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# Effect of inorganic fertilizers and biofertilizers on growth and nodulation of soybean [*Glycine max* (L.) Merrill]

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**Abstract**
The field investigation entitled "Effect of Inorganic Fertilizers and Biofertilizers on Profitability and Productivity of Soybean [*Glycine max* (L.) Merrill]" during *kharif*, 2022 was conducted at instructional farm, College of Agriculture, Ummedganj-Kota. An experiment was laid out with Factorial Randomized Block Design with twelve treatment combinations with three replications, which includes inorganic fertilizers [50% RDF (10:20:20), 75% RDF (15:30:30) and 100% RDF (20:40:40) kg/ha] and biofertilizers (*Rhizobium* @ 600 g/ha, NPK Consortia @1250 ml/ha and *Rhizobium* @ 600 g/ha + NPK Consortia @1250 ml/ha). Results revealed that application of higher levels of inorganic fertilizers (100% RDF 20:40:40 kg NPK per ha) significantly improved the plant height (56.11 cm), chlorophyll content (2.87 mg/g), leaf area index (5.11), number of nodules/plant (53.04), fresh weight of nodules (172.76 mg/plant) and dry weight of nodules (68.18 mg/plant) of soybean than rest of treatments. Also, seed inoculated with *Rhizobium* @ 600 g/ha + NPK Consortia @1250 ml/ha recorded significantly higher plant height (53.16), chlorophyll content (2.79mg/g), leaf area index (4.42), number of nodules/plant (50.28), fresh weight of nodules (170.75 mg/plant) and dry weight of nodules (62.78 mg/plant) of soybean than individual inoculation of *Rhizobium* @ 600 g/ha and NPK Consortia @1250 ml/ha.

**Keywords:** *Bradyrhizobium japonicum*, NPK consortia, growth, nodules, soybean

## Introduction
Soybean [*Glycine max* (L.) Merrill] is the most important major oilseed crop among the edible oil seed crops. It has emerged as a potential protein as well as oilseed crop worldwide, as efficient producer of the two scarce nutritional resources *i.e.*, richest source of protein (40%) and oil (20%). It is a good source of protein, unsaturated fatty acids and minerals like Ca and P including vitamins A, B and D that meet different nutritional needs (Rahman, 1982). In India, soybean occupied an area of 12.27 M ha with production of 12.99 MT during 2021-22 (Agricultural Statistics at a Glance, 2022) [1]. Rajasthan occupied an area of 1.16 M ha and production of 0.93 MT having hovering productivity of 801 kg/ha (Agricultural Statistics at a Glance, 2022) [1]. Hence, south-eastern plain zone V of Kota division and Kota district occupied an area of 7.59 & 1.88 lakh ha and production of 5.48 & 1.88 lakh tons and having productivity of 722 & 999 kg/ha, respectively (Anonymous 2021-2022) [2].

Soybean is grown in rainy season and like any other *kharif* season crop, it is a high protein and energy crop and its productivity is often limited by the low availability of essential nutrients and it faces fertility problems due to imbalance use of fertilizers and resulted low yield. Hence, a balanced nutrients application is must to harness the productivity of the crops. The improvement in quantity and quality of soybean can be achieved by balance nutrition along with N and adequate supply of phosphate and potash is highly important. Nitrogen is an essential constituent of protein and chlorophyll which is present in many other compounds of great physiological importance in plant metabolism such as nucleotides, phosphate alkaloids, enzymes, hormones, vitamins etc. Phosphorus plays important role in growth as well as development and maturity of plant it helps in flowering and seed development. It also improves quality of seed. Out of total uptake of phosphorus by soybean plant 60 per cent phosphorus comes into seed therefore, application of Phosphorus is must for soybean crop. Biofertilizers helps to increase microbial activity in soil to solubilize and mobilize the nutrients to reach the plant roots. The application of biofertilizers enhances the nutrient levels of soil which support plant growth and productivity in agricultural field (Kumar and Meena, 2020) [5].

Liquid and solid biofertilizers having a variety of beneficial microorganisms may restore soil fertility by activating soil microorganism, which can enhance the crop yield and quality. Liquid biofertilizers have the capacity to replace the traditional chemical fertilizers and carrier based biofertilizers which play a major role in restoring the soil health (Lavanya *et al.*, 2018) [6].

Therefore, use optimum dose of fertilizer and bio-fertilizer assumes special attention for their economic, eco-friendly, environmentally safe and sustainability in nature, besides improving the physical, chemical and biological properties of soil and in turn crop yield per unit area (Mahmud *et al.*, 2021) [7].

## Material and Methods

A field experiment was conducted at instructional farm, College of Agriculture, Ummedganj-Kota. the soil of experimental field was clay loam in texture with adequate drainage facility, having moderately alkaline reaction, medium in organic carbon (0.52%), available nitrogen (264.5 kg/ha), phosphorus (21.7 kg/ha) and high in available potassium (388.6 kg/ha). The experiment was laid out with Factorial Randomized Block Design with three replications and twelve treatment combinations, which includes inorganic fertilizers (0% RDF, 50% RDF 10:20:20 kg/ha, 75% RDF 15:30:30 kg/ha, 100% RDF 20:40:40 kg/ha) and biofertilizers (*Rhizobium* @ 600 g/ha, NPK Consortia @ 1250 ml/ha and *Rhizobium* @ 600 g/ha + NPK Consortia @ 1250 ml/ha). The gross plot size and net plot size were 5.0 m x 4.20 m and 4.0 m x 3.0 m, sowing was done at 25 June 2022. Total rainfall during the crop season was 1089 mm. The minimum temperature ranged from 22.7 °C to 28.6 °C and maximum temperature ranged from 31.6 °C to 39.9 °C was observed during growing period, respectively.

The inorganic fertilizers 100% RDF (20:40:40 kg/ha), 75% RDF (15:30:30 kg/ha) and 50% RDF (10:20:20 kg/ha) were applied through urea, diammonium phosphate and murate of potash as basal dose and seed inoculation with *Rhizobium* @ 600 g/ha and NPK Consortia @ 1250 ml/ha before sowing was done as per treatments in the marked plots of the field experiment.

The crop was harvested at physiological maturity stage on 26th September, 2022, plot wise separately when pods were fully ripened. The effects of treatments were evaluated in term of growth, yield attributes, yield, quality, nutrient content and uptake, available nutrients status of soil after harvest of crop. Oil content was estimated by automatic Soxhlet extraction unit (A.O.A.C., 1965) and the protein content in seed was calculated by multiplying the nitrogen percentage in seed with a factor 6.25 (A.O.A.C., 1975). Oil and protein yield was worked out by multiplying the seed yield with oil content and protein content for each corresponding treatment. To find out the effect of inorganic fertilizers and biofertilizers on growth and nodulation of soybean.

## Results

The results revealed that inorganic fertilizer and biofertilizers are effective in plant growth promotion and enhance the plant growth by producing growth regulators that enhance the activity of other beneficial microorganisms, accelerating the mineralization of plant nutrients and uptake of certain nutrients.

### Plant height

Results revealed that the plant Hight at 30 DAS found non-significant and at harvest, plant height (56.11cm) was increase significantly by inorganic fertilizers up to 100% RDF (20:40:40) as compared to control. The increase in plant height of soybean due to 100% RDF (20:40:40) was 15.07 and 6.27 per cent at harvest, respectively over control and 50% RDF (10:20:20).

Among the bio fertilizers, the plant Hight at 30 DAS found non-significant and highest plant height (53.16 cm) at harvest was observed with the treatment of *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha which was statistically at par with the NPK consortia @ 1250 ml/ha but found significantly superior over *Rhizobium* @ 600 g/ha. The increase in plant height of soybean due to application of *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha was 5.02 per cent at harvest over *Rhizobium* @ 600 g/ha.

### Chlorophyll content

Results revealed maximum chlorophyll content (2.87 mg/g) in leaf of soybean (45 DAS) was recorded with the application of 100% RDF (20:40:40) which was closely followed by application of 75% RDF (15:30:30) and found significantly superior to 50% RDF (10:20:20) and control.

In case of biofertilizers, Application of *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha found higher chlorophyll content (2.79 mg/g) at 45 DAS which was significantly superiors over *Rhizobium* @ 600 g/ha by 30.99 per cent, respectively.

### Leaf area index

Results revealed maximum leaf area index (5.11) of soybean was recorded with the application of 100% RDF (20:40:40) which was closely followed by application of 75% RDF (15:30:30) and found significantly superior to control and 50% RDF (10:20:20).

Whereas in biofertilizers, the maximum increase in leaf area index (4.42) of soybean was observed with *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha which was remained at par with NPK consortia @ 1250 ml/ha but significantly superior over *Rhizobium* @ 600 g/ha by 36.42 per cent.

### Number of nodules/plant at 45 DAS

The application of 100% RDF (20:40:40) produced significantly higher number of nodules/plant (53.04) over control and 50% RDF (10:20:20) and closely followed by application of 75% RDF (15:30:30).

Among the bio-fertilizer treatments application of *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha recorded highest number of nodules/plant (50.28) of soybean over all other remaining treatments but it was found statistically at par with *Rhizobium* @ 600 g/ha.

### Fresh weight of nodules at 45 DAS

Results revealed that the application of 100% RDF (20:40:40) significantly influenced the fresh weight of nodules (172.76 mg/plant) of soybean as compared to control. The per cent increase in fresh weight of nodules/plant due to application of 100% RDF (20:40:40) was 6.20 per cent over control.

In case of biofertilizers, *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha recorded maximum fresh weight of nodules (170.75 mg/plant) of soybean over all other

remaining treatments but it was found statistically at par with *Rhizobium* @ 600 g/ha.

**Dry weight of nodules at 45 DAS**

Application of 100% RDF (20:40:40) recorded the dry weight of nodules (68.18 mg/plant) was significantly higher as compared to control. The enhancement in dry weight of nodules/plant of soybean due to application of 100% RDF (20:40:40) was 30.41 and 13.77 per cent over control and 50% RDF (10:20:20), respectively.

Whereas in biofertilizers, significantly maximum dry weight of nodules/plant (62.78 mg/plant) at 45 DAS was recorded with *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha which was (12.23%) found superior over NPK consortia @ 1250 ml/ha.

**Discussion**

The overall improvement in crop growth under the influence of increasing fertilizers level application could be attributed to better environment for growth and development that might be due to increased availability of nitrogen to the growing plants. The increased availability of phosphorus to plant might have enhanced early root growth and cell multiplication leading to more absorption of other nutrients from deeper layers of soil ultimately resulting in increased plant growth in terms of plant height, fresh and dry weight of nodules/plant of soybean. have also observed significant increased growth parameters of soybean with RDF (5 tons FYM + 50:75 kg $N:P_2O_5$/ha). The results of present investigation are also in close conformity with the findings of Paliwal *et al.* (2011) [10], Vyas and Khandwe (2013) [16], Verma *et al.* (2017a) [14], Verma *et al.* (2017b) [15] and Morya *et al.* (2018) [8].

Whereas in biofertilzers, the highest values of above parameters were recorded when combined application of *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha (Table 1 2). It can be ascribed mainly to the greater availability and uptake of nitrogen and phosphorus by plants as these inoculations play a very important role in improving availability of N and P in many ways. Inoculation of seed with symbiotic nitrogen fixers might have increased the concentration of an efficient and healthy strain of rhizosphere, which in turn resulted in greater fixation of atmospheric nitrogen in soil for use by the plants and consequently resulting in to higher growth. Application of RDF and *Rhizobium* with PSB recorded significantly higher growth and yield of soybean reported by (Navasare *et al.*, 2019) [9]. The results obtained in present investigation are in line with the findings of Konthoujam *et al.* (2013) [4], Raja and Takankhar (2017) [12], Desai *et al.* (2019) [3] and Yaduwanshi *et al.* (2019) [17], Samarakoon and Yapa (2019) [13].

**Table 1:** Effect of inorganic fertilizers and biofertilizers on plant height, chlorophyll content and leaf area index at different growth stages of soybean

| Treatments | Plant height (cm) at 30 DAS | Plant height (cm) at harvest | Chlorophyll content (mg/g) at 45 DAS | Leaf area index at 45 DAS |
|---|---|---|---|---|
| **Inorganic fertilizers (NPK kg/ha)** | | | | |
| Control | 17.70 | 48.76 | 2.09 | 2.75 |
| 50% RDF (10:20:20) | 18.47 | 52.80 | 2.56 | 4.16 |
| 75% RDF (15:30:30) | 19.26 | 54.02 | 2.67 | 4.56 |
| 100% RDF (20:40:40) | 19.68 | 56.11 | 2.87 | 5.11 |
| S.Em± | 0.52 | 0.88 | 0.10 | 0.23 |
| CD (P=0.05) | NS | 2.59 | 0.29 | 0.68 |
| **Biofertilizers** | | | | |
| *Rhizobium* @ 600 g/ha | 17.93 | 50.62 | 2.13 | 3.24 |
| NPK consortia @ 1250 ml/ha | 18.67 | 51.80 | 2.39 | 3.81 |
| *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha | 18.82 | 53.16 | 2.79 | 4.42 |
| S.Em± | 0.45 | 0.76 | 0.08 | 0.20 |
| CD (P=0.05) | NS | 2.24 | 0.25 | 0.59 |
| CV | 8.27 | 6.01 | 5.20 | 6.88 |

**Table 2:** Effect of inorganic fertilizers and biofertilizers on nodules/plant, fresh weight of nodules/plant and dry weight of nodules/plant at 45 DAS of soybean

| Treatments | Nodules/plant (Nos.) at 45 DAS | Fresh weight of nodules (mg/plant) at 45 DAS | Dry weight of nodules (mg/plant) at 45 DAS |
|---|---|---|---|
| **Inorganic fertilizers (NPK kg/ha)** | | | |
| Control | 43.68 | 162.67 | 52.28 |
| 50% RDF (10:20:20) | 48.72 | 169.89 | 59.93 |
| 75% RDF (15:30:30) | 52.39 | 171.44 | 63.96 |
| 100% RDF (20:40:40) | 53.04 | 172.76 | 68.18 |
| S.Em± | 1.05 | 3.96 | 2.01 |
| CD (P=0.05) | 3.07 | 11.61 | 5.89 |
| **Biofertilizers** | | | |
| *Rhizobium* @ 600 g/ha | 47.66 | 167.19 | 57.45 |
| NPK consortia @ 1250 ml/ha | 46.86 | 166.04 | 55.94 |
| *Rhizobium* @ 600 g/ha + NPK consortia @ 1250 ml/ha | 50.28 | 170.75 | 62.78 |
| S.Em± | 0.91 | 3.43 | 1.74 |
| CD (P=0.05) | 2.66 | 10.05 | 5.10 |
| CV | 6.34 | 7.02 | 9.86 |

## Conclusion

On the basis of present investigation, it may be concluded that the application of inorganic fertilizers (100% RDF) along with seed inoculation of *Rhizobium* @ 600 g/ha + NPK Consortia @1250 ml/h recorded significantly higher plant hight, of soybean over no application of fertilizer. Therefore, it was concluded that combination of inorganic fertilizers (100% RDF) along with seed inoculation of *Rhizobium* @ 600 g/ha + NPK Consortia @1250 ml/h may result in the better performance of soybean crop.

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