Response of Soybean (*Glycine max l.*) to Potassium Fertilizer under Different Crop Geometry

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

An experiment was carried out at experimental cum demonstration field, SVIAg, SVVV, Indore during *rabi* 2023-24. The experiment consists of twelve treatment combinations with three main plot treatment (crop geometry) *viz.* C_1: 30 cm x 20 cm, C_2: 40 cm x 15 cm, and C_3: 60 cm x 10 cm and K_1: 0 kg K_2O ha^{-1}, K_2: 20 kg K_2O ha^{-1}, K_3: 40 kg K_2O ha^{-1}, and K_4: 60 kg K_2O ha^{-1} as four sub-plot treatments (potassium levels). Each experimental unit was replicated thrice having the gross plot size of 4.0 x 3.0 m^2. Sowing of soybean at 30 cm x 20 cm spacing recorded maximum growth attributes, *viz.* plant height (40.92 cm) at harvest, number of branches plant^{-1} (10.66) at harvest, number of functional leaves (27.18) plant^{-1} at 60 DAS, dry matter accumulation plant^{-1} (22.64 g) at harvest, leaf area plant^{-1} (12.64 dm^2) at 60 DAS, number of root nodules plant^{-1} (54.91) at 60 DAS

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and dry weight of root nodules (1.078 g) at 75 DAS, higher yield attributes such as number of pods (37.48) plant^{-1}, number of seeds pods^{-1} (2.68), and number of seeds plant^{-1} (100.88 g). The highest seed yield (15.67 q ha^{-1}), straw yield (24.01 q ha^{-1}), and biological yield (39.68 q ha^{-1}) was also observed under crop geometry of 30 cm x 20 cm. Sowing of soybean at 30 cm x 20 cm obtained higher gross monetary returns (₹ 78337.10 ha^{-1}), net monetary returns (₹ 33714.05 ha^{-1}) and B:C ratio (1.72). While in potassium levels, treatment application of 60 kg K$_2$O ha^{-1} was recorded significantly higher growth parameters of soybean such as., plant height (43.22 cm) at harvest, number of branches (11.30) plant^{-1} at harvest, number of functional leaves (27.42) plant^{-1} at 60 DAS, leaf area (12.82 dm^2) plant^{-1} at 60 DAS, dry matter accumulation plant^{-1} (23.13 g) at harvest, number of root nodules plants^{-1} (56.10) at 60 DAS, and dry weight of root nodules (1.103 g) at 75 DAS, yield parameters viz., number of pods (36.88) plant^{-1}, number of seeds pods^{-1} (2.69) and number of seeds plants^{-1} (103.05), as compared to other potassium levels. Amongst the potassium levels 60 kg K$_2$O ha^{-1} recorded significantly higher seed yield (16.34 q ha^{-1}), straw yield (24.57 q ha^{-1}) and biological yield (40.91 q ha^{-1}) in contrast to the other potassium level. In potassium levels, higher gross monetary returns (₹ 81699.35 ha^{-1}) and net monetary returns (₹ 34450.64 ha^{-1}) were obtained under treatment 60 kg K$_2$O ha^{-1} than rest of treatments with higher B:C ratio (1.69).

1. INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) belongs to family Fabaceae and has Eastern Asian origin. It is one of the most important pulse crops in the world which supplies most of the protein and oil requirements. It is known by various names in different regions such as soja bean, soya bean, Chinese pea and manchurian bean and considered as a 'wonder crop', 'Golden bean' and 'Gold of soil' of the 21st century due to its various quality such as ease in cultivation, less requirement of fertilizer and labour.

In recent years, soya foods have expanded to include fresh beans and sprouts, grain products soya bread, pasta and flour, dairy substitutes such as soymilk, cheese, meat substitutes, soya paneer, soya-yogurt, soya-ice cream, soya-flour, soya fortified food stuffs and biscuits that have good acceptability among the people, because of its cost specific and nutritional advantages (Rathwa et al., 2023). Soybean oil is used as a raw material in manufacturing antibiotics, paints, lubricants varnishes and adhesives *etc*. Soya meal is an excellent feedstuff for livestock and poultry. Soya meal comprises 60 percent of the global oil production.

It is an excellent health food containing 40 to 44% quality protein, 20% cholesterol free oil, 20% carbohydrate and 0.69% phosphorous. Soybean protein has 5% lysine, which is deficit in most of the cereals and enriching the cereal flour with soybean improves the nutritive quality. It's a rich source of fats, amino acids, vitamins and minerals. Nutritionally, soybean oil is high in unsaturated fats, such as oleic acid (OA), linoleic acid (LA), and α-linolenic acid, and represents an important way for consumers to reduce the intake of SFAs, as recommended in the Dietary Guidelines for Americans. LA and ALA are essential fatty acids that must be obtained through dietary intake. Soybean oil is the most common source of LA and ALA, have been linked with a decreased risk of cardiovascular disease.

The efficient production of soybean crop is constraint, with several biotic, abiotic factors, and crop management practices. Fertilization is one of the cultivation technologies that can be done to increase the productivity of plants (Chakrabarty et al., 2014). This is due to the availability of essential nutrients through improved soil capacity providing nutrients, as well as improved physical and biological properties of soil after fertilizer. Potassium (K) is one element in the fertilizer, as it plays an important role in regulating the availability of other nutrients, stimulating the process of photosynthesis and plant growth, assisting in the process of photosynthate distribution, becoming a catalyst in protein synthesis, and improving crop quality. Potassium fertilizer is easy to decompose and very mobile in the ground. It is a vital nutrient to soybean crop involved in numerous cellular activities and reduces susceptibility of soybean to rust disease. Kibet et al., (2023). Most bean crops, one of which is soybean, require high amounts of potassium, so it will be greatly affected if there is a deficiency of potassium. The deficiency of K element can cause a decrease in the number of leaves and

leaf size. Due to its importance in plant growth and development, there is need to undertake more studies on optimisation of K application rates and its effects on growth, grain yield, protein and oil content of selected soybean varieties. The purpose of this study was to determine the level of potassium fertilizer application for the optimum yield, protein and oil content of three soybean varieties.

Spacing is also one of the important parameters, which ultimately affects the nutrients uptake, growth and yield of plant. Increase in spacing, the total population decrease, but with more nutrition the individual plant grows better and get more yield and vice-versa. The increase or decrease of row spacing's and plant population has definite pattern in relation to the yield. In these simultaneous opposing effects of the two components there should be a point where maximum yield is expected and that should be at the optimum spacing. Among various agronomic yield limiting factors, planting pattern is considered of great importance. (Keisham et al., 2021).

Application of fertilizers / nutrients specially potassium in proper amount can help to increase nutrient use efficiency and maintaining the optimum spacing in soybean can help to utilize the resources such as nutrient, water, sunlight, etc. Thus, increasing growth and yield of soybean. Keeping the above points in view, a research work entitled "Response of soybean (*Glycine max.* L.) to potassium fertilizer under different crop geometry." was conducted.

2. MATERIALS AND METHODS

The field experiment was conducted at experimental cum demonstration field, SVIAG, SVVV Indore during 2023. The experimental plot had a plain topography. In view to know the initial fertility status of the soil, representative and composite soil samples were collected from experimental site from 0-30 cm depth randomly from five different locations. The soil samples were analysed in departmental laboratory by using standard analytical methods for determination of soil physical and chemical properties of soil. The soil was clay loam in texture low in available nitrogen (209 kg ha^{-1}), medium in phosphorus (14.65 kg ha^{-1}) and high in potassium (453.12 kg ha^{-1}). The soil organic carbon content, pH, and EC was 0.52%, 7.25, and 0.74 dSm^{-1}, respectively.

The experiment consists of twelve treatment combinations with three main plot treatment (crop geometry) and four sub-plot treatments (potassium levels). The treatments were replicated three times in split plot design. The field was divided into 36 plots with gross plot size of 4.0 m x 3.0 m. The details of the treatment and symbols used during research work are presented in Table 1.

Recommended dose of fertilizer 20:40 kg N: P_2O_5 ha^{-1} and doses of K_2O as per the treatment was applied at the time of sowing to soybean. The truthful seed of soybean (Cv. JS- 9560) was obtained from seed sale unit, Jawaharlal Neharu Krishi Vishwavidyalaya, Jabalpur and treated with *Rhizobium japonicum* before sowing. The line sowing was done under different crop geometry.

The various biometric observations were recorded on five randomly selected plants from each net plot. The selected plants were tied with tags for their easy identification. All the biometric observations were recorded at 15 days interval commencing from 30 after sowing up to harvest. The same plants were harvested separately for generating data on yield attributes. At physiological maturity stage,

Table 1. Details of treatment and symbols used

Sr. No.	Treatments	Symbol
A.	**Main plot treatment (crop geometry)**	
1.	30 cm x 20 cm	C_1
2.	40 cm x 15 cm	C_2
3.	60 cm x 10 cm	C_3
B.	**Sub plot treatment (Potassium levels)**	
1.	0 kg K_2O ha^{-1}	K_1
2.	20 kg K_2O ha^{-1}	K_2
3.	40 kg K_2O ha^{-1}	K_3
4.	60 kg K_2O ha^{-1}	K_4

initially all border rows from each gross plot were harvested separately and thereafter the remaining plots were harvested as net plot produce. Harvesting of soybean was done manually by cutting plants at their base with sickle and harvested produce was kept for drying for 2 days. The sundried soybean plants were threshed by beating the pods. Then seed and straw yield were separated by winnowing and weighed separately. Thus, plot-wise yields obtained were tabulated, analyzed, and interpreted in experimental result.

The evaluation of results were statistically analysed by using the technique of "Analysis of variance" (Fisher, 1950) and test of significance (Panse and Sukhatme,1985) in split plot design.

3. RESULTS AND DISCUSSION

3.1 Effect of Crop Geometry

3.1.1 Growth studies

As per the data presented in Table 2, the crop geometry of 30 cm x 20 cm has shown noticeably greater growth characters such as., plant height (40.92 cm), number of branches plant^{-1} (10.66), number of functional leaves (27.18) plant^{-1}, leaf area plant^{-1} (12.64 dm^2) at 60 DAS, number of root nodules plant^{-1} (54.91) at flowering whereas, dry matter accumulation plant^{-1} (22.64 g) at harvest. The lowest growth characters viz. plant height (36.00 cm), number of branches plant^{-1} (7.94), number of functional leaves (22.74) plant^{-1}, leaf area plant^{-1} (9.60 dm^2) at 60 DAS, number of root nodules plant^{-1} (51.53) at flowering and dry matter accumulation plant^{-1} (18.14 g) at harvest was recorded under treatment 60 cm x 10 cm.

The increased plant height may be due to factors explaining increased plant height in higher plant densities due to reduced inter-row spacing influenced light quantity and quality. The higher plant density can lead to increased competition for sunlight, water, and nutrients. As a response to this competition, soybean plants may produce more branches to increase their leaf area and maximize light capture. Higher density can also lead to change in the levels of hormones such as auxins and cytokinin, which regulate leaf growth and development. These hormonal changes can promote the formation of more leaves in densely planted condition. These results are close conformity with the findings of Khan et al., (2015), Rahman et al., (2013), Singh (2011),

Mondal et al., (2014), Anusha et al., (2021) and Durga et al., (2018).

The increase in total dry matter plant^{-1} could be due to a balance between plant density, air circulation and resources competition resulting in higher total dry matter production. Similar results were recorded by Sharma 2011 and Mondal et al., (2014).

3.1.2 Yield studies

The data related to yield attributes and yield is presented in Table 3. In a similar vein of growth parameters, noticeably higher yield contributing character such as number of pods (37.48) plant^{-1}, number of seeds pods^{-1} (2.68), and number of seeds plant^{-1} (100.88), was recorded in treatment 30 cm x 20 cm. Whereas, the minimum number of pods (29.35) plant^{-1}, number of seeds pods^{-1} (2.55), and number of seeds plant^{-1} (90.15), was recorded under treatment 60 cm x 10 cm.

The highest seed yield (15.67 q ha^{-1}), straw yield (24.01 q ha^{-1}), and biological yield (39.68 q ha^{-1}) at harvest was observed under crop geometry of 30 cm x 20 cm as compared to rest of the crop geometries.

The increase in yield attributes could be due to more favourable growing environment for soybean plants, allowing for reduced competition, better light interception, improved nutrient and water uptake, enhanced air circulation, and healthier root development. The plant geometry of 30 x 20 cm spacing result in reduced plant stress. Lower stress allows the plants to allocate more resources to seed production rather than survival. Similar results were reported by Durga et al., (2018).

Test weight was not influenced significantly due to different crop geometry treatment at harvest.

The seed yield is the chain reaction of growth parameter and yield attributing characters. During the experiment 30 x 20 cm spacing recorded higher values of reproductive parameter of individual plants over other spacing resulting in higher values for seed yield. Increase in dry matter accumulation might result in increase in straw yield. The increase in biological yield could be attributed due to better plant development in more uniform distribution of plants. Similar results were reported by Durga et al., (2018).

Table 2. Growth attributes of soybean as influenced by different treatments

Treatment	Growth attributes					
	Plant height (cm)	Number of branches plant^{-1}	Number of functional leaves plant^{-1}	Leaf area (dm^2) plant^{-1}	Number of root nodules plant^{-1}	Dry matter (gm) plant^{-1}
A) Crop geometry						
C_1: 30 x 20 cm	40.92	10.66	27.18	12.64	54.91	22.64
C_2: 40 x 15 cm	38.92	9.80	25.21	11.85	53.48	20.81
C_3: 60 x 10 cm	36.00	7.94	22.74	9.60	51.53	18.14
S. Em. $\pm$	0.72	0.38	0.68	0.59	0.53	0.76
CD at 5%	2.11	1.11	1.98	1.71	1.56	2.22
B) Potassium level						
K_1: 00 kg ha^{-1}	33.78	8.10	22.84	9.74	50.32	17.69
K_2: 20 kg ha^{-1}	37.22	8.61	23.87	10.49	52.91	19.52
K_3: 40 kg ha^{-1}	40.22	9.86	26.04	12.41	53.90	21.79
K_4: 60 kg ha^{-1}	43.22	11.30	27.42	12.82	56.10	23.13
S. Em. $\pm$	1.13	0.54	0.74	0.75	0.78	0.87
CD at 5%	3.28	1.58	2.17	2.19	2.28	2.54
C) Interaction effect						
C x K	NS	NS	NS	NS	NS	NS
General mean	**38.61**	**9.47**	**25.04**	**11.36**	**53.31**	**20.53**

Table 3. Yield attributes and yield of soybean as influenced by different treatments

Treatment	Yield attributes and yield						
	Number of pods plant^{-1}	No. of seeds pod^{-1}	No. of seeds plant^{-1}	Test weight	Seed yield q ha^{-1}	Straw yield q ha^{-1}	Biological yield q ha^{-1}
A) Crop geometry							
C_1: 30 x 20 cm	37.48	2.68	100.88	107.95	15.67	24.01	39.68
C_2: 40 x 15 cm	35.92	2.64	98.53	106.67	14.07	22.79	36.87
C_3: 60 x 10 cm	29.35	2.55	90.15	105.73	11.33	19.06	30.39
S. Em. +	0.69	0.05	0.84	0.63	0.61	0.46	0.98
CD at 5%	2.03	NS	2.46	NS	1.79	1.34	2.87
B) Potassium level							
K_1: 00 kg ha^{-1}	31.86	2.52	90.23	105.17	10.94	18.85	29.79
K_2: 20 kg ha^{-1}	33.20	2.61	93.81	106.10	12.47	21.46	33.92
K_3: 40 kg ha^{-1}	35.06	2.66	98.99	107.41	15.02	22.94	37.96
K_4: 60 kg ha^{-1}	36.88	2.69	103.05	108.46	16.34	24.57	40.91
S. Em. +	0.83	0.06	1.91	1.07	0.72	0.87	1.52
CD at 5%	2.44	NS	5.58	NS	2.09	2.54	4.45
C) Interaction effect							
C x K	NS	NS	NS	NS	Sig.	Sig.	Sig.
General mean	34.25	**2.62**	**96.52**	**106.78**	**13.69**	**21.96**	**35.65**

Table 3.a. Interaction effect between crop geometry and potassium levels on seed yield of soybean

Crop geometry (C)	Seed yield (q ha^{-1})			
	C_1: 30 x 20 cm^2	C_2: 40 x 15 cm^2	C_3: 60 x 10 cm^2	Mean
Potassium levels (k)				
K_1: OO kg per ha	12.07	11.69	9.05	10.94
K_2: 2O kg per ha	12.82	14.40	10.18	12.47
K_3: 4O kg per ha	13.27	18.14	13.65	15.02
K_4: 6O kg per ha	24.51	12.07	12.44	16.34
Mean	15.67	14.07	11.33	
Source		**S. Em (±)**	**CD at 5%**	
Between two sub plots means at the same level of main plot means		1.24	3.62	
Between two main plots means at the same level of sub plot means		1.16	3.38	

Table 3.b. Interaction effect between crop geometry and potassium levels on straw yield of soybean

Crop geometry (C)	Straw yield $(q\ ha^{-1})$			
Potassium levels (k)	C_1: 30 x 20 cm^2	C_2: 40 x 15 cm^2	C_3: 60 x 10 cm^2	Mean
K_1: OO kg per ha	19.98	20.36	16.21	18.85
K_2: 2O kg per ha	21.49	24.77	18.10	21.46
K_3: 4O kg per ha	21.19	26.06	21.57	22.94
K_4: 6O kg per ha	33.37	19.98	20.36	24.57
Mean	24.01	22.79	19.06	
Source		**S. Em (±)**	**CD at 5%**	
Between two sub plots means at the same level of main plot means		1.50	4.39	
Between two main plots means at the same level of sub plot means		1.02	2.98	

Table 3.c. Interaction effect between crop geometry and potassium levels on biological yield of soybean

Crop geometry (C)	Biological yield $(q\ ha^{-1})$			
Potassium levels (k)	C_1: 30 x 20 cm^2	C_2: 40 x 15 cm^2	C_3: 60 x 10 cm^2	Mean
K_1: OO kg per ha	32.05	32.05	25.26	29.79
K_2: 2O kg per ha	34.31	39.18	28.28	33.92
K_3: 4O kg per ha	34.46	44.19	35.22	37.96
K_4: 6O kg per ha	57.88	32.05	32.81	40.19
Mean	39.68	36.87	30.39	
Source		**S. Em (±)**	**CD at 5%**	
Between two sub plots means at the same level of main plot means		2.64	7.71	
Between two main plots means at the same level of sub plot means		1.44	4.22	

3.1.3 Economic studies

Significantly higher gross monetary returns (₹ 78337.10 ha^{-1}) and net monetary returns (₹ 33714.05 ha^{-1}) of soybean were obtained under crop geometry 30 cm x 20 cm than rest of treatments with higher B:C ratio (1.72), while lowest gross monetary returns (₹ 56655.35 ha^{-1}) and net monetary returns (₹ 15180.72 ha^{-1}) of soybean were obtained under crop geometry 60 cm x 10 cm with B:C ratio of (1.36).

Higher gross monetary returns might have resulted in maximum net monetary returns for soybean crop for the treatment of 30 cm x 20 cm. Also, the higher yield per unit area is directly contributed to increase in net monetary return. These result are in confirmity with finding of Rajeshkumar et al., (2017) and Karwal et al., (2023). Higher gross monetary returns and net monetary returns for soybean crop might have resulted in maximum B: C ratio.

3.2 Effect of Potassium Levels

3.2.1 Growth studies

Application of 60 kg K_2O ha^{-1} was recorded significantly higher growth parameters of soybean such as, plant height (43.22 cm) at harvest, number of branches (11.30) plant^{-1}, number of functional leaves (27.42) plant^{-1}, leaf area (12.82 dm^2) plant^{-1} at 60 DAS, number of root nodules plants^{-1} (56.10) at flowering, dry matter accumulation plant^{-1} (23.13 g) at harvest. The lowest growth characters *viz.* plant height (33.78 cm) at harvest, number of branches (8.10) plant^{-1} at harvest, number of functional leaves (22.84) plant^{-1}, leaf area (9.74 dm^2) plant^{-1} at 60 DAS, number of root nodules plants^{-1} (50.32) at flowering, and, dry matter accumulation plant^{-1} (17.69 g), dry weight of root nodules (0.972 g) at 75 DAS was recorded under treatment 0 kg K_2O ha^{-1}.

The use of larger dose of potash in these treatments may be the cause of the rise in soybean height. The higher potassium level likely provides Potash is known to augment cell division and cell expansion by providing more favourable environment for the plants physiological processes, leading to increased growth attributes of soybean. The growth in total dry matter accumulation can be partially ascribed to the beneficial effect of potash fertilization. The phenomenon could be attributed to increased photosynthetic activity, which is subsequently followed by the effective transfer of metabolites and their accumulation. These results are close conformity with Thesiya et al., (2012), Dixit et al. (2011) and Sherawat and Singh (2009).

3.2.2 Yield studies

The potassium level 60 kg ha^{-1} recorded significantly highest number of pods (36.88) plant^{-1}, number of seeds pods^{-1} (2.69) and number of seeds plants^{-1} (103.05), as compared to other potassium levels. Whereas, minimum number of pods (31.86) plant^{-1}, number of seeds pods^{-1} (2.52) and number of seeds plants^{-1} (90.23) was recorded in treatment 0 kg K_2O ha^{-1}.

Table 4. Economics of soybean as influenced by different treatments

Treatments	Gross monetary returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net monetary returns (₹ ha^{-1})	B:C ratio
A) Crop geometry				
C_1: 30 x 20 cm	78337.10	44623.05	33714.05	1.72
C_2: 40 x 15 cm	70371.42	43760.64	26610.77	1.60
C_3: 60 x 10 cm	56655.35	41474.63	15180.72	1.36
S. Em. +	3067.47	--	3067.47	--
CD at 5%	8953.75	--	8953.75	--
B) Potassium level				
K_1: 00 kg per ha	54675.72	38924.50	15751.22	1.40
K_2: 20 kg per ha	62342.89	41889.19	20453.69	1.48
K_3: 40 kg per ha	75100.55	45082.03	30018.52	1.66
K_4: 60 kg per ha	81699.35	47248.71	34450.64	1.69
S. Em. +	3584.59	--	3584.59	--
CD at 5%	10463.192	--	10463.19	--
C) Interaction effect				
C x K	NS	NS	NS	NS
General mean	68454.63	43286.11	25168.52	1.56

Amongst the potassium levels 60 kg K_2O ha^{-1} recorded significantly higher seed yield (16.34 q ha^{-1}), straw yield (24.57 q ha^{-1}) and biological yield (40.91 q ha^{-1}) in contrast to the other potassium level. While lowest seed yield (10.94 q ha^{-1}), straw yield (18.85 q ha^{-1}) and biological yield (29.79 q ha^{-1}) was noticed under treatment 0 kg K_2O ha^{-1}.

Test weight of soybean was not influenced significantly due to different potassium levels at harvest.

Increase in number of pods could be attributed to the fact that potassium plays a significant role in photosynthesis by regulating the opening and closing of stomata, the pores on leaves that control gas exchange. Adequate potassium ensures better carbon dioxide uptake thus more efficient photosynthesis, providing more energy for pod formation. Potassium enhances various physiological processes in plants, including photosynthesis, nutrient transport, and stress resistance. These improvements contribute to better pod and seed development, ultimately leading to an increased number of seeds pod^{-1}. Similar results were reported by kjam et al., (2023) and Thesia et al., (2013).

By providing 60 kg of potassium, plants receive a more optimal nutrient balance, which can result in improved growth conditions and higher seed yield. Similar results were described by Mali et al., (2017) and Farhad et al., (2010) with the increase in potassium level yield of crop also increase.

The increase in biological yield with the increase in potassium level may be due to the positive effect of K on crop yield might also be requirement in carbohydrate synthesis and translocation of photosynthesis and may be due to improved yield attributing characters, shoot growth and nodulation. Similar results were reported by Chaudhari et al., (2018).

3.2.3 Economic studies

Significantly higher gross monetary returns (₹ 81699.35 ha^{-1}) and net monetary returns (₹ 34450.64 ha^{-1}) of soybean were obtained under in treatment 60 kg K_2O ha^{-1} than rest of treatments with higher B:C ratio (1.69), while lowest gross monetary returns (₹ 54675.32 ha^{-1}) and net monetary returns (₹ 15751.22 ha^{-1}) of soybean were obtained under 60 kg K_2O ha^{-1} with B:C ratio of (1.40).

Higher gross monetary returns and net monetary returns for soybean crop might have resulted in maximum B: C ratio. These result are in confirmity with finding of Karwal et al.,(2023).

3.3 Interaction Effects of Crop Geometry and Potassium Levels

The interaction effects between crop geometry and potassium levels in relation to growth attributes, yield attributes and economics was found to be non-significant. The interaction effects between crop geometry and potassium levels on seed yield, straw yield and biological yield was found to be significant. Sowing of soybean at 30 cm x 20 cm along with 60 kg K2O ha^{-1} recorded highest seed yield, straw yield and biological yield as compared to rest of the treatment combination.

4. CONCLUSION

Based on experimentation, it could be concluded that sowing at 30 cm x 20 cm along with application of 60 kg potassium ha^{-1} registered maximum growth, yield attributes, yield and quality parameters of soybean. The spacing 30 cm x 20 cm proved to be the most effective among the different spacing for obtaining higher net monetary returns, gross monetary returns and B:C ratio. On the other hand, it was discovered that application of 60 kg K_2O ha^{-1} was more remunerative.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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