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Effect of different fertilizer levels and seed treatments on growth and yield of soybean (*Glycine max* L. Merrill)

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Abstract
A field experiment was conducted during *kharif*, 2023 at Experimental Farm, Department of Agronomy, College of Agriculture, Latur on clayey soil to study the effect of different fertilizer levels and seed treatments on growth and yield of soybean. The experiment was laid out in factorial randomised block design with two factors and replicated thrice. First factor comprises three different fertilizer levels *viz*., F_1- 75% RDF, F_2-100% RDF and F_3-125 second factor consists of three seed treatments *viz*., T_1- Rhizophos, T_2- *Tricoderma viride*, and T_3-Biomix. The results showed that the plant height plant^{-1} (48.64 cm), number of branches plant^{-1}(26.90), number of leaves plant^{-1} (26.97), leaf area plant^{-1} (6.12 dm^2), total dry matter plant^{-1} (25.92 g), number of pods plant^{-1} (67.8), pod yield plant^{-1} (23.2 g), seed yield plant^{-1} (17.11g), seed yield 1778 kg ha^{-1}, biological yield 4072 kg ha^{-1}, gross monetary return (₹89344 ha^{-1}), net monetary return (₹38392 ha^{-1}) and B:C Ratio (1.75) were higher with the application of 125% RDF (F_3) which were at par with 100% RDF (F_2). Among different seed treatments application of Biomix (T_3) recorded highest value of plant height plant^{-1} (50.14 cm), number of branches plant^{-1}(27.04), number of leaves plant^{-1} (25.36), leaf area plant^{-1} (5.82 dm^2), total dry matter plant^{-1} (27.71 g), number of pods plant^{-1} (68.2), pod yield plant^{-1} (23.0 g), seed yield plant^{-1} (16.93 g), seed yield (1815 kg ha^{-1}), biological yield (4141 kg ha^{-1}), gross monetary return (₹91204 ha^{-1}), net monetary return (₹41441 ha^{-1}) and B:C Ratio (1.83) compared to other treatments.

Keywords: Soybean, RDF, fertilizer levels, seed treatment

Introduction
Soybean (*Glycine max* L.) is a leguminous crop belonging to the Fabaceae family and Faboideae subfamily. Originally domesticated in China. Soybean is rich in nutrients, containing approximately 40% protein and 20% cholesterol-free oil, making it a vital ingredient in animal feeds. Soybean contribution to soil fertility improvement through biological nitrogen fixation. Soybean can be grown in varied agro climatic conditions and India is the fifth largest soybean growing country in the world after USA, Brazil, Argentina and China and is mainly cultivated in Indian states like Madhya Pradesh, Maharashtra, Uttar Pradesh and Rajasthan in India.

India is the second-largest fertilizer user globally, yet nutrient insufficiency remains a concern, leading to soil fertility depletion. The reliance on mineral fertilizers has degraded soil structure and caused nutrient imbalances, necessitating a judicious approach to fertilizer use to sustain long-term productivity. While chemical fertilizers will continue to be essential for agricultural production, integrating biofertilizers can reduce costs and enhance yields, particularly in legume crops.

Biofertilizers, such as Rhizobium and phosphate-solubilizing bacteria (PSB), cannot fully replace chemical fertilizers but can significantly lower their input. They improve soil fertility by fixing atmospheric nitrogen and converting insoluble phosphates into soluble forms, promoting sustainable farming practices. Recognizing their potential can advance global agricultural sustainability. Rhizophos contains *Bacillus amyloliquefaciens*, which helps restore soil biology and make phosphorus more available to plants. This product aids in establishing beneficial biofilms in the rhizosphere, enhancing seedling resilience. Trichoderma species are renowned for their ability to control soil-borne pathogens through antifungal chemical production and

competitive exclusion. *Trichoderma viride* is especially effective against various diseases, persisting well in diverse soil types due to its rapid growth. Biomix is a blend of 14 beneficial fungi and bacteria developed by VNMKV Parbhani, effectively controlling diseases like wilt and root rot while improving nutrient availability and promoting a pollution-free atmosphere. Considering above points in view the present experiment entitled "Effect of different fertilizer levels and seed treatments on growth and yield of soybean (*Glycine max* L. Merrill)" has been planned.

Materials and Methods

A field experiment was conducted during *kharif*, 2023 at Experimental Farm, Department of Agronomy, College of Agriculture, Latur on clayey soil to study the effect of different fertilizer levels and seed treatments on growth and yield of soybean. The experimental field was levelled and well drained. The soil of experimental plot was clayey in texture, low in available nitrogen (229.6 kg ha^{-1}), medium in available phosphorus (17.6 kg ha^{-1}) and high in available potassium (447.28 kg ha^{-1}). The soil was moderately alkaline in reaction having pH 7.8. The experiment was conducted in Factorial randomized block design with three replications. First factor consists of three fertilizer levels *viz*., F_1- 75% RDF, F_2- 100% RDF and F_3- 150% RDF and second factor consists of three-row spacing *viz*., T_1- Rhizophos, T_2- Tricoderma viride and T_3: Biomix. The gross plot size of each experimental unit was 5.4 m x 4.5 m and net plot size was 4.5 m x 3.9 m respectively. Sowing was done by dibbling method on 25th July, 2023 at the spacing 45 cm x 5 cm with seed rate of 65 kg ha^{-1}. The soybean variety MAUS-158 was tested for this experiment along with these treatments. The recommended dose of fertilizer of 30:60:30 NPK kg ha^{-1} was applied. The recommended cultural practices and plant protection measure were undertaken. The statistical technique for the analysis of variance was employed to analyse the recorded data (Panse and Sukhatme, 1967) [6].

Results and Discussion

Growth attributing characters

The data presented in Table 1 showed that among fertilizer levels, application of 125% RDF recorded significantly higher growth attributes i.e plant height plant^{-1}(48.64 cm), number of branches plant^{-1}(26.90), number of leaves plant^{-1} (26.97), leaf area plant^{-1} (6.12 dm^2) and total dry matter plant^{-1} (25.92 g) which were at par with application of 100% RDF and found significantly superior over 75% RDF. It might be due to increased nutrient availability during grand growth period of the crop resulting increased the growth attributes of soybean. The results are in close agreement with the findings of Gawali *et al.*, (2016) [2], Meena *et al.* (2016) [5] and Jamliya and Vyas (2017) [4].

Among the seed treatments seed treatment of biomix (T_3) recorded significantly higher growth attributes *i.e*., plant height plant^{-1} (50.14 cm) plant^{-1}, number of branches plant^{-1} (27.04), number of functional leaves plant^{-1} (25.36), leaf area plant^{-1} (5.82 dm^2) and dry matter plant^{-1} (27.71 g) and found significantly superior over application of seed treatment with rhizophos and *Tricoderma viride*. The plant height was increased due to increased availability of nutrients and responsible for healthy growth and development. Similar results were reported by Dalvi *et al*., (2020) [1].

Yield attributing characters

The data presented in Table 2 revealed that higher number of pods plant^{-1} (67.8), pod yield plant^{-1} (23.2 g) and seed yield plant^{-1} (17.11g) were recorded with the application of 125% RDF and it found at par with 100% RDF and significantly superior over 75% RDF. It might be due to enhanced growth attribute with higher level of fertilizer application resulted in higher yield attributes. The above results are in conformity of findings reported by Gawali *et al.*, (2016) [2], Meena *et al.* (2016) [5] and Jamliya and Vyas (2017) [4].

Among the seed treatments seed treatment of biomix (T_3) recorded significantly higher number of pods plant^{-1} (68.2), pod yield plant^{-1} (23.0 g) and seed yield plant^{-1} (16.93g) compared to seed treatments with rhizophos and *tricoderma viride*. Similar results were also reported by Jaga and Sharma (2015) [3], and Dalvi *et al.*, (2020) [1].

Yield

Higher grain yield (1778 kg ha^{-1}) and biological yield (4072 kg ha^{-1}) were observed with the application of application of 125% RDF (Table 2) which were at par with 100% RDF and significantly superior over 75% RDF. This might be due to increased availability of nutrients with higher level of fertilizers which helped in regaining photosynthetic efficiency of crop and thereby increasing the crop yield. Similar findings are confirmed with the report of Gawali *et al.*, (2016) [2], Meena *et al.* (2016) [5] and Jamliya and Vyas (2017) [4].

Among the seed treatments seed treatment of biomix (T_3) recorded significantly higher grain yield (1815 kg ha^{-1}) and biological yield (4141 kg ha^{-1}) compared to seed treatments with rhizophos and *tricoderma viride*. Similar results were also reported by Jaga and Sharma (2015) [3], Dalvi *et al.*,(2020) [1] and Rahangdale *et al.*, (2021) [7].

Economics

Data presented in Table 2 regarding to the gross monetary return (GMR), net monetary returns, and B:C as influenced by various treatments. The highest gross monetary returns (₹ 89,344 ha^{-1}) and net monetary returns (₹ 38,392 ha^{-1}) was recorded with the application of 125% RDF which was at par with 100% RDF and significantly superior over 75% RDF. Highest B:C ratio (1.75) was also observed with the application of 125% RDF. Similar results were reported by Singh and Kushwaha (2020) [8].

Among the various seed treatments, seed treatment of biomix (T_3) recorded significantly higher gross monetary returns (₹ 91,204 ha^{-1}) and net monetary returns (₹ 41,441 ha^{-1}) compared to seed treatments with rhizophos and *tricoderma viride*. Highest B:C ratio (1.83) was also observed wth the seed treatment of biomix (T_3) Similar results were also reported by Rahangdale *et al.*, (2021) [7].

Table 1: Plant height plant^{-1} (cm), number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1} (dm^2) and total dry matter plant^{-1} (g) of soybean as influenced by different treatments.

Treatments	Plant height	No. of branches plant^{-1}	No. of leaves plant^{-1}	Leaf area plant^{-1}	Total dry matter plant^{-1}
Fertilizer levels (F)					
F_1: 75% RDF	43.27	23.00	19.99	4.63	23.25
F_2: 100% RDF	48.44	25.99	25.55	5.74	25.67
F_3: 125% RDF	48.64	26.90	26.97	6.12	25.92
S.E. m ±	1.02	0.73	0.50	0.16	0.63
CD at 5%	3.08	2.19	1.52	0.50	1.89
Seed Treatment (T)					
T_1: Rhizophos	45.19	24.61	23.39	5.27	23.99
T_2: Tricoderma viride	45.03	24.23	23.05	5.16	23.14
T_3: Biomix	50.14	27.04	25.36	5.82	27.71
S.E. m ±	1.02	0.73	0.50	0.16	0.63
CD at 5%	3.08	2.19	1.52	0.50	1.89
Interaction (F×T)					
S.Em ±	1.78	1.27	0.88	0.32	1.09
CD at 5%	NS	NS	NS	NS	NS

Table 2: Number of pods plant^{-1}, pod yield plant^{-1} (g), seed yield plant^{-1} (g), seed yield (kg ha^{-1}), biological yield (kg ha^{-1}), net Monetary return (₹ha^{-1}) and B:C Ratio of soybean as influenced by different treatments

Treatments	Number of pods plant^{-1}	Pod yield plant^{-1} (g)	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Gross Monetary Return (₹ha^{-1})	Net Monetary Return (₹ha^{-1})	B:C Ratio
Fertilizer levels (F)								
F_1: 75% RDF	57.8	20.0	12.41	1501	3544	75425	28305	1.60
F_2: 100% RDF	64.2	22.1	15.59	1717	3949	86279	35476	1.69
F_3: 125% RDF	67.8	23.2	17.11	1778	4072	89344	38392	1.75
S.E. m ±	1.91	0.57	0.59	56	86	3170	3170	-
CD at 5%	5.7	1.72	2.21	169	286	9504	9504	-
Seed Treatment (T)								
T_1: Rhizophos	62.0	21.0	14.59	1596	3724	80199	28968	1.56
T_2: Tricoderma viride	59.7	20.9	14.33	1585	3700	79646	27025	1.51
T_3: Biomix	68.2	23.0	16.93	1815	4141	91204	41441	1.83
S.E. m ±	1.91	0.57	0.59	56	86	3170	3170	-
CD at 5%	5.7	1.72	2.21	169	286	9504	9504	-
Interaction (F×T)								
S.E. m ±	3.32	0.99	1.03	97.5	157.2	5491	5491	-
CD at 5%	NS	NS	NS	NS	NS	NS	NS	-

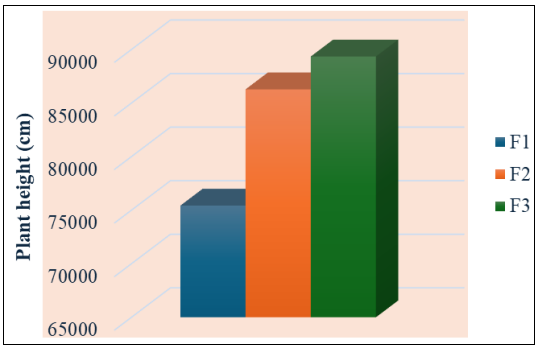

Fig: 4.1 (a): Plant different height (cm) of soybean influenced by different fertilizer levels

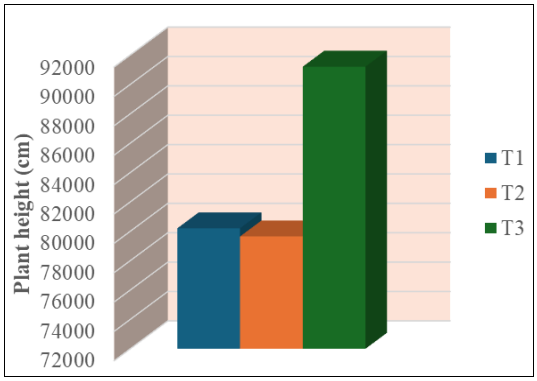

Fig: 4.2 (b): plant different height (cm) of soybean influenced by different seed treatments

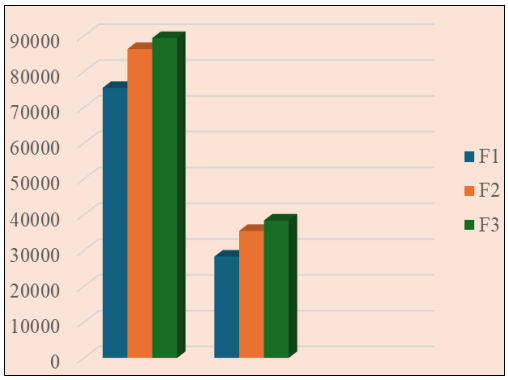

Fig: 4.6 (a): Seed yield and Biological yield (kg ha^{-1}) of soybean influenced by different fertilizer levels

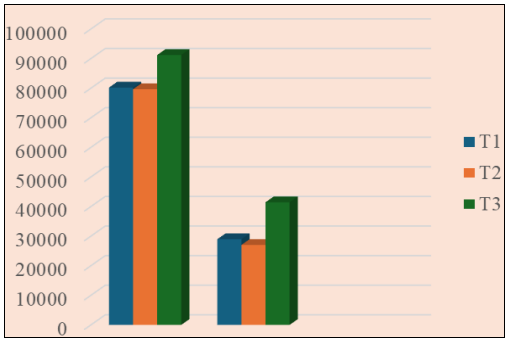

Fig: 4.6 (b): Seed yield and Biological yield (kg ha^{-1}) of soybean influenced by different seed treatments

Drone view of experimental field

Conclusion

It can be concluded that the application of 125% RDF was recorded higher values of all growth attributes, yield attributes, yield, GMR and NMR which was at par with 100% RDF and significantly superior over 75% RDF. Among the seed treatments, seed treatment with biomix was found to be more remunerative for getting higher values growth attributes, yield attributes, yield, GMR and NMR.

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