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CONTENTS

Foliar nutrition for higher soybean productivity in north western plain zone of India

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ABSTRACT: A field experiment was conducted at the N.E.Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during *kharif*-2016 and 2017 seasons, to study the response of foliar nutrition on soybean crop.The treatments included T-1 Recommended Dose of Fertilizer (RDF)20:60:40, N:P_2O_5: K_2O + water spray at pod initiation, T-2 RDF + Urea 2% spray at pod initiation, T-3 RDF + Di Ammonium Phosphate 2% spray at pod initiation, T-4 RDF + Muriate of Potash 0.5% at pod initiation, T-5 RDF + 19:19:19 (N,P_2O_5, K_2O) 2% spray at pod initiation, T-6 RDF + sodium molybdate 0.5% spray at pod initiation, T-7 RDF + borax 0.5% spray at pod initiation, T-8 RDF + chelatedzinc 0.5% spray at pod initiation and T-9 RDF (20:60:40, N, P_2O_5, K_2O) only. Foliar application of nutrients was done at pod initiation stage and RDF was applied as basal at the time of sowing. Application of RDF + 19:19:19 (N,P_2O_5, K_2O) 2% spray at pod initiation stage in treatment T-5 resulted in higher yield attributing characters viz., branches per plant and pods per plant during both the years. The highest seed and haulm yield was also recorded in the treatment T-5 (RDF + 19:19:19 (N,P_2O_5, K_2O) 2% spray at pod initiation. The per cent increase in seed yield due to treatment T-5 was 26.7 and 13.9 per cent over RDF alone during 2016 and 2017 respectively. The highest harvest index of 28.85 and 27.57 was also recorded in the treatment T-5 (RDF+ 19:19:19, 2% spray at pod initiation)during 2016 and 2017, respectively.

Key words: Boron, foliar nutrition, molybdenum, soybean,zinc

Soybean (*Glycine max*) is a leading oilseed crop globally with production of 364.07 million tones (FAOSTAT, 2018).It is widely grown for oil, feed and high protein content. It contributed 25 per cent of the total edible vegetable oil produced globally (SOPA, 2019).In India the soybean crop isbeing cultivated on11.13 million hectare area with production of 13.27 million tonnes in the year 2018-19 (Agriculture Statistics at a Glance, 2020). The productivity of soybean in India is only 1192 kg/ha against the world average productivity of 1780 kg/ha.Among the different reasons, proper nutrition and its time of application is one of the key factors resulting in lower productivity (Pushpendra *et al.*, 2017).Application of adequate major and micro nutrients is required for enhancing the productivity.Foliar application of nutrient is one of the most economical waysfor fertilizer application to increase the productivity. Foliar application of nutrient leads to quick absorption of nutrients and results in increased cropgrowth and higher yield (Gutte *et al.,* 2018).

At pod formation stage the demand of soybean crop for nutrients is high and foliar nutrition can enhance the uptake. If the supply of nutrients is not adequate at this stage it results in flower drop. Foliar nutrition arrests the flower drop and enhance flowering and pod filling (Gutte *et al.,* 2018).Foliar application of nutrient at flowering or at pod initiation stage also meets the nutrient requirement of the crop and leads to increase in yield as well as productivity (Katyal and Rattan, 2003).Therefore, an experiment was planned to study the impact of foliar application of different nutrients on yield attributes and yield of soybean during *kharif* seasons of 2016 and 2017.

MATERIALS AND METHODS

A field experiment was conducted at the N.E.Borlaug Crop Research Centre, GovindBallabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during *kharif*-2016 and 2017, to study the response of foliar nutritionon soybean crop. The soil of the experimental field was sandy loam, with pH of 6.86. The organic carbon content in the soil was 0.56 per cent. The soil of the experimental field was low in available nitrogen

(216.2 kg/ha), medium in available P_2O_5(22.6 kg/ha) and medium in available K_2O (133.1 kg/ha). The experiment was laid out in a randomized block design with nine treatments and three replications. The treatments included, T-1Recommended Dose of fertilizer (RDF 20:60:40, N:P_2O_5: K_2O)+ water spray at pod initiation, T-2RDF + Urea 2% spray at pod initiation, T-3 RDF + Di Ammonium Phosphate 2% spray at pod initiation, T-4 RDF + Muriate of Potash 0.5% at pod initiation, T-5RDF + 19:19:19 (N,P_2O_5, K_2O) 2% spray at pod initiation, T-6 RDF + sodium molybdate 0.5% spray at pod initiation, T-7 RDF + borax 0.5% spray at pod initiation, T-8 RDF +chelatedzinc 0.5% spray at pod initiation and T-9 RDF (20:60:40, N, P_2O_5, K_2O)only. Foliar application of nutrients was done at pod initiation stage and RDF was applied as basal at the time of sowing. For spraying of molybdenum, sodium molybdate was applied and for spraying boron,borax was applied. The amount of water used for spraying of nutrients was 500 liters per hectare. The soybean variety grown in the experiment was Pant Soybean 1347 with the seed rate of 75 kg/ha. Seeds were treated with fungicide carbendazim 50% @ 2.0 gram per kg seed and with *Bradyrhizobium japonicam* @ 5g/kg seed before sowing during both the years.The experimental data recorded during the course of investigation were analysed statistically as per standard methods prescribed by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect on yield attributes of soybean

Foliar application of N P K, 19:19:19 along with RDF in treatment T-5 resulted in the highest branches per plant during 2016 and 2017, though the differences among treatments were non-significant (Table1). Foliar application of nutrients resulted in increased number of pods per plant over application of RDF alone. The application of different nutrients at pod formation stage met the nutrient demand for grain filling and pod development. Pods per plant were significantly influenced by different foliar nutrition treatments during both the years(Table1). During 2016, significantly higher pods per plant were recorded in treatment T-5 (RDF + 19:19:19, N: P_2O_5, K_2O 2% sprayat pod initiation,) treatment and lowest pods per plant were recorded in treatment T-1 (RDF 20:60:40, N: P_2O_5: K_2O) + water spray at pod initiation). In the year 2017 treatment T-5 (RDF + 19:19:19 N: P_2O_5, K_2O) recorded significantly higher pods per plant as compared to remaining treatments.Similar findings were also observed with pods per plant due to the application of 19:19:19@ 2% spray at pod initiationby Singh *et al.*(2018).

Seed index varied from 8.33 g to 9.17 g among the different treatments during 2016, and the differences were non-significant (Table1). In 2016, the highest seed index of 9.17g was recorded in the treatment T2 (RDF + urea 2% spray at pod initiation) and T3 (RDF + DAP 2% spray at pod initiation). In 2017 the seed index varied from 8.08 to 8.98g among the different treatments and the differences were non-significant (Table 1) and the highest seed index of 8.98g was recorded in the treatment T7 (RDF + Borax 0.5% spray at pod initiation)

Effect on seed and haulm yield of soybean

Higher seed yield was recorded during 2016 as compared to 2017 and this increase could be due to higher rainfall received during the crop growing season in 2016 from July to October -2016 (873.3mm) as compared to 2017 (804.7mm). More rainfall during 2016 led to better moisture content in soil and resulted in higher yield. During 2016, the highest seed yieldwas recorded in the treatment T5 (RDF + 19:19:19, N: P_2O_5, K_2O, @ 2% spray at pod initiation)which being at par with treatment T2 (RDF + urea 2% spray at pod initiation) recorded significantly higher seed yieldover all the remaining treatments.Foliar application of urea@2% in treatment T2 resulted in 16.8%higher yield over RDF application in T9 (Table 2).

During the year 2017 seed yield in treatment T5 (RDF + 19:19:19, N: P_2O_5, K_2O) being at par with treatment T3, T4, T6 and T8 was significantly higher over the remaining treatments (Table 2).The percent increase in seed yield due to treatment T5 was 26.7 and 13.9 over RDF alone during 2016 and 2017

Table1: Influence of foliar nutrition on yield attributes of soybean

Treatments	Branches/ plant at Harvest		Pods/plant at Harvest		Seed index (g)	
	2016	2017	2016	2017	2016	2017
T-1: RDF + water spray at pod initiation	6.0	6.22	37.0	45.4	8.88	8.42
T-2: RDF + Urea 2% spray at pod initiation	6.0	6.23	46.0	72.2	9.17	8.82
T-3: RDF + DAP 2% spray at pod initiation	5.3	6.22	54.0	75.0	9.17	8.60
T-4: RDF + MOP 0.5% spray at pod initiation	6.3	5.89	61.3	59.3	8.50	8.47
T-5: RDF + 19:19:19 (NPK) 2% spray at pod initiation	7.0	7.0	78.3	89.8	9.09	8.08
T-6: RDF + Sodium Molybdate 0.5% spray at pod initiation	6.5	5.89	43.8	74.0	8.97	8.48
T-7: RDF + Borax 0.5% spray at pod initiation	6.5	6.00	53.0	74.0	8.33	8.98
T-8: RDF + chelatedzinc 0.5% spray at pod initiation	6.5	5.3	43.1	67.2	8.87	8.75
T-9: RDF only	6.0	5.44	43.0	54.2	8.58	8.62
SEm ±	0.63	0.62	2.83	3.26	0.226	0.37
CD (p=0.05)	NS	NS	8.26	10.1	NS	NS

Table 2: Soybean yield, harvest index and economics as influenced by various foliar treatments

Treatment	Seed yield (kg/ha)		Haulm yield (kg/ha)		Harvest index (%)		B:C ratio		Grain production efficiency (kg/ha/day)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
T-1: RDF + water spray at pod initiation	1470	1157	3686	3463	28.45	25.07	1.07	1.24	12.25	12.78
T-2: RDF + Urea 2% spray at pod initiation	1773	1393	4275	4099	29.42	25.49	1.50	1.49	14.78	12.21
T-3: RDF + DAP 2% spray at pod initiation	1574	1456	4097	4156	27.72	26.16	1.20	1.56	13.12	10.56
T-4: RDF + MOP 0.5% at pod initiation	1557	1204	4045	3751	27.72	24.34	1.19	1.28	12.98	10.15
T-5: RDF + 19:19:19 (NPK) 2% at pod initiation	1924	1471	4768	3872	28.85	27.57	1.59	1.51	16.04	12.90
T-6: RDF + Sodium Molybdate 0.5% at pod initiation	1555	1362	4205	3713	26.97	26.96	1.18	1.46	12.95	11.94
T-7: RDF + Borax 0.5% at pod initiation	1461	1302	4091	4104	26.27	24.13	1.05	1.39	12.18	11.42
T-8: RDF + chelated zinc 0.5% at pod initiation	1499	1316	3990	4133	27.37	24.14	1.06	1.38	12.49	11.54
T-9: RDF only	1518	1292	3965	3833	27.75	25.22	1.16	1.40	12.65	11.33
SEm±	65.1	53.2	167.1	275.5	0.008	1.27	-	-	0.41	0.47
CD (P=0.05)	190.0	159.5	487.6	NS	NS	NS	-	-	1.20	1.40

respectively. The peak flowering and pod formation stage in soybean coincides with the start of degeneration of *Rhizobium* nodules, thus the supply of nitrogen through foliar application resulted in higher seed yield in treatment T5 during both the years.Foliar nutrition of N: P_2O_5, K_2O 19:19:19+ RDF increase the photosynthetic activity and delayed the senescence of leaves, which enhanced the supply of photosynthates available for grain filling, thus resulted in higher grain yield (Singh *et al*., 2018).During both the years of experimentation application of micronutrients did not influence the seed yield and all three micronutrients treatments T6 (RDF + Sodium molybdate 0.5% spray at pod initiation), T7 (RDF + Borax 0.5% spray at pod initiation) and T8 (RDF + chelated zinc 0.5% spray at pod initiation) were at par with treatment T9 (RDF only). Among the micronutrients, application of sodium molybdate resulted in 2.5 % and 5.4 % higher yield over RDF in 2016 and 2017 respectively (Table 2). Similar findings of increase in seed yield due to application of foliar nutrients was also reported by Saxena *et al.* (2010), Billore *et al.* (2015) and Singh *et al.* (2018). During both the years, the highest haulm yield was recorded in the treatment T5 (NPK 19:19:19+ RDF). In 2016 significantly highest haulm yield was recorded in treatment T5 as compared to remaining treatments, while in 2017 the differences were non-significant.

Effect on harvest index, B:C ratio and grain production efficiency

Harvest index during 2016 ranged from 26.3% to 29.4, while in 2017 it ranged from 24.1% to 27.6%, though the differences were non-significant during both the years (Table 2).During 2016 the highest B: C ratio was also recorded in the treatment T5

followed by T2 and the lowest B:C ratio was recorded in T7 treatment, while in 2017 the highest B:C ratio was recorded in the treatment T3 followed by treatment T5 and the lowest value was recorded in treatment T1 (Table 2).

Grain production efficiency is the economic yield produced per day during the crop growth duration. It varied between 16.0 to 12.2 kg/ha/day during 2016 and the highest grain production efficiency was recorded in the treatment T-5 and the lowest in the treatment T7, while in 2017 the grain production efficiency ranged from 10.2 to 12.9 kg/ha/day and thehighest value was recorded in the treatment T5 and least in the treatment T4 (Table 2).

CONCLUSION

On the basis of results from the present investigation, it may be concluded that foliar application of N:P:K 19:19:19, along with RDF at pod initiation stage resulted in the highest pods per plant, highest seed and haulm yields and also the highest harvest index.

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