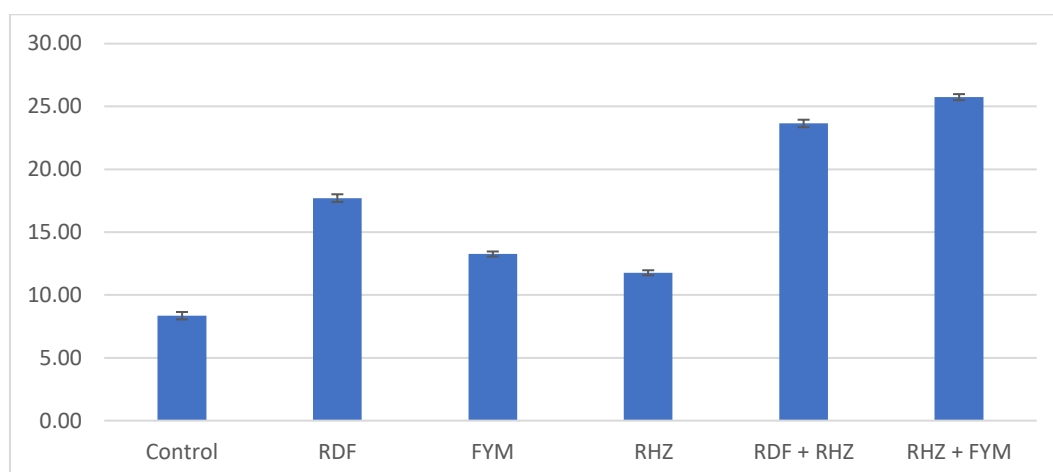


Fig. 6. Effect of Bio-fertilizer, FYM and inorganic fertilizers on pod yield pot⁻¹

4.1 Plant Biomass and Shoot Length

Data showed that plant growth parameters was significantly affected by the different treatments. The data of the plant biomass was in the range of 12.05 to 22.34 gm plant⁻¹. The highest plant biomass was recorded in combination of seed inoculation with rhizobium and FYM however, it was at par with RDF with combination of rhizobium and sole application of RDF treatment. While, the lowest biomass was observed in 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 nutrient demand of plant and improve the plant biomass. For shoot length recorded highest under the influence of rhizobium seed inoculated FYM treatment combination which was at par with RDF with rhizobium inoculated treatment combination while, lowest plant height was observed in control. According to Pandey *et al.* [12] 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 over the course of the growth period. According to Satpute *et al.* [13] the increase in plant height with higher level of nitrogen and phosphorus application was result of enhanced activities of meristematic tissues of the plant, increase in number and size of the cell and the efficient utilization of nutrients uptake. Plant height significantly increased by FYM and rhizobium inoculation [14]. The combined application of FYM, RDF and seed inoculation of biofertilizers improve all growth and yield components and it

could be ascribed as the extended period of available moisture and nutrients and hence improved photosynthetic activity [15].

4.2 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 par 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.* [16] also reported the similar result. Qureshi *et al.* [14] reported that root length was significantly increased with FYM and rhizobium inoculation over control.

4.3 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 nodules number mainly due 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 nodules 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 nodules dry weight. The nodules dry weight increased due to a greater number of nodules recorded in that treatment. Significantly increased in nodules number by *Bradyrhizobium* inoculation as compared to the uninoculated plants but the reduction of nodules number was found due to inorganic application Argaw [17]. In contrast, Konthoujam et al. [18] and Pal et al. [16] reported the similar results in root nodulation improvement with biofertilizer and organic source application.

5. 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. [19] 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 [20].

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 better result as comparison to sole application of rhizobium and FYM. For plant biomass it was at par with RDF with rhizobium

treatment combination and single application of RDF. In case of shoot length rhizobium with FYM was at par 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 par 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 nodules dry weight) were significantly improved by different treatments application. In the treatment combination of rhizobium inoculation and FYM maximum number of nodules plant⁻¹ (17.30 and 23.60 at 30 and 60 DAS respectively) and nodules 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 source application. Highest pod yield was recorded in rhizobium inoculation with FYM treatment (25.74 gm) combination followed by combine application of RDF with rhizobium inoculation (23.65 gm) while the lowest was recorded in control.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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