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Response of *kharif* soybean (*Glycine max*) varieties to sulphur levels with respect to yield and quality

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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 the Post Graduate Research Farm, R.C.S.M. College of Agriculture, Kolhapur (MS) in split plot design with three replication and 15 treatment combinations consisting five varieties and three sulphur levels on medium black soil. The yield and quality attributes like number of pods plant^{-1}, weight of pods plant^{-1}, number of seeds pods^{-1}, weight of seeds plant^{-1}, 100 seeds weight, oil and protein content as well as 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}) yield. Similarly the oil and the protein content (19.36% and 43.16%) was also maximum in the variety KDS 726. As regards to the sulphur levels the yield and quality attributes like number of pods plant^{-1}, weight of pods plant^{-1}, weight of seeds plant^{-1}, 100 seeds weight, oil and protein content as well as yield were also maximum and influenced significantly by application of 30 Kg S ha^{-1} but comparable 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, as well as the oil and the protein content (19.06% and 42.92%).

Keywords: Variety, sulphur, yield, quality, soybean

Introduction

Soybean (*Glycine max* L.) is known as Chinese pea and Manchurian bean. Soybean is the major oilseed crop in the world, accounting for nearly 50% of the total oilseeds acreage as well as production. It stands third in vegetable oil economy in India, after groundnut and rapeseed-mustard. 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) [4]. 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) [5]. 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) [20]. 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) [21]. 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 bears pH 7.68, EC 0.30 dS m^{-1} and organic carbon 0.18%, The available nutrient viz. N, P_2O_5, K_2O, S were 207.00, 28.70, 287.00 and 7.42 kg ha^{-1}, respectively. The 15 treatment combinations consisting 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 9305 and 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

Yield parameters

Effect of varieties

The different yield attributing characters recorded at harvest as influenced by different treatments are presented in Table 1. The significantly highest values of all growth characters viz. number of pods $plant^{-1}$, weight of pods $plant^{-1}$, number of seeds pod^{-1}, weight of seeds $plant^{-1}$ and 100 seeds weight at harvest were recorded by variety KDS 726, however it was comparable with the variety KDS 344. Both these varieties are significantly superior over other varieties v*iz.*, JS 335, DS 228 and JS 9305. The results of field experiment in M.P. showed better performance of cultivar JS-73-22 than three cultivars tested by Thakur *et al*., (2003) [19].

Effect of sulphur levels

The data presented in Table 1. Revealed that application of 30 kg S ha^{-1} recorded significantly the highest mean number of pods $plant^{-1}$, weight of pods $plant^{-1}$, number of seeds pod^{-1}, weight of seeds $plant^{-1}$ and 100 seeds weight as compared to rest of the sulphur levels, however comparable with 20 kg S ha^{-1} at the time of harvest. The mean number of pods $plant^{-1}$, weight of pods $plant^{-1}$, number of seeds pod^{-1}, weight of seeds $plant^{-1}$ and 100 seeds weight increased with increasing levels of sulphur and reached maximum with 30 kg S ha^{-1}. The increasing rate of soil application of sulphur to S deficient soil must have increased the number of pods $plant^{-1}$ as reported earlier by Shivran *et al.,* (2012) and Devi, K. N. (2012) [18, 6].

Soybean yield

Effect of varieties

The mean seed yield, stover yields and harvest index of soybean as influenced by different treatments presented in Table 2. The data in table reveled that among the varieties the variety KDS 726 produced maximum mean seed yield, stover yields 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, which produced comparable seed yield.

Effect of sulphur levels

The yield data as influenced by different treatment presented in Table 2. Revealed 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 yields and harvest index increased with each increasing levels 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) [7], 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) [2] and Mengel and Kirkby (1996) [16] documented that when supply of sulphur is optimum, greater translocation of photosynthates occurs from leaves to seed.

Quality parameters

Effect of varieties

The mean oil content, protein content, oil yield and protein yield differed significantly due to different varieties of soybean presented in Table 2. The variety KDS 726 produced maximum mean oil content, protein content, oil yield and protein yield in seed after harvest and found significantly superior than the varieties, JS 335, DS 228 and JS 9305, however comparable with the variety KDS 344. Patel *et al.,* (2012) [17] reported the suitability of early genotype JS-81-1504 than other under test.

Effect of sulphur levels

The application of 30 kg S ha^{-1} recorded significantly the highest mean oil content, protein content, oil yield and protein yield in seed as compared to 10 kg ha^{-1} the sulphur levels, however on par with the application of sulphur @ 20 kg S ha^{-1} after harvest. Mean oil content, protein content, oil yield and protein yield in seed increased with each increasing level of sulphur application.

The high response of soybean was observed by the balanced application of N and S. These nutrients involved in the biosynthesis of proteins and many other important biomolecules, a balanced application of S and N enhanced their use efficiency in crop plants. Maximum oil yield was obtained in rapeseed mustard only, when S and N applications were balanced Ahmad *et al.,* (1998) [1]. As well as Gokhale *et al.,* (2005) [8] recorded highest oil content (37.26%) in soybean with application of 40 kg S ha^{-1}. Oil seed crops responsed to liberal application of sulphur because it is involved in the synthesis of fatty acids and also increased protein quality through the synthesis of certain amino acids such as cystine, cysteine and methionine as reported by Havlin *et al.,* (1999) [9]. The increase in protein content of soybean with increasing level of S was also reported by Kumawat *et al*., (2000) [15].

Conclusion

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

1. Among the soybean varieties KDS 726 (Phule Sangam) is suitable for Kolhapur region.
2. The sulphur application @ 20 Kg ha^{-1} is beneficial for better yield and quality of soybean.

Table 1: Effect of varieties and sulphur levels on yield parameters of soybean at harvest

Treatments	Number of pods $plant^{-1}$	Weight of pods $plant^{-1}$ (g)	Number of seeds pod^{-1}	Weight of seeds $plant^{-1}$ (g)	100 seeds weight (g)
Main Plot : Soybean varieties					
V_1- DS 228 (Phule Kalyani)	54.26	27.97	2.59	18.35	12.47
V_2- KDS 344 (Phule Agrani)	69.73	35.66	2.87	23.76	12.82
V_3- JS 335	57.20	28.41	2.50	19.51	12.23
V_4- KDS 726 (Phule Sangam)	72.23	37.92	2.92	25.11	13.03
V_5- JS 9305	52.28	27.12	2.67	18.00	11.98
S. Em±	1.45	0.90	0.02	0.44	0.17
C. D. at 5%	4.48	2.76	0.06	1.37	0.50
C. V. %	7.74	8.07	5.06	7.03	5.68
Sub Plot : Sulphur levels					
S_1 - 10 Kg S ha^{-1}	58.76	29.93	2.70	19.93	12.15
S_2 - 20 Kg S ha^{-1}	60.96	30.97	2.70	20.83	12.51
S_3 - 30 Kg S ha^{-1}	63.70	33.35	2.73	22.09	12.86
S. Em±	1.30	0.90	0.03	0.56	0.18
C. D. at 5%	3.87	2.71	NS	1.66	0.55
C. V. %	8.31	11.31	2.17	10.43	5.75
Interaction : V × S					
S. Em±	2.93	2.05	0.06	1.26	0.42
C. D. at 5%	NS	NS	NS	NS	NS
General mean	60.14	31.42	2.71	20.95	12.51

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 quality of soybean after harvest

Treatments	Oil content in seed (%)	Oil yield (kg ha^{-1})	Protein content in seed (%)	Protein yield (kg ha^{-1})
Main Plot : Soybean varieties				
V_1- DS 228 (Phule Kalyani)	17.76	414.41	41.31	962.38
V_2- KDS 344 (Phule Agrani)	18.80	509.06	42.85	1158.45
V_3- JS 335	17.97	444.53	40.23	998.38
V_4- KDS 726 (Phule Sangam)	19.36	555.20	43.16	1235.81
V_5- JS 9305	17.34	388.34	40.75	911.73
S. Em±	0.45	17.48	0.53	29.73
C. D. at 5%	1.38	52.44	1.63	89.19
C. V. %	7.05	10.34	5.60	8.47
Sub Plot : Sulphur levels				
S_1 - 10 Kg S ha^{-1}	17.66	421.73	40.53	966.94

S_2 - 20 Kg S ha^{-1}	18.16	456.71	41.54	1039.63
S_3 - 30 Kg S ha^{-1}	19.06	514.48	42.92	1153.47
S. Em±	0.31	19.73	0.63	44.80
C. D. at 5%	0.92	59.19	1.88	134.4
C. V. %	7.13	11.53	6.03	10.47
Interaction : V × S				
S. Em±	0.70	44.13	1.43	100.18
C. D. at 5%	NS	NS	NS	NS
General mean	18.24	462.31	41.66	1053.35

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