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Effect of different spacing and nutrient management on growth and yield of soybean (*Glycine max* L. Merr.)

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Abstract
At the Experimental Farm, Department of Agronomy, College of Agriculture, Latur (Maharashtra), an agronomic investigation was carried out in the *kharif* of 2021 to examine the impact of varying spacing and nutrient management on the growth and yield of soybeans. Nine treatment combinations, each consisting of two factors with different spacing and nutrient management. Three levels of each factor were included in the Factorial Randomized Block Design (FRBD) experiment set up. The factor-A consist of three spacings *viz*. S_1-45 cm × 5 cm, S_2-60 cm × 10 cm, S_3-60 cm × 15 cm and factor-B consist of three nutrient management practices *viz*. N_1-RDF (30:60:30:20 NPKS kg ha^{-1}), N_2-RDF+ multimicronutrient grade-II @ 0.5% at 20 DAS and N_3-RDF+multimicronutrient grade-II @ 0.5% at 20 DAS+00:52:34 @ 1% at 60 DAS. The result of the experiment revealed that spacing 45 cm × 5 cm recorded significantly highest seed yield over spacing 60 cm × 10 cm and 60 cm × 15 cm. The nutrient of RDF + multimicronutrient grade-II @ 0.5% at 20 DAS+ 00:52:34 @ 1% at 60 days after sowing recorded highest growth features and seed yield.

Keywords: Soybean, different spacing, nutrient management, multi micronutrient grade-ii, growth and yield

Introduction
The soybean (*Glycine max* (L.) Merrill) is a member of legumes family (Leguminosae), which includes the subfamily Faboideae (Papilionoideae). Due to its excellent nutritional value, wide range of geographical adaptation, functional health benefits, and variety of end-uses, it is a significant crop globally.

An annual herbaceous plant, soybeans are grown for their edible seeds. Typically, soybean plants are erect shrubs with leaves arranged in an alternate pattern and woody stems. Three separate, oval- or lance-shaped leaflets, each measuring 3–10 cm (1.2–4.0 in) in length, are present on the leaves. The soybean plant produces small white or purple flowers and curved seed pods which are 3-15 cm (1.2-6 in) in length and can contain between 1 to 5 seeds. The colors of the seeds can range from yellow to green to brown to black, or they can have a mottled pattern. Because of all of its applications, soybean is sometimes referred to as the "Golden bean" or the "Miracle crop". Eighteen to twenty percent of soybean seeds are oil, forty percent protein, thirty percent carbohydrates, four percent saponins, and five percent fiber. Lysine, a vital amino acid that is lacking in most cereals, is abundant in soy protein (5 percent). Additionally, 60 percent of it is composed of polyunsaturated fatty acids (5.2 percent linolenic acid and 7.2% linoleic acid).

When it comes to fertilizer elements, oil seed crops require a significantly higher amount of sulfur than other crops. The liberal application of sulfur yields response from oil seed crops. According to Vaiyapuri *et al*. (2010) [10], sulfur is involved in the synthesis of fatty acids and also improves the quality of protein through the synthesis of specific amino acids like cystein and methionine. Generally speaking, 87% of soil is sulfur deficient.

Zinc is thought to be the crop production limiting factor. Zn is required by plants for the synthesis of tryptophane, which is a protein and some harmones (IAA). As a result, plants with low Zn have smaller internodes, leaves, and slower plant growth. Zinc plays a role in cell membrane integrity, enzyme activation, and chlorophyll synthesis. According to Malewar and Randhawa (1978) [11], 34.4% of soil samples in Maharashtra had insufficient amounts of available zinc, indicating a zinc deficiency in Indian soils.

In addition to being helpful in numerous physiological processes like the movement of sugars and nutrients from leaves to reproductive organs, enhanced pollination, and seed development, boron is necessary for the overall growth of plants.

Because boron is essential for the development of flowers and the production of seeds, yields may decline if the B supply is reduced during this crucial stage (Schon and Blevins, 1987) [12]. Deosarkar *et al*. (2001) [13] reported that the application of boron increased the yield of soybean straw.

Photosynthesis and nitrogen fixation both depend on iron. This element is necessary for the synthesis of many ferrous proteins, thylakoids, and chlorophyll. Iron (Fe) is incorporated into a wide range of plant enzymes, including cytochromes, ferredoxin, superoxide dismutase (SOD), and catalyzed reactions (CAT). Iron plays a major role in the redox reactions of photosynthesis and respiration. Both nitrate reductase and peroxide. The synthesis of proteins and carbohydrates was negatively impacted by Fe deficiency because it is involved in the electron transport systems of oxidative anabolism.

Poor agronomic management techniques, incorrect plant geometry, fertilizer levels, seed rate, and use of low-quality seed, are blamed for the lower yield at the farmer's level. When low-quality seeds are planted, there will be irregular plant establishment and poor seedling emergence. Lack of access to high-quality seeds is another factor in the crop's slow adoption. Plant spacing is one of the many agronomic management techniques that significantly influences soybean crop yield.

The increased use of high-analysis chemical fertilizers, a significant decline in crop residue recycling, and a lack of bulky manures in modern agriculture all contribute to a greater depletion of micronutrients in the soil, which lowers crop productivity.

Therefore, the field experiment was carried out to study the effect of different spacing and nutrient management on growth and yield of soybean (*Glycine max* L.).

Material and Methods

In order to find out how different spacing and nutrient management affect soybean growth and yield, an agronomic investigation was carried out in the *kharif* of 2021 at the Experimental Farm, Department of Agronomy, College of Agriculture, Latur. The soil at the experimental site had a clayey texture and an alkaline reaction. Its available nitrogen content was low (125.3 kg ha^{-1}), its available phosphorus content was medium (18.20kg ha^{-1}), and its available potassium content was high (498.58 kg ha^{-1}). Soil was well drained, with good moisture retention capacity. Nine treatment combinations, each consisting of two factors with different spacing and nutrient management. The three levels of each factor were included in the Factorial Randomized Block Design (FRBD) experiment setup. The factor-A consist of three spacings *viz*. S_1-45 cm x 5 cm, S_2-60 cm x 10 cm, S_3-60 cm x 15 cm and factor-B consist of three nutrient management practices *viz*. N_1-RDF (30:60:30:20 NPKS kg ha^{-1}), N_2- RDF+ multimicronutrient grade-II @ 0.5% at 20 DAS and N_3-RDF+multimicronutrient grade-II @ 0.5% at 20 DAS+00:52:34 @ 1% at 60 DAS. The gross plot size of each experimental unit was 5.4 m × 4.5 m and net plot size was 4.5 m × 3.9 m. Pure seed of soybean variety MAUS-158 was sown with drilling and dibbling method on 09th July, 2021 as per treatments. The crop was harvested on 18th Oct, 2021.

Results and Discussion

Growth attributes

Effect of different spacing

The spacing of S_1-45 cm x 5 cm reported highest plant height (41.72 cm) which was significantly superior over the spacing S_3- 60 cm x 15 cm (35.67 cm) and found at par with the spacing S_2-60 cm x 10 cm (38.11 cm). The competition for available space and solar radiation might be the cause of the increased plant height. The current investigation's findings are consistent with those of Kumar and Badiyala (2005) [14]. The significantly highest values of number of branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf area $plant^{-1}$, dry matter accumulation $plant^{-1}$ and number of pod $plant^{-1}$ were recorded with the spacing S_3-60 cm x 15 cm, which was at par with the spacing S_2-60 cm x 10 cm and found significantly superior over the spacing S_1- 45 cm x 5 cm. Same results were concluded by Thakur *et al*. (2003) [8] and Garcia *et al*. (2018) [3].

Effect of nutrient management

The application of N_3-RDF+multimicronutrient grade-II @ 0.5% at 20 DAS + 00:52:34 @ 1% at 60 DAS reported higher plant height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf area $plant^{-1}$, dry matter accumulation $plant^{-1}$, and number of pods $plant^{-1}$ than application of N_1-RDF (30:60:30:20 NPKS kg ha^{-1}) and found at par with the application of N_2-RDF + multimicronutrient grade II @ 0.5% at 20 DAS. The current study's findings are consistent with the findings of Dash *et al*. (2005) [2], Adkine *et al*. (2011) [11] and Ghare (2014) [4].

Interaction (S×N)

The interaction effect of different spacing and nutrient management on growth of soybean was recorded to be non-significant

Yield attributes

Effect of different spacing

The spacing of S_1-45 cm x 5 cm registered highest seed yield (2013 kg ha^{-1}) which was noticeably better than the wider spacings of S_2-60 cm x 10 cm (1363 kg ha^{-1}) and S_3-60 cm x 15 cm (1251 kg ha^{-1}) Zhou *et al*. (2011) [15] and Taylor, H.M. (1980) came to same conclusions. Highest seed yield might be the result of higher plant population under closer spacing. The significantly highest values of number of seed $plant^{-1}$, pod yield $plant^{-1}$ (g) and seed yield $plant^{-1}$ (g) were recorded with the spacing S_3- 60 cm x 15 cm, which was at par with the spacing S_2- 60 cm x 10 cm and found significantly superior over the spacing S_1-45 cm x 5 cm. The current investigation's results are consistent with the conclusions of Jaybhay *et al*. (2015) [6].

Effect of nutrient management

The application of N_3-RDF+multimicronutrient grade-II @ 0.5% at 20 DAS+00:52:34 @ 1% at 60 DAS recorded higher number of seed per plant, pod yield per plant(g), seed yield $plant^{-1}$ (g) and seed yield (kg ha^{-1}) than application of N_1-RDF (30:60:30:20 NPKS kg ha^{-1}) and found at par with the use of N_2-RDF+ multimicronutrient grade-II @ 0.5% at 20 DAS. Similar results were concluded by Gokhale *et al*. (2005) [5] and Thalooth *et al*. (2006) [9].

Interaction (S×N)

It was discovered that the interaction between varying spacing and nutrient management had no significant effect on soybean yield.

Table 1: Effect of different spacing and nutrient management on growth attributes of soybean crop

Treatments	Plant height (cm)	No. of branches plant^{-1}	No. of leaves plant^{-1}	Leaf area plant^{-1} (dm^2)	Dry matter (g plant^{-1})	No. of pod plant^{-1}	Seed yield (kg ha^{-1})
A: Spacing							
S1- 45 cm x 5 cm	41.72	7.56	20.37	9.28	23.64	30.11	2013
S2- 60 cm x 10 cm	38.11	8.34	25.41	12.86	28.07	44.06	1363
S3- 60 cm x 15 cm	35.67	9.03	26.48	13.77	29.82	47.50	1251
SE±	1.17	0.25	0.67	0.33	0.80	1.47	39
CD @ 5%	3.49	0.77	2.01	1.01	2.39	4.40	118
B: Nutrient management							
-1 N1 : RDF (30:60:30:20 NPKS kg ha)	35.07	7.74	22.94	10.63	24.41	31.44	1448
N2 RDF+ Multimicronutrient grade-II @ 0.5% at 20 DAS	38.93	8.26	24.13	12.38	27.81	44.06	1554
N3 RDF+ Multimicronutrient grade-II @ 0.5% at 20 DAS+00:52:34 @ 1% at 60 DAS	41.50	8.93	25.19	12.89	29.31	46.17	1625
SE±	1.17	0.25	0.67	0.33	0.80	1.47	39
CD @ 5%	3.49	0.77	2.01	1.01	2.39	4.40	118
Interaction (SxN)							
SE±	2.02	0.44	1.16	0.59	1.38	2.55	68
CD @ 5%	NS	NS	NS	NS	NS	NS	NS
General mean	38.50	8.31	24.09	11.97	27.18	40.56	1543

Table 2: Effect of different spacing and nutrient management on yield attributes of soybean crop

Treatments	No. of seed plant^{-1}	Pod yield plant^{-1} (g)	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})
A: Spacing				
S1- 45 cm x 5 cm	85.78	14.53	6.76	2013
S2- 60 cm x 10 cm	129.06	24.65	11.42	1363
S3- 60 cm x 15 cm	140.89	25.77	12.58	1251
SE±	5.08	0.57	0.45	39
CD @ 5%	15.24	1.73	1.35	118
B: Nutrient management				
-1 N1 : RDF (30:60:30:20 NPKS kg ha)	88.22	19.59	8.42	1448
N2 : RDF+ Multimicronutrient grade-II @ 0.5% at 20 DAS	130.11	22.17	10.89	1554
N3 : RDF+ Multimicronutrient grade-II @ 0.5% at 20 DAS+00:52:34 @ 1% at 60 DAS	137.39	23.19	11.45	1625
SE±	5.08	0.57	0.45	39
CD @ 5%	15.24	1.73	1.35	118
Interaction (SxN)				
SE±	8.81	1.00	0.78	68
CD @ 5%	NS	NS	NS	NS
General mean	118.57	21.65	10.25	1543

Conclusion

The spacing of S_1-45 cm x 5 cm proved to be the most effective among the different spacings for obtaining higher growth attributes and soybean seed yield. On the other hand, it was discovered that application N_3-RDF + Multimicronutrient grade-II @ 0.5% at 20 DAS + 00:52:34 @ 1% at 60 DAS was more remunerative for increasing soybean growth characteristics and seed yield.

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