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Research Article

Thiourea fertilization effect on nutrient content and uptake of soybean cultivar

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Abstract

In the *kharif* season of 2020, an experimental trial was executed at Govind Ballabh Pant University of Agriculture and Technology which is situated in Pantnagar, India. The objective of this study was to evaluate how soybean's nutrient content and uptake responded to the application of thiourea through foliar means. The experiment was laid out in factorial randomized block design and comprised of two soybean cultivars viz., PS 1347 and SL 958 and five foliar sprays viz., control, water spray, thiourea spray @ 250 ppm, 500 ppm, and 750 ppm which were replicated four times. This study demonstrates the potential of foliar thiourea application to enhance the sulfur content and uptake of soybean cultivars in the kharif season. The findings of the study indicated that the N, P, and K content of soybean were not impacted by the type of variety used or by the foliar sprays administered. However, it was observed that the highest S content in both seeds (0.375%) and haulm (0.179%) was recorded when thiourea was applied through foliar means at a rate of 750 ppm. This result was statistically equivalent (0.368% in seed and 0.173% in haulm) to the outcome obtained from a 500 ppm foliar spray and both of these treatments were found to be more effective than the other foliar spray methods tested. Regarding the uptake of nutrients, it was observed that the highest levels of N, P, K, and S uptake by both seed and haulm as well as the total uptake, were recorded when a foliar spray containing 750 ppm of thiourea was used.

Keywords cultivar, nutrient uptake, soybean, thiourea

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Introduction

Soybean (*Glycine max* L.) or wonder crop belongs to the sub-family Faboideae and family Leguminosae. In India, Soybean is the second most important source of vegetable oil with a share of 23 % in total vegetable oil production after mustard (35 %) [1]. Soybean contains 20 % oil and 40 % protein. Apart from this, it also contains a considerable amount of minerals, vitamins (thiamine and riboflavin), antioxidants, and polyunsaturated fatty acids (55 %). There are several other constraints for the low productivity of soybean which includes poor availability of quality inputs, poor adoption of improved technology, soil moisture stress, high-temperature stress, erratic rainfall, and biotic stresses like pests and diseases. However, abiotic stress and nutrient management are still a matter of concern for achieving a good yield of soybean. For mitigating abiotic stresses and improving the nutrient management

system, thiourea can be utilized efficiently in soybean cultivation. Thiourea is a compound that contains both nitrogen and sulfur and has a high solubility in water and a strong absorption potential. It is well known to confer tolerance towards various abiotic stresses. Its use and effectiveness have also been seen in increasing the filling of grain during drought periods. At the physiological level, this process is closely linked with the improvement of photosynthesis, increased translocation of metabolites, and the coordinated regulation of the relationship between the plant's sources and sink [2]. The nutrition of all plants depends on the availability and uptake of nutrients from the soil. Foliar spray of agrichemicals can be highly beneficial in situations where the roots are unable to supply the required nutrients or the uptake of nutrients by the plant is restricted [3]. Additionally, the efficiency of spraying is greater, and the expense of applying the chemicals through foliar means is comparatively lower when compared to soil application [4]. Taking these factors into account, the current study was conducted to assess how various concentrations of thiourea foliar spray, applied at various phases of crop growth, would impact the nutrient content and nutrient uptake of soybean. The present study investigated the effect of foliar application of thiourea at various growth stages on nutrient content and uptake in two soybean varieties so that a wider perspective of nutrient management rather than just basic NPK management and soil application of Sulphur can be explored.

It is also quite understandable and acceptable that the current study may have overlooked certain aspects that merit further exploration, leading to a possible research gap in the investigation on the effects of thiourea foliar spray on critical nutrients like potassium, calcium, and magnesium in soybean crops. Additionally, the study did not address the implications of thiourea foliar spray on soybean yield or its economic feasibility. Consequently, further research can concentrate on these areas to offer a more comprehensive understanding of the possible advantages and drawbacks of utilizing thiourea foliar spray in soybean cultivation.

Methodology

Experimental procedures

The research trial was executed during the *Kharif* season, 2020 at D7 block of Norman Ernst Borlaug CRC of G.B. Pant University of Agriculture and Technology, Pantnagar, India. This location is positioned at a latitude of 29 degrees North and a longitude of 79.50 degrees East, with an altitude of 243.84 meters above the mean sea level. The soil at the experimental site was neutral in reaction with pH 6.8. Available N, P_2O_5, K_2O and S content of soil was 233 kg ha^{-1}, 22.50 kg ha^{-1}, 144 kg ha^{-1}, 20.50 kg ha^{-1} respectively. The trial was outlaid in a factorial randomized block design (RBD) that consists of factor A (variety *i.e.*, PS 1347 and SL 958) and factor B (Thiourea spray *i.e.*, control, water spray, thiourea application @ 250, 500 and 750 ppm at 23 and 54 DAS) with ten treatments formed by combination and four replications. The choice of factorial RBD over split plot design for the mentioned two factor experiment is because of the requirement of the same plot size and precision for both factors. Additionally, the Factorial RBD design also enabled the study of the effect of each factor separately along with their interaction. Urea, NPK, MOP, and bentonite sulfur were used to apply nitrogen, phosphorus, potassium, and sulfur to each plot as per RDF N_{20} P_{40} $K_{60}S_{20}$. During cultivation, all recommended agronomic practices were followed.

Data recorded

From each plot, seed and haulm samples were collected. Haulm was dried at 60°C in a hot air oven and then grounded by using a Wiley mill so that it can pass through a one mm screen for the chemical analysis. The analysis of all three primary macronutrients and sulfur content of seed and haulm was done as per [5-7] chemical methods listed in Table. 1. The nutrient uptake was resolute by using the formula

$$\text{Nutrient uptake (Kg ha}^{-1}) = \frac{\text{Nutrient content (\%)in seed or haulm X seed or haulm yeild}}{100}$$

Table 1. Method used for nutrient analysis

SN.	Parameters	References
1.	Nitrogen content	Snell and Snell [5]
2.	Phosphorus content	Jackson [6]
3.	Potassium content	Jackson [6]
4.	Sulphur content	Tabatabai and Brenner [7]

Statistical analysis

The data and information were collected and analyzed using two-way ANOVA following a factorial-RBD [8]. The significance of treatment means was tested using an F-test with a level of significance of 5% ($P<0.05$).

Results

The data presented in Table 2, Figures 1 and 2 indicate that neither the varieties used nor the foliar spray applied had a significant effect on the nitrogen and phosphorus content found in the seed and haulm of the soybean crop. Nevertheless, a noticeable improvement was observed in the uptake of nitrogen and phosphorus by both the seed and haulm. Significantly higher uptake of nitrogen was recorded in the seeds of PS 1347 (152 kg ha^{-1}) in comparison to the seeds of SL 958 (128 kg ha^{-1}). It was found that N uptake by both the seed and haulm, as well as the total nitrogen uptake by PS 1347 (152, 94, and 246 kg ha^{-1}, respectively) was higher by 18.7, 16.05 and 17.70 %, respectively over SL 958. In the case of a foliar spray, thiourea @ 750 ppm recorded maximum nitrogen uptake by seed (158 kg ha^{-1}), haulm (100 kg ha^{-1}) as well as their total nitrogen uptake (258 kg ha^{-1}). However, no interaction was evident between the varieties and foliar spray in terms of nitrogen content and uptake. While in the case of phosphorus uptake (Table 2 and Figure 2), PS 1347 recorded an increase of 19.58, 9.60, and 13.50 % in phosphorus uptake by seed, haulm, and total uptake. Foliar application of thiourea @ 750 ppm recorded 12.5, 20, and 32.5 kg ha^{-1} phosphorus absorbed and assimilated by seed, haulm, and total biomass, respectively and it was found to be 43.67, 21.95, and 29.48 % higher than the recorded observations in the control plot. However, the application of 250 and 500 ppm thiourea as foliar spray also gave an approximately similar and non-significant result in comparison to the application of thiourea at 750 ppm. Data presented in Table 3, Figures 3 and 4 show about how the different treatments affected the content and uptake of potassium and sulfur. It was found that treatments did not have any impact on potassium levels of soybean's haulm and seed. However, sulfur levels in the haulm and seed of soybean were affected by the foliar application of thiourea. Like the other two primary nutrients, the uptake of potassium by seed, haulm, and total uptake in kg ha-1 was higher in the case of PS 1347 as compared to SL 958. The enhancement in seed, haulm, and total uptake was 23.51, 14.06 and 18.81 %, respectively. Foliar application of thiourea recorded a positive influence on the nutrient uptake and significant variation was observed over control and water spray.

Table 2. Impact of various treatments on nitrogen and phosphorus content in soybean crop

Treatments	N content (%)		P content (%)	
	Seed	Haulm	Seed	Haulm
Variety				
PS 1347	7.07	1.87	0.53	0.39
SL 958	6.97	1.72	0.53	0.37
SEm±	0.12	0.05	0.01	0.01
CD (p = 0.05)	NS	NS	NS	NS
Spray				
Control	6.75	1.64	0.49	0.36
Water spray	7.00	1.66	0.51	0.36
Thiourea @ 250 ppm	7.09	1.84	0.54	0.39
Thiourea @ 500 ppm	7.10	1.84	0.55	0.40
Thiourea @ 750 ppm	7.15	1.97	0.56	0.39
SEm±	**0.19**	**0.08**	**0.02**	**0.01**
CD (p = 0.05)	**NS**	**NS**	**NS**	**NS**

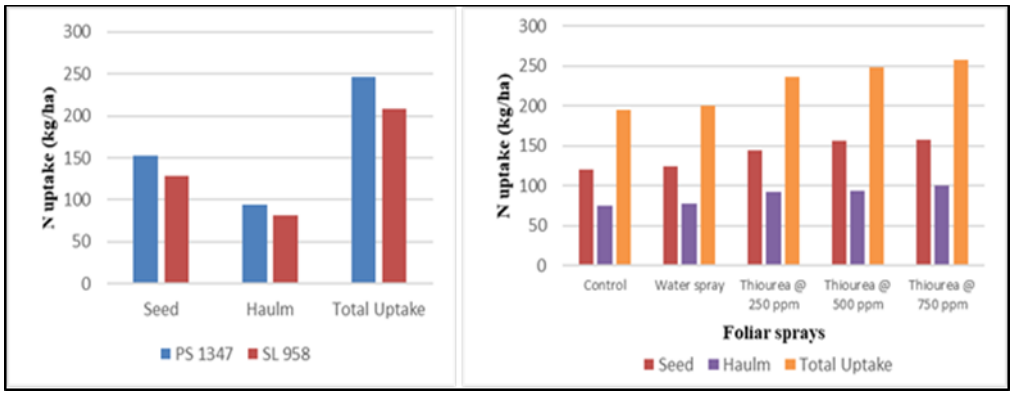

Figure 1. Effect of varieties and foliar sprays on N uptake of soybean crop

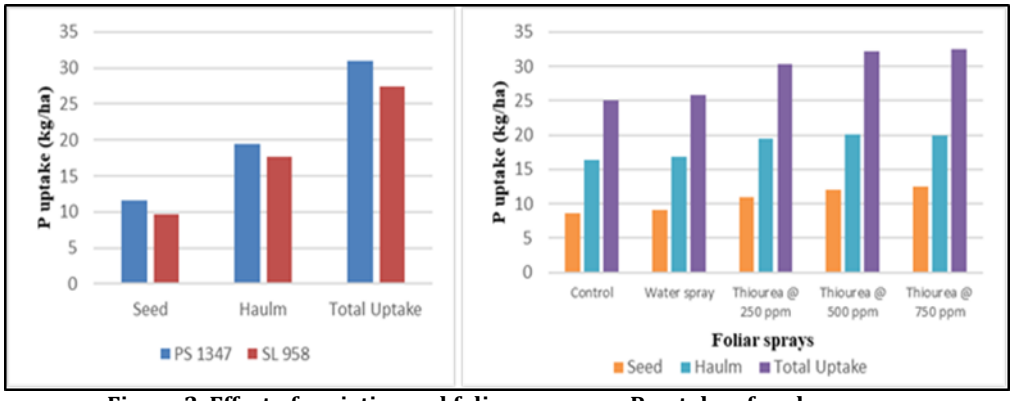

Figure 2. Effect of varieties and foliar sprays on P uptake of soybean crop

Application of 250 ppm thiourea elevated the potassium absorption by seed, haulm, and overall uptake by 19.53, 17.59, and 18.50 % respectively. In the case of sulfur content, foliar spray of thiourea at 500 and 750 ppm recorded maximum in the seed (0.368 and 0.375%) and haulm (0.173 and 0.179%) and were statistically at par with each other. It was found that thiourea application at all

the concentrations was superior over the water spray and control in terms of sulfur content present in the seed and haulm. In the case of sulfur uptake, seed and haulm of the PS 1347 variety recorded

Table 3. Impact of various treatments on potassium and Sulfur content in soybean crop

Treatments	K content (%)		S content (%)	
	Seed	Haulm	Seed	Haulm
Variety				
PS 1347	1.82	0.81	0.345	0.163
SL 958	1.73	0.76	0.336	0.162
SEm±	0.03	0.02	0.003	0.001
CD (p = 0.05)	NS	NS	NS	NS
Spray				
Control	1.71	0.74	0.306	0.147
Water spray	1.69	0.75	0.312	0.152
Thiourea @ 250 ppm	1.77	0.80	0.341	0.162
Thiourea @ 500 ppm	1.83	0.79	0.368	0.173
Thiourea @ 750 ppm	1.87	0.82	0.375	0.179
SEm±	**0.05**	**0.03**	**0.005**	**0.002**
CD (p = 0.05)	**NS**	**NS**	**0.015**	**0.007**

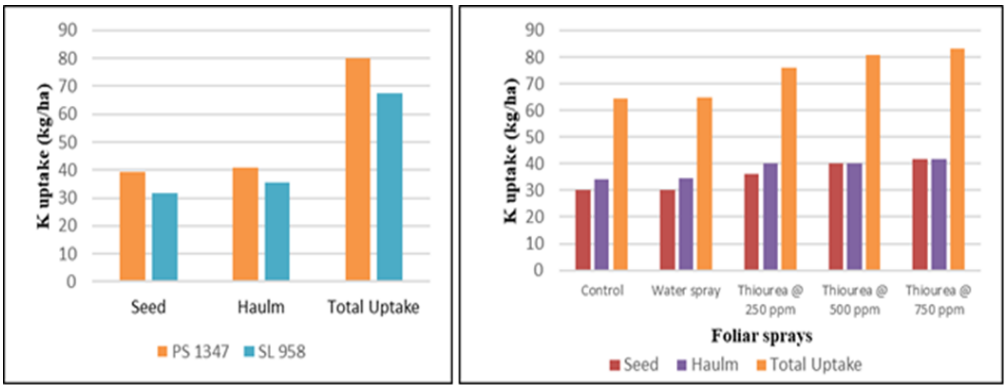

Figure 3. Effect of varieties and foliar sprays on K uptake of soybean crop

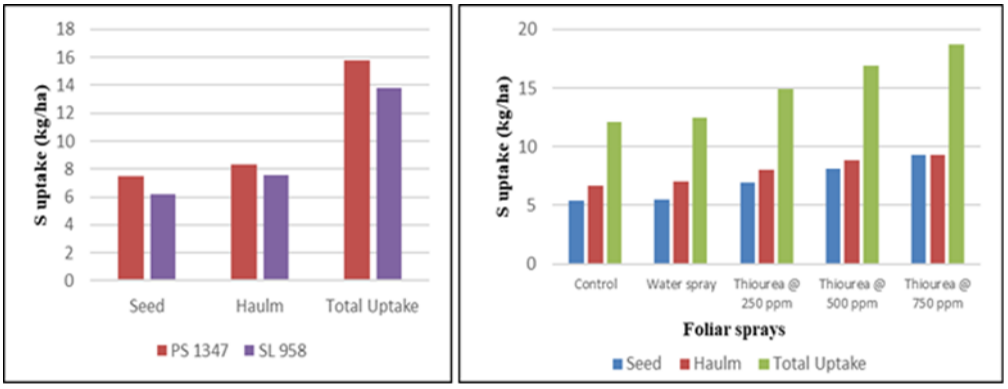

Figure 4. Effect of varieties and foliar sprays on S uptake of soybean crop

an increase of 20.96 and 9.21 %, respectively over SL 958 variety. The improvement was also considered in the case of foliar application of thiourea. Foliar application of thiourea at the rate of 250, 500, and 750 ppm improved the total sulfur uptake by 23.96, 39.66, and 43.80 % over control.

No significant interaction was observed between varieties and foliar spray concerning sulfur intake by seed, haulm, and overall sulfur intake by plants.

Discussion

The current study indicates that there was no discernible impact of the use of varieties and foliar sprays on the N, P, and K content [9] as reported by similar findings. Despite the lack of significant variation in the nitrogen content of the seed and haulm, there was a notable improvement in uptake, according to the findings of the study. As there is no substantial variation in nitrogen content in seed and haulm but the uptake shows clear improvement. Thus, it can be understood that the variation in uptake was directly attributed to the seed, haulm, and total biological yield obtained under the influence of these factors. However, foliar spray of thiourea influenced the S % level in haulm and seed but not varieties. The highest sulfur content in the seed and haulm was observed when the foliar spray of thiourea was applied at a concentration of 750 ppm, and this level was statistically similar to the results obtained with a concentration of 500 ppm. These two concentrations were found to be better than the other foliar spray treatments, according to the findings. In terms of nutrient uptake, the increment in N, P, K, and S intake by seed, haulm, and overall S intake, it was found that maximum intake was recorded with the application of 750 ppm thiourea as a foliar spray. Similar findings are reported by [10-11]. This is due to the fact that improvement in the uptake of nutrients is directly related to the improvement in seed and haulm yield under the influence of two factors at different levels. The positive influence on the metabolism and growth of plants could also be one of the reasons for the increased nutrient uptake as it made the plants more efficient in terms of nutrient uptake and assimilation. The study's results suggest that the application of thiourea increased nitrogen uptake and metabolic processes, leading to enhanced growth and dry matter accumulation in maize. [12].

Conclusion

Based on experimental results, it was concluded that soybean cultivars PS 1347 and SL 958 performed quite similarly, and foliar spray of thiourea at the concentration of 500 and 750 ppm performed improved nutrient uptake and S content in plants in comparison to thiourea @ 250 ppm, control, and water spray. However, the interaction between the two factors was non-significant. Thus, further research can be carried out by analyzing the foliar application of thiourea on the oil content of soybean as improvement in S content has paved the way forward.

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Conflict of Interest

The authors declare no conflict of interest.

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