Ann. Agric. Res. New Series Vol. 46 (3) : 296-301 (2025)

Effect of soil and foliar application of nutrients on growth, root nodules and yield of soybean under Vertisols

Barkha Kumari Verma[1*], Vinod Kumar Yadav[1], Rajendra Kumar Yadav[2], Manoj Kumar Sharma[2], Harphool Meena[2] and Manisha Kumawat[3]

College of Agriculture, Ummedganj-Kota (Rajasthan)
Corresponding Author's Email: vermabarkha780@gmail.com

Received: May 2025; Revised Accepted: August 2025

Abstract

A field experiment was conducted at Instructional Farm, College of Agriculture, Ummedganj-Kota (Rajasthan) during *kharif* season of 2022. The experiment was laid out in randomized block design with three replications. The ten treatments were comprised as T_1- control, T_2-RDF + 2% urea spray at 35 and 60 DAS, T_3-RDF + 2% DAP spray at 35 and 60 DAS, T_4-RDF + 2% NPK (18:18:18) spray at 35 and 60 DAS, T_5-RDF + 0.5% Zn spray at 35 and 60 DAS, T_6-RDF + 0.5% Fe spray at 35 and 60 DAS, T_7-RDF + 0.5% Fe and 0.5% Zn spray at 35 and 60 DAS, T_8- RDF + 2% NPK (18:18:18) + 0.5% Fe spray at 35 and 60 DAS, T_9-RDF + 2% NPK (18:18:18) + 0.5% Zn spray at 35 and 60 DAS and T_{10}- RDF + 2% NPK (18:18:18) + 0.5% Fe and 0.5% Zn spray at 35 and 60 DAS. Results indicated that the application of RDF + 2% NPK (18:18:18) + 0.5% Fe and 0.5% Zn spray at 35 & 60 DAS significantly increased plant height (32 and 55.1 cm) at 45 DAS and at harvest, number of root nodules plant^{-1} (52.2), dry weight of root nodules (48.07 mg plant^{-1}) and leghemoglobin (2.36 mg g^{-1}) content in root nodules at 45 DAS of soybean over rest of the treatments. Application of RDF + 2% NPK (18:18:18) + 0.5% Fe and 0.5% Zn spray at 35 & 60 DAS significantly increased the chlorophyll content (3.01 and 2.35 mg g^{-1}) and leaf area index (5.32 and 3.41) at 45 and 70 DAS of soybean over rest of the treatments.

Keywords: Soybean, foliar spray, root nodules, leghemoglobin and leaf area index.

Introduction

Soybean [*Glycine max* (L.) Merrill] is an important leguminous oilseed crop. It is a native of Asia and the crop has been recently introduced in India. It is second largest oilseed crop in India after groundnut. In India, it is mainly grown as an oilseed as well as pulse crop. It became miracle crop of 20th century and designated as "Golden Bean". Among all oilseed crops, soybean occupied third position in the edible oil scenario of India. Nutritional point of view, soybean is an outstanding source of protein and oil. It contains high amount of protein (38-42 per cent) and cholesterol free oil (18-20 per cent). It is also a rich source of vitamin A, B and D. It contains 38-43 per cent minerals and 2 per cent phospholipids. In addition, soybean is legume crop and has considerable potential to fix atmospheric nitrogen (Jagdale *et al*., 2020), because of its high fat content (<"20 per cent of the dry weight), the caloric density of the soybean exceeds that of other beans, so it can more readily contribute to meeting energy requirements and the requirements for both essential fatty acids, the omega-6 fatty acid linoleic acid and the omega-3 fatty acid alpha-linolenic acid, which represent approximately 54.4 and 7.9 per cent of the total fat content, respectively (Messina, 2022).

*Corresponding author: vermabarkha780@gmail.com
[2] Agricultural Research Station, Ummedganj-Kota (Rajasthan)
[3]S.K.N. College of Agriculture, Jobner (Rajasthan)

Foliar spraying is a new method for crop feeding in which micronutrients in the form of liquid are applied to leaves (Nasiri *et al*., 2010). Nutrients applied through the fertilizers at the time of sowing are not fully utilized by the crop and are lost through leaching, fixation etc. and the crop may suffer from want of nutrients at the later stage. The deficiency of any nutrient during reproductive stage can be aptly managed through foliar nutrition, which is the fastest way to boost crop growth as it facilitates the nutrient availability during the pod filling stage. Under rainfed condition whenthe availability of moisture becomes scarce, the application of fertilizers as foliar spray resulted in efficient absorption and usage which areeconomical in respect the other methods of fertilizer application. Flower senescence and improper pod filling are the major drawbacks in soybean, which can be managed through foliar application of nutrients (Meena *et al*., 2018). Since application rates are lesser as compared to soil application, same quantity of nutrient application could be supplied easily and crop reacts to nutrients application immediately. Crop roots are unable to absorb some important nutrients such as zinc, because high soil pH, lime or heavy texture, and in this situation, foliar spraying is better as compared to soil application (Kinaci and Gulmezoglu, 2007). Narimani *et al*., (2010) reported that foliar application of micronutrients is equal or in some cases more effective as compared to micronutrients applied in soil. Soybean is a member of pulses and probably the most valuable crop in world. Fertilization is one of the main economic and health-promoting factors in crop cultivation. In view of this it is very important to assess the effect of soil and foliar nutrition on growth and yield of soybean.

Materials and Methods

An experiment was conducted at Instructional Farm, College of Agriculture, Ummedganj, Kota (Rajasthan) during *kharif* season, 2022. According to Agro-ecological region map brought out by National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), Kota falls in Agro-ecological region No. 06. Geographically, College of Agriculture, Ummedganj, Kota is situated at South-Eastern part of Rajasthan at 75°.25′ E longitude, 25°.13′ N latitude and an altitude of 258 meter above mean sea level. The total rainfall was 1156.6 mm in 58 rainy days. The maximum temperature ranged from 31.6°C to 39.9°C and minimum temperature ranged from 22.7°C to 28.6°C was observed during the crop growing season. All the weather data are taken from the meteorological observatory at the Agricultural Research Station, Ummedganj, Kota**.**

Soil of the experimental site was clay loam in texture (sand 22.8 %, silt 37.2 % and clay 40 %), with normal EC (0.52 dS m^{-1}). The experimental soil was medium in available nitrogen (264 kg ha^{-1}), phosphorus (21.7 kg ha^{-1}), sulphur (15.8 kg ha^{-1}) while high in potassium (388 kg ha^{-1}) and sufficient in DTPA extractable micronutrients (Zn 0.43 mg kg^{-1}, Fe 5.24 mg kg^{-1}, Cu 0.84 mg kg^{-1} and Mn 2.93 mg kg^{-1}) with pH (7.61). The experiment laid out in randomized block design with three replications. The ten treatments comprised as T_1- control, T_2-RDF + 2% urea spray at 35 and 60 DAS, T_3-RDF + 2% DAP spray at 35 and 60 DAS, T_4-RDF + 2% NPK (18:18:18) spray at 35 and 60 DAS, T_5-RDF + 0.5% Zn spray at 35 and 60 DAS, T_6-RDF + 0.5% Fe spray at 35 and 60 DAS, T_7-RDF + 0.5% Fe and 0.5% Zn spray at 35 and 60 DAS, T_8-RDF + 2% NPK (18:18:18) + 0.5% Fe spray at 35 and 60 DAS, T_9-RDF + 2% NPK (18:18:18) + 0.5% Zn spray at 35 and 60 DAS and T_{10}- RDF + 2% NPK (18:18:18) + 0.5% Fe and 0.5% Zn spray at 35 and 60 DAS. The experimental field was prepared by once ploughing with disc plough and followed by harrowing and planking. The experimental field was demarcated as per plan of layout with provision of irrigation/buffer channels and sowing was done by seed drilled at 3-4 cm depth, keeping inter row spacing of 30 cm between rows and 10 cm between plants. First hoeing cum weeding was done manually at 20 DAS and second was done manually at 40 DAS with the help of *khurpi*. However, weeds pulled out manually throughout the crop season to maintain weed free condition. RDF was applied as basal through urea, DAP and MOP, respectively at the time of sowing and different treatments of nutrient foliar spray were applied at 35 and 60 DAS Five tagged plants were harvested for the purpose of recording observation. In order to test the significance of variation

in experimental data obtained for various treatment effects, the data were statistically analyzed as described by (Gomez and Gomez, 1984 and Rana *et al*., 2014).

Results and Discussion

Growth and root nodulation

Data showed that the various nutrients treatments of soil and foliar application significantly influenced plant growth of soybean (Table 1). Application of RDF + 2 % NPK (18:18:18) + 0.5 % Fe and 0.5% Zn spray at 35 & 60 DAS significantly increased the plant height (32 and 55.1 cm) as compared to rest of the treatments. Whereas, the lowest plant height (19.2 and 37.6 cm) was recorded under control at 45 DAS and at harvest of soybean. An examination of data clearly shows that the various treatments of soil and foliar application significantly influenced nodules and their dry weight at 45 DAS in soybean. The maximum number of root nodules plant^{-1} (52.2), root nodules dry weight (48.07 g plant^{-1}) and leghemoglobin content (2.36 mg g^{-1}) at 45 DAS was recorded with application of RDF + 2 % NPK (18:18:18) + 0.5 % Fe and 0.5% Zn spray at 35 & 60 DAS followed by RDF + 2 % NPK (18:18:18) + 0.5% Zn spray at 35 & 60 DAS and RDF + 2% NPK (18:18:18) + 0.5% Fe spray at 35 & 60 DAS of soybean, but it was found significantly superior over rest of the treatments.

Application of RDF + 2 % NPK (18:18:18) + 0.5 % Fe and 0.5% Zn spray at 35 & 60 DAS registered significantly higher chlorophyll content (3.01 and 2.35 mg g^{-1}) at 45 and 70 DAS over rest of the treatments, while minimum value of chlorophyllcontent (2.16 and 1.68 mg g^{-1}) at 45 DAS and 70 DAS was secured in soybean under control. The maximum leaf area index (5.32 and 3.41) of soybean at 45 DAS and 70 DAS was recorded with application of RDF + 2 % NPK (18:18:18) + 0.5 % Fe and 0.5% Zn spray at 35 & 60 DAS over control.

The reason for better growth and development in the above treatment might be due to increased availability of nutrients to the plant through fertilizers. The higher values of growth attributes were might be due to the beneficial effect of nutrients in water-soluble fertilizers in

Table 1. Effect of soil and foliar application of nutrients on plant height of soybean

Treatments	Plant height (cm)		Nodules (plant^{-1})	Dry weight of nodules (mg plant^{-1})	Leghemoglobin (mg g^{-1})	Chlorophyll content (mg g^{-1})		Leaf area index	
	At 45 DAS	At harvest				At 45 DAS	At 70 DAS	At 45 DAS	At 70 DAS
T_1 – control	19.2	37.6	42.2	31.43	1.91	2.16	1.68	3.23	2.24
T_2 – RDF + 2% urea spray at 35 & 60 DAS	25.1	46.9	44.2	39.93	2.17	2.69	1.98	4.07	2.84
T_3 – RDF + 2 % DAP spray at 35 & 60 DAS	25.6	47.8	44.6	40.23	2.18	2.71	2.02	4.18	2.89
T_4 – RDF + 2 % NPK (18:18:18) spray at 35 & 60 DAS	26.4	47.7	45.4	40.95	2.20	2.72	2.07	4.27	2.92
T_5 – RDF + 0.5% Zn spray at 35 & 60 DAS	23.5	44.7	43.2	38.66	2.05	2.34	1.76	3.83	2.70
T_6 – RDF + 0.5% Fe spray at 35 & 60 DAS	23.2	44.5	43.0	38.47	2.00	2.48	1.83	3.87	2.65
T_7 – RDF + 0.5% Fe and 0.5 % Zn spray at 35 & 60 DAS	24.0	45.9	43.6	38.83	2.13	2.58	1.91	3.93	2.71
T_8 – RDF + 2% NPK (18:18:18) + 0.5% Fe spray at 35 & 60 DAS	28.4	48.0	46.2	41.03	2.25	2.91	2.26	4.45	2.94
T_9 – RDF + 2 % NPK (18:18:18) + 0.5% Zn spray at 35 & 60 DAS	28.4	48.5	46.6	41.46	2.31	2.82	2.16	4.60	2.97
T_{10} – RDF + 2 % NPK (18:18:18) + 0.5 % Fe and 0.5% Zn spray at 35 & 60 DAS	32.0	55.1	52.2	48.07	2.36	3.01	2.35	5.32	3.41
SEm±	1.19	2.11	1.81	2.21	0.01	0.03	0.02	0.19	0.13
CD(P=0.5)	3.53	6.56	5.38	6.55	0.04	0.09	0.06	0.56	0.40

readily available form which were supplied through foliar spray. These nutrients were directly absorbed by plant either through cuticle or stomata and might have participated in photosynthesis activity in plant leaves and enhanced the process of photosynthesis and regulated other metabolic processes in the plant, resulting in higher plant growth (Banasode *et al.*, 2018). Foliar spray resulted in timely supply of optimum quantity of nutrients to the plant and their subsequent absorption by soybean leaves resulting in better assimilation and translocation of nutrients. The result might be due to combine application of NPK, Zn and Fe along with RDF in soybean due to which improvement in nutrient uptake particularly iron and zinc, which increased transformation of photosynthetic activity towards growing plant parts and resulting growth of plant (Chavan *et al*., 2022).These findings are supported by Biradar *et al*. (2022) and Dass *et al*. (2022).

Yield attributes and yield

Result showed that the yield attributes and yield of soybean significantly increased under various treatments at harvest (Table 2). The result revealed that the maximum pods (41.8 plant^{-1}) and number of seeds (2.8 pod^{-1}) were recorded with application of RDF + 2% NPK (18:18:18) + 0.5% Fe and 0.5% Zn spray at 35 & 60 DAS as compared to rest of the treatments. While, the minimum pods (31.2 plant^{-1}) and number of seeds (1.6 pod^{-1}) were observed under control.

Seed yield of soybean significantly influenced under various soil and foliar application treatments. Application of RDF + 2% NPK (18:18:18) + 0.5% Fe and 0.5% Zn spray at 35 & 60 DAS was registered significantly highest seed yield (1789 kg ha^{-1}) of soybean followed by RDF + 2% NPK (18:18:18) + 0.5% Zn spray at 35 & 60 DAS (1603 kg ha^{-1}) and RDF + 2% NPK (18:18:18) + 0.5% Fe spray at 35 & 60 DAS (1594 kg ha^{-1}). Lowest seed yield (1027 kg ha^{-1}) was noticed under control. The magnitude of increased in seed yield of soybean (74.19 per cent) higher due to application of RDF + 2% NPK (18:18:18) + 0.5% Fe and 0.5% Zn spray at 35 & 60 DAS as compared to control.

Results revealed that application of RDF + 2% NPK (18:18:18) +0.5% Fe and 0.5% Zn spray at 35 & 60 DAS registered significantly higher straw yield (3202 kg ha^{-1}) over rest of the treatments. However, the lowest straw yield (2059 kg ha^{-1}) was recorded under control. The magnitude of increased in straw yield of soybean was (55.51 per cent) higher due to application of RDF + 2% NPK (18:18:18) + 0.5% Fe and 0.5% Zn spray at 35 & 60 DAS as compared to control.

The increasing in the yield and yield attributes might be due to foliar applied nutrients directly absorbed by plants thereby increasing the metabolism of the plants resulting in increased synthesis of photosynthetic products (Biradar *et al*., 2022). The highest pods plant^{-1} due to the foliar application could be attributed to significant effect of microelements on reproductive organs, such as stamens and pollens. Since soybean is a self-pollinated crop, stamen activity enhances the num-

Table 2. Effect of soil and foliar application of nutrients on yield attributes and yield of soybean.

Treatments	Pods (plant^{-1})	Seeds (pod^{-1})	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1 : Control	31.2	1.6	1027	2059
T_2 : RDF + 2% urea spray at 35 & 60 DAS	34.6	2.0	1442	2792
T_3 : RDF + 2% DAP spray at 35 & 60 DAS	35.2	2.2	1469	2825
T_4 : RDF + 2% NPK (18:18:18) spray at 35 & 60 DAS	35.8	2.2	1568	2845
T_5 : RDF + 0.5% Zn spray at 35 & 60 DAS	34.0	2.0	1299	2565
T_6 : RDF + 0.5% Fe spray at 35 & 60 DAS	33.8	1.8	1260	2512
T_7 : RDF + 0.5% Fe and 0.5% Zn spray at 35 & 60 DAS	34.4	2.0	1349	2621
T_8 : RDF + 2% NPK (18:18:18) + 0.5% Fe spray at 35 & 60 DAS	36.0	2.4	1594	2862
T_9: RDF + 2% NPK (18:18:18) + 0.5% Zn spray at 35 & 60 DAS	36.2	2.4	1603	2880
T_{10} : RDF + 2% NPK (18:18:18) + 0.5% Fe and 0.5% Zn spray at 35 & 60 DAS	41.8	2.8	1789	3202
SEm±	1.68	0.10	56.35	107.34
CD(P=0.5)	4.99	0.31	167.42	318.93

ber of flowers that can fertile well and as a result, larger number of podsplant^{-1} will be produced (Heidarian *et al*., 2011). These micronutrients also helped in efficiently transferring photosynthetic products from source to sink, thereby increasing seed weight in pods ultimately resulting in higher seed yield. Decreased flower drop due to prolonged assimilatory activity of leaves might be another possible reason for higher number of pods plant^{-1} (Kumar *et al*., 2019). It might be due to constant supply of nutrients due to foliar spray at reproductive stage of the crop and enhanced the yield components like number of pods plant^{-1} and number of seeds pod^{-1}, which had direct influence on the seed yield. The increase in straw yield is directly related to increase in the vegetative growth of the plant (Raushan *et al*., 2020). Similar results were reported by Kolekar *et al*. (2018), Chauhan *et al*. (2020), and Chavan *et al*. (2022).

Conclusion

It can be concluded that significant improvement in growth parameters, chlorophyll content, leghemoglobin content, leaf area index of soybean crop could be obtained with application of RDF + 2% NPK (18:18:18) + 0.5% Fe and 0.5% Zn foliar spray at 35 and 60 DAS.

References

Banasode, C. and Math, K. K. 2018. Effect of foliar fertilization of water-soluble fertilizers on growth and economics of soybean in a vertisol. *Journal of Pharmacognosy and Phytochemistry*. **7**(2): 2391-2393.

Biradar, M., Gundlur, S. S., Salakinkop, S. R., Kuligod, V. B. and Jagadeesh, B. R. 2022. Influence of zinc and iron foliar nutrition to Chickpea (*Cicer arietinum* L.) crop on growth, yield and nutrient uptake characteristics and its economics. *The Pharma Innovation Journal*. **11**(8): 880-884.

Chauhan, S., Sukumar, K. and Reddy, M. R. 2020. Impact of foliar spray of nutrients seed yield and economics of soybean *(Glycine max* L. Merrill). *The Indian Society of Oilseeds Research*. **37**: 178-181.

Chavan, N.S., Adsul, P.B., Kadam, D. M., Lingayat, N.R. and Jaybhaye, B.B. 2022. Effect of iron and zinc on growth, yield and quality of soybean (*Glycine max* L.) in Inceptisol. *The Pharma Innovation Journal*. **11**(12): 1823-1830.

Dass, A., Rajanna, G. A., Babu, S., Lal, S. K., Choudhary, A. K., Singh, R. and Kumar, B. 2022. Foliar application of macro-and micronutrients improves the productivity, economic returns, and resource-use efficiency of soybean in a semiarid climate. *Sustainability*. **14**(10): 5825.

Gomez, K. A. and Gomez, V. A. 1984. Statistical Procedure for Agriculture Research. John Wiley and Sons Inc., New York, USA.

Heidarian., A.R., Kord, H., Mostafavi, K., Lak, A.P. and Mashhadi, F.A. 2011. Investigation Fe and Zn foliar application on yield and its components of soybean at different growth stages. *Journal of Agricultural Biotechnology and Sustainable Development*. **3**(9): 189-197.

Jagdale A., Dhamak, A., Pagar, B. and Wagh, P. 2020. Effect of different organic formulation on growth and yield of soybean. *International Journal of Chemical Studies*. **8**(4): 1634-1638.

Kinaci, E. and Gulmezoglu, N. 2007. Grain yield and yield components of triticale upon application of different foliar fertilizers. *Interciencia*. **32**(9): 624-628.

Kolekar, P. T., Nawale, S. S., Zambare, P. B. and Kadlag, A. D. 2018. Yield, quality and nutrient uptake of soybean as influenced by water soluble fertilizer, micro-nutrient and plant growth regulators. *Journal of Pharmacognosy and Phytochemistry*. **7**(1): 2186-2188.

Kumar, D., Singh, R. P. and Simaiya, V. 2019. Effect of foliar application of nutrients on yield and economics of black gram (*Vigna mungo* {L.} Hepper) under rainfed Vertisols of Central India. *Journal of Pharmacognosy and Phytochemistry*. **8**(1): 2373-2379.

Meena, S.M., Laharia, G.G., Hadole, S.S., Sathyanarayan, E., Dhule, D.T. and Ghatol, P.U. 2017. Interactive effect of phosphorus and zinc on yield, quality and fertility status of soil after harvest of soybean. *Agriculture and Engineering*. **6**(19): 2277-7601.

Messina, M. 2022. Perspective: soybeans can help address the caloric and protein needs of a growing global population. *Frontiers in Nutrition*. **9**.

Narimani, H., Rahimi, M.M., Ahmadikhah, A. and Vaezi, B. 2010. Study on the effects of foliar spray of micronutrient on yield and yield components of durum wheat. *Archives of Applied Science Research*, **2**(6): 168-176.

Nasiri, Y., Zehtab, S.S., Nasrullahzadeh, S., Najafi, N. and Ghassemi, G.K. 2010. Effects of foliar application of micronutrients (Fe and Zn) on flower yield and essential oil of chamomile (*Matricaria chamomilla* L.). *Journal of Medicinal Plants Research*, **4**(17): 1733-1737.

Rana, K.S., Choudhary, A.K., Sepat, S., Bana, R.S., Dass, A. 2014. Methodological and Analytical Agronomy (New Delhi: IARI), 276.

Raushan, R. K., Singh, H., Pankaj, B., Upadhaya, B. and Kishor, K. 2020. Effect of foliar application of nutrients on yield and economics of black gram (*Vigna mungo* L.) under rainfed condition. *International Journal of Chemical Studies*, **8**(1): 2487-2490.