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Research Article

INFLUENCE OF NITROGEN AND SULPHUR APPLICATION ON NUTRIENT UPTAKE, PROTEIN CONTENT AND YIELD PARAMETERS OF SOYBEAN

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ABSTRACT
The present investigation reports the effect of nitrogen and sulphur application on nutrient uptake, protein content and yield parameters in SL525 soybean cultivar in year 2013. In pot experiment, soybean plants were grown under different treatments viz. control, recommended dose of nitrogen as urea @ 31.25 kg N ha^{-1}, sulphur as gypsum @ 20 kg S ha^{-1} or in combination. Nutrient uptake and protein content in soybean seeds increased in all the treatments as compared to control whereas N alone or combined with S significantly increased seed yield. Data suggested that S (gypsum @ 20 kg S ha^{-1}) significantly increased nutrient uptake and seed yield when given alongwith recommended dose of N and can be used as optimum recommended source for improving soybean seed yield under local agroclimatic conditions.

Keywords: *Nitrogen, Nutrient Uptake, Protein, Seed Yield, Soybean, Sulphur*

INTRODUCTION

Soybean seed is an excellent source of vegetable protein for both humans and livestock. It has high yield potential, wide adaptability and high nutritional quality with multiple uses as food and industrial products. It can also fix large amount of atmospheric nitrogen and takes up residual and mineralized N from the soil (Yadav *et al.*, 2013). Both nitrogen (N) and sulphur (S) are important components of seed storage proteins and their uptake and mobilization from vegetative tissue to seed is important for protein production and amino acid composition. Nitrogen is also an integral part of many compounds such as chlorophyll, enzymes essential for plant growth processes, nucleic acids and proteins (Marschner, 2002). It is necessary for carbohydrate use in plants and for stimulation of root growth, and development as well as uptake of other nutrients, improvement of soil fertility and improved yield (Morshed *et al.*, 2009). Sulphur plays an important role in various plant growth and developmental processes being a constituent of S containing amino acids methionine (21% S) and cysteine (27% S) and other metabolites such as glutathione (Devi *et al.*, 2012).

Soybean is not able to meet the high N requirements from symbiotic N fixation, so chemical nitrogenous fertilizers are being used for obtaining high yields and also maintaining the soil N level throughout the world. Nitrogen plays an important role in improving yield, protein content and nutrient uptake of soybean (Morshed *et al.*, 2008). Lack of S limits the efficiency of added N, so S addition is required to achieve maximum efficiency of applied N fertilizers (Fazli *et al.*, 2008). Application of S fertilzers also increases its uptake and seed yield (Piri *et al.*, 2011).

The nutritional aspects of soybean grown in Punjab region of northwest India have been studied in detail (Goyal *et al.*, 2012; Sharma *et al.*, 2004). But soybean is not yet been popularized due to its low yield as compared to rice under crop diversification. Different agronomic practices are being employed to improve seed yield. The recommended dose of N for optimum yield is urea @ 31.25 kg N ha^{-1}. Earlier studies in our laboratory have shown that application of different S sources and doses increased the protein quality parameters in soybean and maximum effects were observed with gypsum @ 20 kg S ha^{-1}. This paper reports the effect of recommended dose of N (urea @ 31.25 kg N ha^{-1}) and S (gypsum @ 20 kg S ha^{-1}) alone or in combination on nutrient uptake, protein content and yield in soybean.

MATERIALS AND METHODS

A pot experiment was conducted at the experiment space of Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana, Punjab, during *Kharif* season of year 2013, using soybean cultivar SL525 as test crop. The experiment was laid out in randomized block design with four different treatments; each treatment replicated four times. The four fertilizer treatments were control (no fertilizer), application of urea @ 31.25 kg N ha^{-1}, gypsum @ 20 kg S ha^{-1} and combined application of urea @ 31.25 kg N ha^{-1} and gypsum @ 20 kg S ha^{-1}. The experimental soil was sandy loam in texture having pH 7.6, electrical conductivity 0.27 mmoles cm^{-1}, organic carbon 0.57 % and available phosphorus and potassium contents were 9.6 and 114 kg $acre^{-1}$, respectively. Cemented pots with diameter 40 cm were initially filled up to 1/3rd level with dried soil collected from experimental farm of Punjab Agricultural University, Ludhiana. Fertilizers were mixed with the soil according to the dose and then, fertilizer mixed soil was added in the upper 15 cm area of the pots. Pots were laid out according to the experimental design and placed at least one meter apart from one another in fields.

Soybean seeds were soaked in distilled water for 16 h and put for germination (15 seeds/row) in plastic trays containing wet sand under glass house conditions. The trays were regularly sprinkled with water to maintain the required moisture until the seedlings emerged. Five healthy seedlings were then transplanted to the pots filled with fertilizer mixed soil. Weed removal was done whenever necessary to keep the plants healthy. Different plant growth related parameters viz. plant height, pods per plant, seeds per pod were recorded before harvesting. The plants were collected from each pot at maturity and seed yield per plant, 100 seed weight was determined. Seeds were further analyzed for total nitrogen (Mckenzie and Wallace, 1954), sulphur (Chesnin and Yien, 1950), phosphorus and potassium content. Total nitrogen in seeds was estimated by Kjeldahl method using KEL PLUS System (*Pelican Equipments*, India). Phosphorus and potassium contents were determined by vanadomolybdo phosphoric yellow colour method and flame photometer method, respectively. Data was subjected to analysis of variance (ANOVA, $P \leq 0.05$) using CPCS1 software. Differences among treatments were analysed by applying Tukey's post-hoc test using SPSS version 16.0 software.

RESULTS AND DISCUSSION

Total N and crude protein content in soybean seeds increased significantly after S treatment alone as compared to other treatments (Table 1). Similarly, P, K and S increased significantly in S treatment as compared to control as well as other treatments. N and S uptake by seeds increased significantly in all the treatments in comparison to control and maximum increase was observed in combined application of N and S although the values varied non-significantly among different treatments (Table 2). Phosphorus uptake increased significantly after gypsum application than control and other treatments. Potassium uptake by seeds increased significantly in all treatments as compared to control and maximum increase was observed by the treatment of S followed by application of N alone or combined with S, respectively.

Table 1: Effect of nitrogen and sulphur supply on protein and nutrient content of soybean seeds

Treatment	**Crude Protein (%)**	**Nutrient content in seeds (%)**			
		N	**P**	**K**	**S**
Control	$38.70^{b} \pm 1.84$	$6.78^{b} \pm 0.32$	$0.10^{b} \pm 0.01$	$1.96^{b} \pm 0.07$	$0.49^{c} \pm 0.22$
Nitrogen (Urea @ 31.25 kg N ha^{-1})	$39.49^{ab} \pm 2.18$	$6.92^{ab} \pm 0.38$	$0.09^{b} \pm 0.01$	$2.06^{b} \pm 0.06$	$0.50^{c} \pm 0.17$
Sulphur (Gypsum @ 20 kg S ha^{-1})	$45.14^{a} \pm 0.28$	$7.91^{a} \pm 0.04$	$0.15^{a} \pm 0.01$	$2.67^{a} \pm 0.14$	$0.68^{a} \pm 0.23$
Nitrogen (Urea @ 31.25 kg N ha^{-1}) + Sulphur (Gypsum @ 20 kg S ha^{-1})	$39.09^{ab} \pm 3.67$	$6.85^{ab} \pm 0.64$	$0.08^{b} \pm 0.01$	$1.92^{b} \pm 0.07$	$0.58^{b} \pm 0.20$
Critical Difference ($P \leq 0.05$)	**4.39**	**0.92**	**0.02**	**0.18**	**0.04**

Values with different letter(s) are significantly ($P \leq 0.05$) different.

Table 2: Effect of nitrogen and sulphur supply on nutrient uptake by seeds of soybean

Treatment	Nutrient uptake by seeds (mg plant^{-1})			
	N	**P**	**K**	**S**
Control	191.22^{b} ± 8.13	2.82^{b} ± 0.77	55.19^{b} ± 10.70	13.98^{b} ± 29.67
Nitrogen (Urea @ 31.25 kg N ha^{-1})	281.43^{a} ± 17.7	3.94^{ab} ± 0.68	84.23^{ab} ± 15.45	20.44^{ab} ± 27.47
Sulphur (Gypsum @ 20 kg S ha^{-1})	272.90^{a} ± 6.82	5.42^{a} ± 0.53	93.25^{a} ± 9.52	23.84^{a} ± 23.52
Nitrogen (Urea @ 31.25 kg N ha^{-1}) + Sulphur (Gypsum @ 20 kg S ha^{-1})	288.18^{a} ± 18.9	3.54^{ab} ± 0.96	80.22^{ab} ± 15.79	24.46^{a} ± 32.73
Critical Difference (P≤0.05)	**26.38**	**1.42**	**24.80**	**5.38**

Values with different letter(s) are significantly (P≤0.05) different

Table 3: Effect of nitrogen and sulphur supply on various yield components in soybean

Treatment	Plant height (cm)	Pods per plant	Seeds per pod	Seed yield (g plant^{-1})	100 seeds dry weight (g)
Control	40.00^{b} ± 2.16	26.00^{c} ± 2.44	2.17^{a} ± 0.04	2.81^{a} ± 0.46	9.27^{a} ± 1.12
Nitrogen (Urea @ 31.25 kg N ha^{-1})	47.50^{a} ± 0.57	36.25^{b} ± 2.06	2.16^{a} ± 0.16	4.07^{a} ± 0.65	8.97^{ab} ± 0.89
Sulphur (Gypsum @ 20 kg S ha^{-1})	46.75^{a} ± 2.21	49.25^{a} ± 2.87	2.02^{a} ± 0.04	3.49^{a} ± 0.23	7.26^{b} ± 0.41
Nitrogen (Urea @ 31.25 kg N ha^{-1}) + Sulphur (Gypsum @ 20 kg S ha^{-1})	41.75^{b} ± 2.62	36.75^{b} ± 2.21	2.15^{a} ± 0.11	4.17^{a} ± 0.65	7.33^{ab} ± 0.10
Critical Difference (P≤0.05)	**3.16**	**3.73**	**NS**	**1.01**	**1.41**

Values with different letter(s) are significantly (P≤0.05) different

Data in table 3 indicate the effect of N and S supply on various yield components in soybean. Plant height significantly increased with treatment of N or S alone as compared to control as well as combined treatment of N and S. The number of pods per plant significantly increased in all the treatments than control however there was non-significant variation among treatments where N alone or in combination with S was given. Treatment with gypsum @ 20 kg S ha^{-1} maximally increased the number of pods per plant in soybean. Non-significant differences in number of seeds per pod among various treatments were observed. Total seed yield per plant increased in all the treatments compared to control however significant increase was observed in treatment with N alone or combined with S. Hundred seed weight decreased significantly by all fertilizer treatments as compared to control with minimum decrease with urea application.

Availability of nutrients and their uptake from soil and then distribution in different plant parts affect the final growth and development of a plant. These events are mainly regulated by nutrient supply or crop demand. Increase in seed protein content due to N or S application is due to increased N and S uptake as these elements are required for protein synthesis. Increase in seed protein percentage increased due to N application has been reported by James (2004) and Babaie (2009). The increase in content of nutrients (N, P, K and S) in soybean seeds by N fertilization has also been reported by Morshed *et al.,* (2008).

In the present study, the uptake of nutrients (N, P, K and S) by soybean seeds maximally increased with S fertilization alone or combined with N. Sulphur is essential for the enzyme activity involved in the nitrate reduction in plants. Therefore, it is imperative that N uptake increased with S application. Higher P uptake in the presence of S might be due to the capacity of S to mobilize soil P into available form. Singh *et al.,* (2001) reported that P and K uptake were stimulated in the presence of S. Improved S uptake could be attributed to increased S availability in the soil due to fertilizer treatment. The improved nutrient uptake associated with combined treatment of N and S might be due to increased root activity and enhanced soil nutrient availability to the crop as reported earlier (Wani *et al.,* 2000).

The increase in seed yield of soybean by S treatment can be related to increase in growth and yield characteristics (plant height, pods per plant etc.) as well as stimulatory effect of applied S in the synthesis of chloroplast protein resulting in greater photosynthetic activity by the crop, which in turn increased the yield (Biswas and Tewatia, 1992). In addition, S has an important role in improving soil reaction. When added into the soil, sulphur is converted to sulphuric acid by sulphur-oxidizing micro-organisms and lowers soil pH (locally) resulting in stabilized nutrient elements (Malhi *et al.,* 2007). Rise in the absorbable amount of these elements in the soil causes an increase in their concentration and absorption by the plant and ultimately increase in grain yield. N application increases seed N due to which N protein precursors are increased; so, the formation of photosynthetic materials and hence, photosynthetic efficiency is improved, resulting in improved seed yield (Holmes and Ainsley, 1979). Highest seed yield by application of 60 kg N ha^{-1} in soybean was reported by Reddy *et al.*, (1990).

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