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AV Satpute
PG Student, Division of Agronomy, RCSM College of Agriculture, Kolhapur, Maharashtra, India

TS Shinde
PG Student, Division of Soil Science and Aril. Chemistry, RCSM College of Agriculture, Kolhapur, Maharashtra, India

SM Shende
PG Student, Division of Agronomy, RCSM College of Agriculture, Kolhapur, Maharashtra, India

Corresponding Author:
AV Satpute
PG Student, Division of Agronomy, RCSM College of Agriculture, Kolhapur, Maharashtra, India

Effect of inorganic and bio-fertilizers on growth of summer groundnut (*Arachis hypogaea* L.)

AV Satpute, TS Shinde and SM Shende

Abstract
A field experiment entitled, "Effect of inorganic and bio-fertilizers on growth, yield and quality of summer groundnut (*Arachis hypogaea* L.)" was conducted at PG Research Farm, Agronomy Section, RCSM College of Agriculture, Kolhapur during summer, 2019. The experiment was laid out in factorial randomized block design (FRBD) with three replications and nine treatment combinations of three inorganic fertilizer levels F_1- 75% of RDF (18.75:37.5:0 kg ha^{-1}), F_2- 100% of RDF (25:50:0 kg ha^{-1}), F_3- 125% of RDF (31.25:62.5:0 kg ha^{-1}) and three bio-fertilizers levels B_1- Control, B_2-*Rhizobium* spp.+ PSB (Lignite based), B_3- *Rhizobium* spp.+ PSB (Liquid based). The application of 100% of RDF ha^{-1} was comparable with 125% of RDF ha^{-1} significantly over 75% RDF ha^{-1} in respect of recording higher value of the growth attributes *viz*., plant height (cm), number of branches $plant^{-1}$, plant spread $plant^{-1}$ (cm), dry matter $plant^{-1}$ (g), number of nodule $plant^{-1}$ and weight of nodule $plant^{-1}$ (g). The dual seed inoculation of *Rhizobium* spp. + PSB (Lignite based) as well as *Rhizobium* spp. + PSB (Liquid based)in respect of recording higher value of growth attributes *viz*., mean plant height (cm), plant spread (cm), number of branches, dry matter $plant^{-1}$ (g), number of nodule $plant^{-1}$ and weight of nodule $plant^{-1}$ (g).

Keywords: Inorganic fertilizer levels, bio-fertilizer levels, growth characters

Introduction
Groundnut (*Arachis hypogaea* L.) belongs to family leguminosae and sub family Papilionaceae. The groundnut is valuable food and oilseed crop and commonly called as the king of vegetable oilseed crops or poor man's nut. The groundnut is native of South American leguminous oil seed. They are rich in protein (21.43 per cent), carbohydrates (6-24.9 per cent) and minerals and vitamins *viz.*, A, B, E and some members of B_2 group except B_{12} (Das, 1997) [4]. Their calorific value is 349 per 100 grams. India is one of the major producers as well as consumer of groundnut in the world with (69.70 lakh tonnes) after China (166.24 lakh tonnes). During 2018-2019 groundnut was sown in around 27.84 million hectares and production was 46.75 million metric tonnes in world. The groundnut crop gives three times higher yield than that of *kharif* season because productivity in summer season due to availability of adequate sunshine, warm temperature and availability of timely irrigation during the different growth stages of crop and restricted incidence of pest and diseases. Along with inorganic fertilizers use of organic fertilizers like bio-fertilizers will also help for improving fertility level of soil. It has been revealed that the use of *Rhizobium* to groundnut crop was found to reduce the requirement of nitrogen fertilizers. The *Rhizobium* inoculants help to meet the additional N demand of plant. The phosphobacterium, a Phosphate Solubilizing Bacteria, which is able to convert the phosphate present in soil from unavailable form to available to the plant. It has indirect effect on nodulation which contribute to increase in yield (Gosh and Poi, 1998) [7]. The application of liquid bio-fertilizers on legumes crops before sowing plus 20 kg N per hectare enhanced the nodule numbers, fresh weight, dry weight of nodule, yield components and grain yield in comparison to conventional farmer's fertilizer level. The crops build up the soil fertility by fixing large amounts of atmospheric nitrogen through the root nodule and also through leaf fall on the groundnut at maturity (Tran *et al.*, 2007) [17]. Several studies had proved that sustainability of higher yield of groundnut could be achieved through conjunctive use of plant nutrients combining inorganic and bio-fertilizers. It also reduces the cost of cultivation and bio-fertilizers increases the fertilizer use efficiency of plant. Hence, inorganic fertilizers have to be used in combination with bio-fertilizers.

Materials and methods
The experiment was laid out in factorial randomized block design (FRBD) with three replications and nine treatment combinations of three inorganic fertilizers levels (F_1-75% of RDF

(18.75:37.5:0 kg ha^{-1}), F_2-100% of RDF (25:50:0 kg ha^{-1}), F_3-125% of RDF (31.25:62.5:0 kg ha^{-1}) and three bio-fertilizers levels (B_1-Control, B_2-*Rhizobium* spp.+ PSB (Lignite based), B_3- *Rhizobium* spp.+ PSB (Liquid based). The gross and net plot size were 5.4 m x 4.8 m and 4.8 m x 3.6 m, respectively.

The soil of the experimental plot was sandy loam in texture, low in available nitrogen (231.24 kg ha^{-1}), moderately high in available phosphorus (24.25 kg ha^{-1}) and moderately high in available potassium (243.16 kg ha^{-1}). The soil was slightly alkaline in reaction (pH 8.23).

The crop, groundnut with variety JL-1085 (Phule Dhani) was sown on 15th of February, 2019 by dibbling method with different inorganic and biofertilizer levels. The crop was fertilized as per treatments by using urea and single super phosphate was given by placement method. In general, the summer season was good for crop growth and development. The experimental data was statistically analyzed by using a standard method of "analysis of variance" as reported by Panse and Sukhatme (1967) [10].

Result and discussion

I) Effect on plant height (cm) of groundnut

A. Effect of inorganic fertilizer levels

Application of 125% RDF recorded significantly higher plant height of groundnut over 75% RDF. However, it was on par with 100% RDF. 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. The similar result was also recorded by Bhalerao *et al.*, (1993) [1] and Saradhi *et al.*, (1990) [15].

B. Effect of bio-fertilizer levels

The dual seed inoculation with *Rhizobium* spp. + PSB (Lignite based) cultures recorded significantly superior over control in case of plant height. However, it was on par with dual seed inoculation with *Rhizobium* spp. + PSB (Liquid based). The phosphorus solubilizing microorganism increase the availability of phosphorus, where as *Rhizobium* spp. also enhances the supply of nitrogen. Therefore combination of both might have increased vegetative growth. This result was inconformity with those More *et al.*, (2002) [9] and Tomar *et al.*, (1994) [16].

C. Effect of interaction

The interaction effect between in organic fertilizer and bio-fertilizers were found to be non-significant in respect of mean plant height of groundnut.

II) Effect on plant spread (cm)

A. Effect of inorganic fertilizer levels

The application of 125% RDF recorded significantly superior plant spread per plant of groundnut over 75% RDF. However, it was on par with 100% RDF. The increase in vegetative growth of plant due to higher inorganic fertilizers might have increased nutrient uptake, resulting into increase plant spread. These results are in conformity with the findings of Bhosale and Pisal (2015) [2] and Waghmode *et al.*, (2017) [19].

B. Effect of bio-fertilizer levels

The dual seed inoculation with *Rhizobium* spp. + PSB (Lignite based) cultures recorded significantly the higher plant spread over control. However, it was on par with dual seed inoculation with *Rhizobium* spp. + PSB (Liquid based). The *Rhizobium* culture along with PSB might have increased the growth attributing characters of plant including plant spread. These results are almost similar with the reports of Panwar and Singh (2003) [11] and Zaltae and Padmani (2009) [20].

C. Effect of interaction

The interaction effect between in organic fertilizer and bio-fertilizers were found to be non-significant in respect of mean plant spread of groundnut.

III) Effect on number of branches $plant^{-1}$

A. Effect of inorganic fertilizer levels

The application of 125% RDF was recorded significantly higher number of branches per plant of groundnut over 75% RDF. However, it was on par with 100% RDF. The number of branches per plant increased with increasing level of nitrogen and phosphorous application. The inorganic fertilizer provides favorable condition for activation of meristematic cells and encourage emergence of branches. It is a result of activation of auxiliary bud which mainly dependent on moisture and nutrient availability. Similar results were reported by Sarade *et al.*, (2016) [14], Patil *et al.*, (2017) [12] and Chaudhari *et al.*, (2018) [3].

B. Effect of bio-fertilizer levels

The mean maximum number of branches per plant of groundnut were recorded significantly higher due to dual seed inoculation with *Rhizobium* spp. + PSB (Lignite based) cultures over control. However, it was on par with dual seed inoculation with *Rhizobium* spp. + PSB (Liquid based). The *Rhizobium* inoculation helped in nitrogen fixation and phosphorous solubilizer organisms enhanced the microbial activity, which that might have effect on increased vegetative growth of plant and mean number of branches per plant. This result was almost similar with reports of Panwar and Singh (2003) [11].

C. Effect of interaction

The interaction effect between in organic fertilizer and bio-fertilizers were found to be non-significant in respect of mean number of branches per plant of groundnut.

IV) Effect on dry matter $plant^{-1}$

A. Effect of inorganic fertilizer levels

The application of 125% RDF recorded significantly higher dry matter per plant of groundnut over 75% RDF. However, it was on par with 100% RDF. The dry matter production increased significantly with every increased level of inorganic fertilizers. The increase in plant vigour in terms of plant height, leaf number, plant spread and their area per plant due to these treatments were found to be useful in increasing photosynthetic activities and thereby accumulation of more carbohydrates and consequently higher dry matter. These result are in agreement with finding of Kulkarni *et al.*, (1986) [8] and Saradhi *et al.*, (1990) [15].

Table 1: Growth characters influenced by different treatments

Treatments	Plant height (cm)	Plant spread (cm)	Number of branches plant^{-1}	Mean dry matter plant^{-1}
Inorganic Fertilizer Levels:				
F_1-75% of RDF	25.13	23.68	9.34	30.59
F_2-100% of RDF	29.92	26.18	11.16	34.54
F_3-125% of RDF	30.56	26.35	11.46	34.83
S. Em±	0.22	0.15	0.10	0.24
C.D. at 5%	0.67	0.47	0.31	0.72
Biofertilizer Levels:				
B_1-Control	26.94	24.23	9.91	31.68
B_2-*Rhizobium* spp.+ PSB (Lignite based)	29.50	26.12	11.12	34.19
B_3-*Rhizobium* spp.+ PSB (Liquid based)	29.18	25.85	10.92	34.08
S. Em±	0.22	0.15	0.10	0.24
C.D. at 5%	0.67	0.47	0.31	0.72
Interactions (F× B):				
S. Em±	0.67	0.47	0.10	0.72
C. D. at 5%	NS	NS	NS	NS
General mean	28.54	25.40	10.64	33.32

B. Effect of bio-fertilizer levels

The dual seed inoculation with *Rhizobium* spp. + PSB (Lignite based) cultures recorded significantly higher dry matter accumulation per plant of groundnut over control. However, it was on par with dual seed inoculation with *Rhizobium* spp. + PSB (Liquid based). This is mainly because P-solubilizer microorganisms and nitrifying bacteria enhanced the plant vegetative growth due to additional nutrient uptake, which ultimately reflected in increasing in plant vigour in terms of plant height, leaf number, plant spread and their area per plant. That might have been useful in harvesting more solar energy which enhanced photosynthetic activities and thereby accumulation of more carbohydrates and consequently higher dry matter. These result are in agreement with finding of More *et al.,* (2002) [9] and Dhadge *et al.,* (2014) [6].

C. Effect of interaction

The interaction effect between in organic fertilizer and bio-fertilizers were found to be non-significant in respect of mean dry matter accumulation per plant of groundnut.

Table 2: Mean number and weight of root nodulesplant^{-1} (g) of groundnut at flowering as influenced by different treatments

Treatments	At flowering	
	Number of nodules plant^{-1}	Weight of nodules plant^{-1} (g)
Inorganic Fertilizer Levels		
F_1-75% of RDF	50.24	0.93
F_2-100% of RDF	53.88	1.23
F_3-125% of RDF	54.71	1.26
S. Em±	0.29	0.01
C. D. at 5%	0.89	0.04
Biofertilizer Levels		
B_1-Control	50.22	0.97
B_2-*Rhizobium* spp.+ PSB (Lignite based)	54.72	1.24
B_3-*Rhizobium* spp.+ PSB (Liquid based)	53.88	1.21
S. Em±	0.29	0.01
C. D. at 5%	0.89	0.04
Interactions (F× B)		
S. Em±	0.89	0.04
C. D. at 5%	NS	NS
General mean	52.94	1.14

V) Effect on number of nodules plant^{-1}

A. Effect of inorganic fertilizer levels

Application of 125% RDF and 100% RDF where at par in respect of number of nodules per plant of groundnut at flowering and significantly superior over 75% RDF. This result was correlated with the finding of Sagare *et al.,* (1986) [13] and Kulkarni *et al*., (1986) [8].

B. Effect of bio-fertilizer levels

The dual seed inoculation with *Rhizobium* spp. + PSB (Lignite based) and *Rhizobium* spp. + PSB (Liquid based) where at par in respect of number of nodule per plant of groundnut at flowering and significantly superior over control. The additional uptake of nitrogen and phosphorus increased the root length of plant. This resulted in increased nodulation. These results are corroborating with the finding of Detroja *et al.,* (1997) [5] and Zaltae and Padmani (2009) [20].

C. Effect of interaction

The interaction effect due to inorganic fertilizer and biofertilizer levels were found to be non-significant in respect of mean number of root nodules per plant of groundnut.

VI) Effect on weight of root nodules plant^{-1} (g)

A. Effect of inorganic fertilizer levels

The mean of the highest weight of root nodules per plant (1.26 g) at flowering stage was recorded with the application of 125% RDF which was significantly higher over 75% RDF, expect 100% RDF. Lowest mean weight of wet root nodules per plant was observed at 75% of RDF ha^{-1} that might be due to lower availability of plant nutrients. Similar, results reported by Kulkarni *et al.,* (1986) [8] and Vala *et al.,* (2017) [18].

B. Effect of bio-fertilizer levels

The application of dual seed inoculation with *Rhizobium* spp. + PSB (Lignite based) cultures recorded highest weight of root nodules per plant (1.24 g) of groundnut over control. However, it was on par with dual seed inoculation with *Rhizobium* spp. + PSB (Liquid based) (1.21 g). The weight of root nodules per plant increased due to the increase in number of root nodules per plant, which was due to the application of bio-fertilizers. These results are corroborating with the finding of Detroja *et al.,* (1997) [5] and Zaltae and Padmani (2009) [20].

C. Effect of interaction

The interaction effect due to inorganic fertilizer and biofertilizer levels were found to be non-significant in respect of mean weight of root nodules per plant of groundnut.

Conclusions

1. The application of 125% RDF and 100% RDF recorded higher growth of groundnut crop, hence 125% RDF fertilizer levels can be recommended for getting better growth and development of groundnut plant.
2. The dual seed inoculation of *Rhizobium* spp. + PSB (Lignite based) as well as *Rhizobium* spp. + PSB (Liquid based) can be effectively used for seed treatment for better growth and development of groundnut plant
3. From the results findings, it can be concluded that groundnut crop is responsive to higher levels of fertilizer. So farmer can go for higher dose of fertilizer for better growth of crop.

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