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Response of *kharif* soybean (*Glycine max* L. Merrill) varieties to sulphur levels with respect to growth, yield and economics

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Abstract
The current investigation was carried out during *kharif* season of 2018 to study the effect of different soybean varieties, sulphur levels and their interaction at Post Graduate Research Farm, R.C.S.M. College of Agriculture, Kolhapur (MS) in split plot design with three replication and 15 treatment combinations consist of five varieties and three sulphur levels, on medium black soil. The variety KDS 726 produced maximum plant height, plant spread, number of branches, leaf area and number of functional leaves than rest of the varieties, however on par with the variety KDS 344 with respect to plant height and number of branches throughout the growth period. The yield were also maximum with the variety KDS 726, however it was comparable with the variety KDS 344. As a result, the variety KDS 726 had the highest seed (28.57 q ha^{-1}) and stover (42.56 q ha^{-1}) yields. The variety KDS 726 had maximum gross monetary returns (Rs. 84,117 ha^{-1}), net monetary returns (Rs. 48,225 ha^{-1}) and B: C ratio (2.34) than rest of the varieties. Various growth attributing characters were influenced significantly due to application of sulphur levels. The growth parameters such as plant height, plant spread, number of branches, leaf area and number of functional leaves were maximum and influenced significantly by application of 30 Kg S ha^{-1}, however comparable with the application of sulphur @ 20 Kg ha^{-1}. The yield were also maximum and influenced significantly by application of 30 Kg S ha^{-1} but on par with 20 Kg S ha^{-1}. As a result the application of 30 Kg S ha^{-1} had the highest seed (26.76 q ha^{-1}) and stover (39.73 q ha^{-1}) yields. The application of 30 Kg S ha^{-1} had maximum gross monetary returns (Rs. 81,072 ha^{-1}), net monetary returns (Rs. 44,968 ha^{-1}) and B: C ratio (2.24) than application of 10 Kg sulphur ha^{-1}.

Keywords: Variety, sulphur, yield, economics, soybean

Introduction
Soybean is reported to have originated in Eastern Asian countries while the cultivated soybean originated in China during 2800 BC. Soybean has become the miracle crop of the 21st century. It belongs to the family Leguminosae, sub-family Papilionaceae and the genus Glycine. It is a triple beneficiary crop, which contains about 40 per cent protein, possessing high level of essential amino-acids methionine and cystine, 20 per cent oil rich in poly unsaturated fatty acids especially omega-6 and omega-3 fatty acids, 6-7 per cent total minerals, 5-6 per cent crude fiber and 17-19 per cent carbohydrates (Chauhan *et al*., 1988) [5]. Besides, it has good amount of iron, vitamin B-complex and isoflavones such as daidzein, genistein of clycitein. Presence of calcium and iron makes it highly suitable for women who suffer from osteoporosis and anemia. The isoflavones of soybean have been found to possess health benefits, as they exhibited properties like cancer prevention, combating menopausal problem and helping to recover from diabetes (Chauhan *et al.*, 2002) [6]. Soybean was considered only as a food and fodder crop till World War-II when its potential as an oilseed crop was realized. Due to its multifaceted uses, soybean has since progressed by leaps and bounds as an oilseed crop. On the global scale it has come to the top of the list of oilseed crops and contributes over one-third of the total supply of the world vegetable oil pool. Indians as such, know soybean since ages as it was in cultivation in northern and north-eastern hills as food plant and is a part of routine diet of the people (Tiwari *et al.*, 1999) [17]. Black-seeded soybean has been grown since early times in the northern and north eastern hills and in scattered area in the central part of the country. Soybean was introduced in India probably as soon as it was domesticated in China (Tiwari and Karmakar, 2000) [18]. India is also considered as a secondary centre of domestication for soybean (Boyden, 1992 and Khoshoo, 1995) [3, 14].

Sulphur performs many important functions in the plant. It is best known for its role in the synthesis of proteins, oils and vitamins. It is a constituent of three amino acids *viz.*, methionine, cysteine and cystine. Sulphur is also a constituent of S-glycosides (mustard oils), coenzyme A, vitamins, biotine and thiamine as also of iron-sulphur proteins called ferrodoxins. Volatile S-compounds, mainly disulphides or polysulphides are the source of pungency in onions. Sulphur is also known to promote nodulation in legumes, thereby promoting nitrogen fixation. Sulphur is associated with production of crops of superior nutritional and market quality.

Materials and Methods

The field experiment was conducted at Post Graduate Research Farm, R.C.S.M. College of Agriculture, Kolhapur during *Kharif* 2018. The topography of experimental field was fairly uniform and levelled. The soil was vertisol (medium black) in nature and about one meter deep with good drainage. The soil of the experimental field possess pH 7.68, EC 0.30 dS m^{-1}, organic carbon 0.18%, whereas available N, P_2O_5, K_2O and S were to the tune of 207.00, 28.70, 287.00 and 7.42 kg ha^{-1}, respectively. The 15 treatment combinations consist of five varieties *viz.*, V_1-DS 228 (Phule Kalyani), V_2-KDS 344 (Phule Agrani), V_3-JS 335, V_4-KDS 726 (Phule Sangam) and V_5-JS 9305and three sulphur levels *viz.*, S_1 (10 kg Sha^{-1}), S_2 (20 kg S ha^{-1}) and S_3 (30 kg S ha^{-1}) replicated three times in split plot design.

Sulphur was applied as per treatments before a week of sowing in the experimental field. All the other recommended package of practices were followed throughout experimentation. Fertilizers were applied uniformly at the rate of 50 kg N and 75 kg P_2O_5 and 45 kg K_2O ha^{-1} by broadcasting method before sowing.

Result and Discussion

I) Growth parameters

Effect of varieties

The different growth attributing characters as influenced by different treatment were presented in Table 1. The significantly highest values of all growth characters viz. plant height, plant spread, number of branches, leaf area and number of functional leaves at 75 DAS were recorded by variety KDS 726, however it was comparable with the variety KDS 344. Both these varieties were significantly superior over other varieties v*iz.*, JS 9305, DS 228 and JS 335. However, Sharma *et al*., (2009) [16] reported the highest plant height with variety JS 335 compared to other varieties under study.

Effect of sulphur levels

The different growth attributing characters as influenced by different treatment were presented in Table No 1. The plant height, plant spread, number of branches, leaf area and number of functional leaves of soybean recorded at 75 DAS was maximum with application of sulphur @ 30 kg ha^{-1}, however it was comparable with 20 kg sulphur ha^{-1} at all the stages. Similarly the lowest dose of sulphur application @ 10 kg ha^{-1} found to be comparable with 20 kg suphur application ha^{-1} at the 75 days after sowing. The increase in plant height, plant spread, number of branches, leaf area and number of functional leaves as observed in the experiment may be due to the favorable effects of sulphur – metabolism and consequently on the vegetative growth of soybean plant (Akter *et al*., 2013). Similar findings were also reported in groundnut (Chaubey *et al.,* 2000) [4] and linseed (Dubey *et al.,* 1997) [8].

II) Yield

Effect of varieties

The mean seed yield, stover yield and harvest index of soybean as influenced by different treatments presented in Table 2. The data revealed that among the varieties the variety KDS 726 produced maximum mean seed yield, stover yield and harvest index after harvest and found significantly superior than the varieties JS 335, DS 228 and JS 9305, however comparable with the variety KDS 344. However, Kathmale *et al.,* (2013) [13] assessed the performance of five genotypes at different locations and concluded that genotype like KDS 347, KDS 378, MAUS-450 should be preferred for higher yield.

Effect of sulphur levels

The data in Table No 2. implied that application of 30 kg S ha^{-1} recorded the highest mean seed yield, stover yield and harvest index as compared to rest of the sulphur levels, however on par with sulphur fertilization @ 20 kg ha^{-1} and significantly superior over 10 kg S ha^{-1}. Mean seed yield, stover yield and harvest index increased with each increment in the level of sulphur.

The sulphur fertilization played a vital role in improving the three major aspects of yield determination i.e. formation of vegetative structure there by photosynthesis strong sink strength through development of reproductive structure and production of assimilates to fill economically important sink. Thus cumulative influence of S application maintained balance in source-sink relationship and ultimately resulted in increased seed yield. The results are in close conformity with the findings of Ganeshmurthy A. N., (1996) [9], Jat L. N., (1997) [12] and Hussain *et al.,* (2011) [11].

Hosmath *et al.,* (2014) [10] reported that sulphur is an important nutrient for the higher yield of soybean crop. Arun Sharma (2011) [1] and Mengel and Kirkby (1996) documented that when supply of sulphur is optimum, greater translocation of photosynthates occurs from leaves to seed.

Economics

Effect of varieties

The variety KDS 726 had maximum gross monetary returns (Rs. 84,117 ha^{-1}), net monetary returns (Rs. 48,986 ha^{-1}) and B: C ratio (2.34) than rest of the varieties. It seems that the variety KDS-726 is significantly superior over rest of the varieties under comparison. The next in order were KDS-344, JS-335, DS-228 and JS-9305.

Effect of sulphur levels

The application of 30 Kg S ha^{-1} had maximum gross monetary returns (Rs. 81,072 ha^{-1}), net monetary returns (Rs. 44,968 ha^{-1}) and B: C ratio (2.24) than 10 kg ha^{-1} sulphur levels. Similarly, Chauhan *et al.,* (2006) [7] at Ujjain, Madhya Pradesh obtained maximum net monetary returns with 20 kg sulphur ha^{-1} as compared to the control treatment. The same trend was also noticed by Hosmath *et al.,* (2014) [10] at Dharwad.

Table 1: Effect of varieties and sulphur levels on growth parameters of soybean at 75 DAS

Treatments	Mean plant height (cm)	plant spread (cm)	Number of Branches	Leaf Area (dm^2)	Number of Functional Leaves
Main Plot : Soybean varieties					
V_1- DS 228 (Phule Kalyani)	47.43	29.11	5.85	131.85	62.78
V_2- KDS 344 (Phule Agrani)	62.58	33.95	6.17	206.78	94.91
V_3- JS 335	44.17	31.95	5.69	154.04	89.64
V_4- KDS 726 (Phule Sangam)	63.58	36.91	6.29	267.73	113.30
V_5- JS 9305	53.40	30.76	5.59	121.70	63.88
S. Em±	0.93	0.46	0.11	3.19	3.26
C. D. at 5%	3.02	1.50	0.37	9.59	9.99
C. V. %	6.12	5.24	5.75	6.00	10.96
Sub Plot : Sulphur levels					
S_1 - 10 Kg S ha^{-1}	52.48	31.14	5.72	171.05	80.07
S_2 - 20 Kg S ha^{-1}	54.37	32.69	5.92	174.84	83.77
S_3 - 30 Kg S ha^{-1}	55.84	33.78	6.15	183.38	88.87
S. Em±	0.72	0.70	0.11	3.10	2.40
C. D. at 5%	2.14	2.10	0.31	9.59	7.09
C. V. %	6.18	8.30	6.92	6.81	11.09
Interaction : V × S					
S. Em±	1.62	1.56	0.24	6.94	5.37
C. D. at 5%	NS	NS	NS	NS	NS
General mean	54.23	32.53	5.93	176.42	83.90

Table 2: Effect of varieties and sulphur levels on yield of soybean

Treatments	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest Index (%)
Main Plot : Soybean varieties			
V_1- DS 228 (Phule Kalyani)	23.24	35.62	39.97
V_2- KDS 344 (Phule Agrani)	26.93	40.68	42.35
V_3- JS 335	24.71	37.45	40.18
V_4- KDS 726 (Phule Sangam)	28.57	42.56	44.01
V_5- JS 9305	22.22	33.05	40.44
S. Em±	0.57	0.85	0.84
C. D. at 5%	1.71	2.57	2.59
C. V. %	7.29	7.24	6.75
Sub Plot : Sulphur levels			
S_1 - 10 Kg S ha^{-1}	23.72	36.39	39.61
S_2 - 20 Kg S ha^{-1}	24.92	37.49	40.72
S_3 - 30 Kg S ha^{-1}	26.76	39.73	43.84
S. Em±	0.71	0.91	1.15
C. D. at 5%	2.09	2.72	3.42
C. V. %	10.93	9.45	10.85
Interaction : V × S			
S. Em±	1.59	2.07	2.59
C. D. at 5%	NS	NS	NS
General mean	25.13	37.87	41.39

Table 3: Effect of varieties and sulphur levels on economics of soybean after harvest

Treatments	Gross monetary returns (Rs ha^{-1})	Net monetary returns (Rs ha^{-1})	B:C Ratio
Main Plot : Soybean varieties			
V_1- DS 228 (Phule Kalyani)	72186	37055	2.08
V_2- KDS 344 (Phule Agrani)	79285	44154	2.23
V_3- JS 335	76380	41249	2.17
V_4- KDS 726 (Phule Sangam)	84117	48986	2.34
V_5- JS 9305	69578	34447	2.02
S. Em±	1612.33	1612.33	-
C. D. at 5%	4834	4834	-
C. V. %	1.58	1.58	-
Sub Plot : Sulphur levels			
S_1 - 10 Kg S ha^{-1}	71734	37655	2.10
S_2 - 20 Kg S ha^{-1}	76071	40861	2.16
S_3 - 30 Kg S ha^{-1}	81072	44968	2.24
S. Em±	1670.88	1670.88	-
C. D. at 5%	5011	5011	-
C. V. %	1.26	2.07	-
Interaction : V × S			
S. Em±	3341.76	3341.76	-

C. D. at 5%	NS	NS	-
General mean	76292	41161	2.17

Conclusion

Based on the result of research experimentation it can be concluded that

1. Among the varieties KDS 726 (Phule Sangam) is suitable for Kolhapur region.
2. Among the sulphur levels tried, the application of sulphur @ 20 kg ha^{-1} can be recommended for better yields.
3. Based on economics, the soybean variety, KDS 726 (Phule Sangam) and sulphur fertilization @ 20 kg ha^{-1} can be adopted for the highest gross, net monetary return as well as B: C ratio in Kolhapur region.

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