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

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Abstract
During *kharif* season of 2021, a field experiment was carried out at the College of Agriculture, Latur (Maharashtra), at the Farm of Agronomy Section to investigate the "Effect of different spacing and nutrient management on yield and economics of soybean (*Glycine max* L.)". The Factorial Randomized Block Design (FRBD) was used to set up the experiment with nine treatment combinations comprising of two factors i.e., different spacing and nutrient management. 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-Recommended Dose of Fertilizer (30:60:30:20 NPKS kg ha^{-1}), N_2-RDF + multimicronutrint grade-II @ 0.5% at 20 DAS and N_3- RDF+ multimicronutrint grade-II @ 0.5% at 20 DAS+ 00:54:34 @ 1% at 60 DAS. The result of the experiment revealed that spacing S_1- 45 cm × 5 cm recorded significantly highest seed yield, GMR, NMR and BC ratio over spacing S_2- 60 cm × 10 cm and S_3- 60 cm × 15 cm. The nutrient of RDF+ multimicronutrient grade-II @ 0.5% at 20 DAS+ 00:52:34 @ 1% at 60 DAS recorded highest seed yield GMR, NMR and BC ratio.

Keywords: Soybean, different spacing, nutrient management, multimicronutrient grade-II, yield and economics

Introduction

Soybeans (*Glycine max* L.) comes under the papilionaceae sub-family of the family Leguminosea is one of the most important protein and oilseed crops throughout the world. Soybean was introduced in India probablyas soon as it was domesticated in China.

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 yields curved seed pods that are 3–15 cm (1.2–6 in) long and can contain one to five seeds, along with tiny white or purple flowers. The colors of the seeds can range be green, yellow, brown, black or they can have a mottled pattern. Because of its many applications, soybean is sometimes referred to as the "Golden bean" or the "Miracle crop". Soybean seed contains 18-20 percent oil, 40 percent protein, 30 percent carbohydrates, 4 percent saponins and 5 percent fiber. Soybean protein is rich in valuable amino acid, lysine (5%) which is deficient in most of the cereals. It also contains 60 percent polyunsaturated fatty acids (52.8% linolenic acid +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. In general, 87% soil are deficient in sulfur.

These days, zinc is thought to be the biggest obstacle to crop production worldwide. 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. One of the main causes of the decline in the production of plants like soybean, bean, rice, and wheat is zinc deficient soil. A zinc deficiency not only decreased crop productivity and yield, but it also lessened the food value of the crops.

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. Fe is essential for oxidative anabolism's electron transport systems, so a deficit in it has a negative impact on the synthesis of proteins and carbohydrates.

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 important agronomic management techniques that significantly influences soybean crop yield.

In today's agriculture, the high-analysis chemical fertilizers used, less crop residues recycled and the infrequent use of bulky manures result in reduction of micronutrients which lowers crop productivity.

Hence, the field experiment was conducted to investigate the impact of different spacing and nutrient management on yield and economics of soybean (*Glycine max* L.).

Material and Methods

During *kharif* season of 2021, a field experiment was carried out at the College of Agriculture, Latur (Maharashtra), at the Farm of Agronomy Section to investigate the "Effect of different spacing and nutrient management on yield and economics of soybean (*Glycine max* L.)". 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 (18.20 kg ha^{-1}), and its available potassium content was high (498.58 kg ha^{-1}). The soil had a good ability to retain moisture and well-drained. The Factorial Randomized Block Design (FRBD) was used to setup experiment with nine treatment combinations comprising of two factors i.e., different spacing and nutrient management. 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. Each experimental unit had a net plot size of 4.5 m × 3.9 m and a gross plot size of 5.4 m × 4.5 m. On July 9, 2021, pure seed of the soybean variety MAUS-158 was sown by the drilling and dibbling method in accordance with treatments. October 18, 2021, was the harvest date of the crop.

Results and Discussion

Yield

Effect of different spacing

The highest harvest index (40.51%), biological yield (4968 kg ha^{-1}), straw yield (2955 kg ha^{-1}), and seed yield (2013 kg ha^{-1}) were recorded when the spacing of S_1-45 cm x 5 cm was used. This was significantly superior over the wider spacing of S_2-60 cm x 10 cm and S_3-60 cm x 15 cm. Garcia *et al*. (2018) [3], Zhou *et al*. (2011) [9] and Bilal *et al*. (2009) [2] came to similar conclusions. This could be because of a higher plant population under closer spacing, which increased photosynthetic activity and allowed for adequate grain filling which result in increased seed yield. The significantly highest values of number of seed $plant^{-1}$ (140.89), pod yield $plant^{-1}$ (25.77 g) and seed yield $plant^{-1}$ (12.52 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 results of the present investigation are in accordance with the findings 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 $plant^{-1}$ (137.39), pod yield $plant^{-1}$ (23.19 g), seed yield $plant^{-1}$ (11.45 g), seed yield (1625 kg ha^{-1}), straw yield (2392 kg ha^{-1}), biological yield (4017 kg ha^{-1}) and harvest index (40.45%) 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. Similar results were concluded by Gokhle *et al*. (2005) [5] and Thalooth *et al*. (2006) [8].

Interaction (S×N)

The interaction effect of different spacing and nutrient management had no significant effect on soybean yield.

Economics

Effect of different spacing

The spacing of S_1-45 cm x 5 cm recorded highest GMR (Rs. 120828 ha^{-1}), NMR (Rs. 83018 ha^{-1}) and B:C ratio (3.19) which was significantly better than the wider spacing S_2- 60 cm x 10 cm and S_3- 60 cm x 15 cm. Garud *et al*. came to similar conclusions (2015). This could be because of closer spacing produced a higher seed yield, which raised the GMR, NMR, and BC ratio.

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 showed higher GMR (Rs. 97501 ha^{-1}), NMR (Rs. 60477 ha^{-1}), and B:C ratio (2.63) than the application of N_1-RDF (30:60:30:20 NPKS kg ha^{-1}) and found at par with the application of N2-RDF+multimicronutrient grade-II @ 0.5% at 20 DAS. Adkine *et al*. (2011) [11] came to similar conclusions.

Interaction (S×N)

The interaction effect of different spacing and nutrient management on economics of soybean was found to be non-significant.

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

Treatments	No. of seed plant^{-1}	Pod yield plant^{-1} (g)	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
A: Spacing							
S1- 45 cm x 5 cm	85.78	14.53	6.76	2013	2955	4968	40.51
S2- 60 cm x 10 cm	129.06	24.65	11.42	1363	2035	3398	40.11
S3- 60 cm x 15 cm	140.89	25.77	12.58	1251	1872	3123	40.05
SE±	5.08	0.58	0.45	39	74	110	-
CD @ 5%	15.24	1.73	1.36	118	224	332	-
B: Nutrient management							
-1 N1: RDF (30:60:30:20 NPKS kg ha)	88.22	19.59	8.42	1448	2164	3612	40.08
N2: RDF+ Multimicronutrient grade-II @ 0.5% at 20 DAS	130.11	22.17	10.89	1554	2306	3860	40.25
N3: RDF+ Multimicronutrient grade-II @ 0.5% at 20 DAS+00:52:34 @ 1% at 60 DAS	137.39	23.19	11.45	1625	2392	4017	40.45
SE±	5.08	0.58	0.45	39	74	110	-
CD @ 5%	15.24	1.73	1.36	118	224	332	-
Interaction (SxN)							
SE±	8.81	1.00	0.78	68	129	191	-
CD @ 5%	NS	NS	NS	NS	NS	NS	
General mean	118.57	21.65	10.25	1543	2287	3830	40.24

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

Treatment	Seed yield (kg ha^{-1})	Gross monetary returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net monetary return (Rs. ha^{-1})	B:C Ratio
A: Spacing					
S1- 45 cm × 5 cm	2013	120828	37810	83018	3.19
S2- 60 cm × 10 cm	1363	81788	34966	46822	2.33
S3- 60 cm × 15 cm	1251	75061	34397	40664	2.18
SE±	39	2359	-	2359	-
CD @ 5%	118	7072	-	7072	-
B: Nutrient management					
N1: RDF (30:60:30:20 NPKS kg ha-1)	1448	86881	34485	52396	2.51
N2: RDF + Multimicronutrient grade-II @ 0.5% at 20 DAS	1554	93295	35664	57631	2.61
N3: RDF + Multimicronutrient grade-II @ 0.5% at 20 DAS+00:52:34 @ 1% at 60 DAS	1625	97501	37024	60477	2.63
SE±	39	2359	-	2359	-
CD @ 5%	118	7072	-	7072	-
Interaction (S×N)					
SE±	68	4086	-	4086	-
CD @ 5%	NS	NS	-	NS	-
General mean	1543	92560	35724	56836	2.59

Conclusion

The spacing S_1-45 cm x 5 cm turned out to be the most successful among the various spacings for obtaining a higher seed yield and economical characteristics of soybean. Whereas the application of N_3-RDF+Multimicronutrient grade-II @ 0.5% at 20 DAS+00:52:34 @ 1% at 60 DAS was found to be more profitable for increasing seed yield and economical attributes of soybean.

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