Growth, yield, quality and uptake of nutrients in soybean as influenced by PSB and AM Fungi

Ghadage AD, Mane SS and Jadhav KT

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Abstract
A Field experiment was conducted during 2017-18 at College of Agriculture Badnapur, VNMKV, Parbhani to study effect of application of PSB and AM fungi on growth, yield, quality and uptake of nutrients by soybean. The results showed that various plant height, number of nodules, dry matter, seed yield, protein content in seed and N, P, K, uptake was increased due to application of 100% RDF along with 5 ton compost ha⁻¹ (T₃). It was also inferred from the results that application of 100 % RDF + PSB +AM fungi (T₅) was found superior over (T₃) for only P availability.

Keywords: Biofertilizers, protein, PSB, AM fungi

Introduction
Phosphate Solubilizing Bacteria are known to solubilize the inorganic phosphates occurring in soil or added as rock phosphate but also mineralize organic phosphate present in the soil as well as added through crop residues and organic manures. PSB inoculants play an important role in making P available to crop plants (Guar and Gaind, 1992) [⁴]. The VAM fungi are known to increase the nutrient uptake, particularly the phosphorus to the host plant which in turn stimulate the nitrogen fixation by *Rhizobium*, (Balachandra and Nagarajan, 1999) [⁵].

Material and Methods
The experiment was conducted during 2017-18 at College of Agriculture, Badnapur in randomized block design with six treatment combinations, replicated four times. The treatment consists of T₁ Absolute control (No fertilizer application), T₂ (100% RDF), T₃ (100% RDF + Compost 5 t ha⁻¹), T₄ (100% RDF + PSB), T₅ (100 % RDF + AM Fungi), T₆ (100 % RDF + PSB + AM Fungi). Each treatment consisted of 10 rows with row to row spacing of 45 cm. The soil was clayey in texture. NPK fertilizer application (30:60:30) and other agronomic practices were carried out uniformly according to the recommendations. physico – chemical properties of experimental site were as, 7.85 pH, 0.28 dSm⁻¹ EC, 5.4 g kg⁻¹ Organic carbon, 65 g Kg⁻¹ 220.4 Kg ha⁻¹ Available Nitrogen, 12.60 Kg ha⁻¹ Available Phosphorus and 480.60 Kg ha⁻¹ Available Potassium. Random five plants were taken from each treatment for counting of number of nodules, noting plant height, dry matter Plant⁻¹, economic yield, Protein content was estimated by multiplying N content with 6.25.

(Note:- Full dose of N,P & K had been applied to all treatment except T₁. Seeds were treated with PSB @ 20 gm kg⁻¹ for T₄ and T₆. VAM had been applied @ 200-250 spores/per m² for T₅ and T₆ treatment after sowing of seed.)

Result and Discussion
Plant height: The height of soybean was monitored at harvesting of crop are presented in Table.1. The plant height was significantly highest in treatment 100% RDF + 5 ton compost ha⁻¹ (T₃) (65.20 cm) at harvesting stage over the control (T₁) which was at par with treatment 100% RDF+ PSB+AM fungi(T₆) (59.92 cm). This increase in plant height might be due to greater availability of macro and micro nutrients from organic sources which helped in acceleration of various metabolic processes. Secondly it might be the availability of optimum levels of N, P and K which helped in better absorption of nutrients coupled with proper distribution of assimilates. Similar result was also noted by More et al. (2008) [⁸].

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Number of nodules per plant
The data presented in Table 1 indicated significant impact of application of 100 % RDF + 5 ton compost ha$^{-1}$ (T3) on number of nodules per plant (46.95) at flowering stage followed by application of 100% RDF + PSB +AM fungi (T6) (41) 100 % RDF + PSB (T4) (38.35). Application of 5 tone compost ha$^{-1}$ improved the soil environmental condition, availability of N, P, and K reflected through nodulation of soybean. Singh et al. (2007) [9] also noted similar results.

| Treatments | Plant height (cm) | No. of nodule plant$^{-1}$ | Dry matter (Kg ha$^{-1}$) | Yield (Kg ha$^{-1}$) | Protein content (%) | N uptake (Kg ha$^{-1}$) | P uptake (Kg ha$^{-1}$) | K uptake (Kg ha$^{-1}$) |
|------------|------------------|-----------------------------|---------------------------|---------------------|---------------------|------------------------|------------------------|------------------------|
| T1         | 33.9             | 26.6                        | 1022.50                   | 770.75              | 23.4                | 115.95                 | 8.375                  | 101.22                 |
| T2         | 44.4             | 28.27                       | 1370.00                   | 1225.00             | 25.51               | 245.55                 | 15.00                  | 160.00                 |
| T3         | 65.20            | 46.95                       | 1920.00                   | 1830.50             | 34.61               | 313.35                 | 18.48                  | 229.35                 |
| T4         | 53.18            | 38.35                       | 1635.00                   | 1485.75             | 30.72               | 294.38                 | 16.40                  | 190.53                 |
| T5         | 51.18            | 32.78                       | 1505.00                   | 1285.27             | 28.60               | 279.68                 | 13.75                  | 171.50                 |
| T6         | 59.92            | 41.00                       | 1775.00                   | 1774.25             | 33.31               | 305.2                  | 20.85                  | 214.42                 |
| CD at 5%   | 4.89             | 3.22                        | 118.21                    | 105.08              | 2.70                | 34.57                  | 1.46                   | 16.09                  |

Dry matter: The mean dry matter was found to be highest due to application of 100% RDF + 5 compost ha$^{-1}$ (T3) (1920 kg ha$^{-1}$) which was significantly higher than other treatments, where as 100% RDF + PSB + AM fungi (T6) was found at par (1775 kg ha$^{-1}$). Minimum dry weight was found in absolute control treatment (T1), i.e.1022.5 kg ha$^{-1}$. Similar finding were also noted by Dhawan et al. (2006) [3].

Economic yield: Application of 100% RDF + 5 ton compost ha$^{-1}$ (T3) had recorded highest seed yield (1830.50 kg ha$^{-1}$) followed by 100% RDF + PSB +AM fungi (T6) and 100% RDF + PSB (T4). While lowest grain yield was recorded in absolute control (T1) i.e.770.75 kg ha$^{-1}$. Application of 100% RDF along with 5 ton compost ha$^{-1}$ (T3) increased the grain yield of soybean by 42.10% over control. The increment in supply of essential elements through organic and inorganic sources, their availability, mobilization and influx into the plant tissues increased and improved growth and yield components and finally the seed yield of soybean. Wandhkekar et al. (2005) [10] also recorded similar findings.

Protein content: The highest protein content (34.61 %) was recorded by application of 100% RDF + 5 ton compost kg ha$^{-1}$ (T3), followed by 100% RDF + PSB +AM fungi (T6) (33.31 %). Nitrogen is main constituent of amino acid biosynthesis and helps in formation of protein. Bisht and Chandel (1996) [2], Goswami et al. (1999) [6] also observed similar findings.

Uptake of nutrients: Application of 100% RDF + 5 ton compost ha$^{-1}$ (T3) had also recorded significantly higher uptake of N and K after harvest (313.35 and 229.35 kg ha$^{-1}$ respectively). This was followed by 100 % RDF + PSB +AM fungi (T6) (305.2 and 214.42 kg ha$^{-1}$ respectively), while minimum uptake of N and K was found in absolute control (T1) (115.95 and 101.22 kg ha$^{-1}$). The increase in N and K uptake could be attributed to enhanced vigour of crop growth, increased utilization and translocation of N in to plant and synergy between N and K in soil system. Similar trend was also reported by Kurhade et al., (2014) [7].

The higher amount of soil P found from the 100 % RDF + PSB + AM fungi (T6) (25.25 kg ha$^{-1}$) followed by 100 % RDF + 5 ton compost ha-1 (22.00 kg ha$^{-1}$). The lowest soil P was found in absolute control (T1) (14.25 kg ha$^{-1}$).VAM is known to help the crop by absorbing more phosphorus with the hyphae extended in soil while phosphorus availability due to PSB also helped the plant indirectly to accumulate more phosphorus. Hall et al. (1977) documented that inoculation of VAM to legume stimulated the uptake of phosphorus at low level of phosphorus.

An application of organic manure may have caused reduction in K fixation and consequently increased K content in soil due to interaction of organic matter with clay besides the direct addition to the soil. These results were in accordance with the findings of Gharpine et al. (2014) [9].

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