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Influence of Foliar Nutrition on the Performance of Soybean [*Glycine max* (L.) Merrill]

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Abstract

A field experiment was conducted during the *kharif* season of 2016 at the Zonal Agricultural Research Station, University of Agricultural Sciences, Bangalore to evaluate the effect of foliar nutrition on productivity of soybean crop (variety MAUS-2). The experiment was laid out in Randomized Block Design with three replications. There were ten treatments consisting of various combinations of nutrient application *viz.,* RDF + water spray, RDF + Urea @ 2 per cent spray, RDF + DAP @ 2 per cent spray at pod initiation, RDF + MOP @ 0.5 per cent spray, RDF + NPK (19:19:19) @ 2 per cent spray, RDF+ Molybdenum @ 0.5 per cent spray, RDF + Boron @ 0.5 per cent spray, RDF + Zinc chelated @ 0.5 per cent spray, RDF + bio-digester liquid spray and RDF through organic source (FYM) @ 13.44 kg plot^{-1}. The treatments were imposed during pod initiation stage of crop growth (45 DAS). The application of RDF + DAP @ 2 per cent spray resulted in significantly higher number of pods plant^{-1} (43.00), number of seeds pod^{-1} (3.00), number of seeds plant^{-1} (88.37) and higher grain yield (3772 kg ha^{-1}) compared to the other treatments. Foliar application of DAP @ 2 per cent also recorded significantly higher net return of Rs.55,808 ha^{-1} and BC ratio of 2.84.

Keywords: Soybean, Foliar nutrition, Productivity

Soybean [*Glycine max* (L.) Merrill] is popularly known as the 'Golden bean' or 'Miracle crop' of the 21st century because of its versatile nutritional qualities. It contains 20 per cent of oil and 40 per cent of protein with high levels of essential amino acids such as lysine (5 %), minerals (4 %), phospholipids (2 %) and the vitamins *viz.,* thiamine and riboflavin. The protein quality of soybean is equivalent to that of meat, milk products and eggs. It is generally grown as a rainy season crop under rainfed situation. In India, soybean occupies an area of 12.2 million hectares with the production of 89.19 lakh tonnes and an average productivity of 983 kg ha^{-1} (Anon., 2015). The productivity of soybean is comparatively very less in India as compared to world average (2484.1 kg ha^{-1}). Global area and production of soybean is 111.27 m.ha. and 276.4 m.t., respectively (Anon., 2015). The major soybean producing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh and Karnataka.

Material and Methods

A field experiment was conducted during the *kharif* 2016 at the Zonal Agricultural Research Station, University of Agricultural Sciences, Bengaluru to evaluate the effect of foliar nutrition on productivity of soybean crop (variety MAUS-2). The experiment was laid out in Randomized Block Design with three replications. There were ten treatments consisting of various combinations of nutrient application *viz.,* RDF + water spray, RDF + Urea @ 2 per cent spray, RDF + DAP @ 2 per cent spray at pod initiation, RDF + MOP @ 0.5 per cent spray, RDF + NPK(19:19:19) @ 2 per cent spray, RDF+ Molybdenum @ 0.5 per cent spray, RDF + Boron @ 0.5 per cent spray, RDF + Zinc chelated @ 0.5 per cent spray, RDF + bio-digester liquid spray and RDF through organic source (FYM) @ 13.44 kg plot^{-1}. The treatments were imposed during pod initiation stage of crop growth (45 DAS).

The soil of the experimental site was red sandy clay loam with neutral pH (6.59) with electrical conductivity of 0.31 dSm^{-1}. The soil was medium in organic carbon (0.35) and in available Nitrogen (264.50 kg ha^{-1}) and medium in available phosphorus (38.34 kg ha^{-1}) and potassium (110.25 kg ha^{-1}).

The land was ploughed with tractor drawn cultivator and disc harrow was passed to remove weeds, crush the clods and levelled the plot. In order to prevent the crop from seed and soil borne diseases, the seeds were treated with Bavistin @ 3 g kg^{-1} of seeds followed by Rhizobium culture @ 5 g kg^{-1} of seeds. Then treated seeds were dried under shade for 3-4 hours before sowing. The seeds were sown manually at 60 kg ha^{-1} with the spacing of 30 cm between the rows and 10 cm between the plant. The recommended dose of fertilizer *i.e.,* 25:60:25 kg NPK ha^{-1} through Urea, SSP and Muriate of Potash (MOP), respectively were applied as basal dose before sowing and mixed properly. All micro nutrients were applied at an early stage of pod initiation and precaution was taken care of during preparation of micro nutrients solution. General weed management practice was adopted at 25 DAS by using pre-emergence herbicide Alachlor @ 1 kg a.i. ha^{-1} followed by one manual hand weeding at 45 DAS.

Harvesting was done manually from the net plot area when the seed became hard and leaves turned yellow in color. The plants were left in the plot for five days to sundry. The bundle weight $plot^{-1}$ was recorded. Threshing of the produce of each net plot was done manually by beating with a wooden stick and after manual winnowing seed yield $plot^{-1}$ was recorded. Randomly selected matured pods of five tagged plants from each plot and their seeds were counted and the average was calculated by dividing the total number of pods of five tagged plants to get the mean number of seeds pod^{-1}. All matured pods of five tagged plants from each plot were picked up and their seeds were counted and the average was calculated by dividing the total number of seeds of five tagged plants to get the mean number of seeds $plant^{-1}$. Randomly seed samples were taken from each net plot and hundred healthy seeds from the produce of each plot were counted and same was oven dried at a temperature of 60 °C for 24 hours then weight (g) was recorded accurately by using an electronic digital balance. Seed yield of the net plot was noted down after threshing, winnowing and drying then calculated in kg ha^{-1} with appropriate multiplication factor (740.74). The harvested produce from each net plot was tied in bundles separately. Bundle weight was recorded with the help of spring balance and converted into kg ha^{-1}. Stalk yield of the plot was calculated after subtraction of seed yield from bundle weight.

Oil was extracted from seeds of soybean with the help of Sacsplus solvent extractor using acetone as a solvent. Protein content (%) of seeds collected from respective plots or treatments was calculated by multiplying the conversion factor (6.25) with nitrogen content estimated by the prescribed method of seed.

The cost of various inputs used and the prices of outputs in the prevailing local markets were considered for estimation of the cost of cultivation, gross returns and net returns $hectare^{-1}$. Net returns were calculated by deducting the cost of cultivation from total gross returns. Benefit-cost ratio was worked as follows:

$$\text{BC ratio} = \text{Gross returns (Rs.ha}^{-1}\text{)} / \text{Cost of cultivation (Rs. ha}^{-1}\text{)}$$

Results and Discussion

The yield and yield attributes of soybean as influenced by the foliar application of nutrients at pod initiation stage *viz.,* number of pods $plant^{-1}$, number of seeds pod^{-1}, test weight (g) and seed yield $plant^{-1}$ (g) arepresented in Table 1. Highest seed yield (3772 kg ha^{-1}) was recorded with RDF + DAP 2 per cent spray at pod initiation stage compared to RDF through organic sources recorded lowest seed yield (1927 kg ha^{-1}). This was attributed to higher values of number of pods (43 $plant^{-1}$), number of seeds (3.00 pod^{-1}), test weight (11.40 g) and seed yield (88.37 g $plant^{-1}$). This increase in yield is due to optimum availability of all nutrients at flower initiation and pod formation stages of crop growth, which resulted in efficient translocation of photosynthates from source to sink. The present study findings are in agreement with Kumar *et al.* (2013) in black gram, Ganapathy *et al*. (2008), Nadergoli *et al*. (2011) in common bean. Significantly higher number of pods $plant^{-1}$ was produced by foliar application of RDF + DAP 2 per cent spray at flowering and pod initiation stage increased the number of pods $plant^{-1}$ could be attributed due to significant effect of

TABLE 1

Yield attributing characters of soybean as influenced by foliar spray of nutrients at pod initiation stage

Treatments	Number of pods plant^{-1}	Number of seeds pod^{-1}	Test weight(g)	Seeds plant^{-1} (g)	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})
T_1: RDF + Water spray	37	1.98	11.01	56.10	2323	2945
T_2: RDF + Urea 2 % spray	41	2.91	11.20	82.37	3431	4152
T_3: RDF + DAP 2 % spray	43	3.00	11.40	88.37	3772	4559
T_4: RDF + MOP 2 % spray	38	2.86	11.00	75.82	3091	3852
T_5: RDF + 19:19:19 (NPK) 2 % spray	37	2.76	10.80	65.48	2581	3297
T_6: RDF + Molybdenum 0.5 % spray	40	2.82	11.00	81.57	3325	3995
T_7: RDF + Boron 0.5 % spray	38	2.67	11.07	62.53	2601	3153
T_8: RDF + Zinc chelated 0.5 % spray	39	2.63	11.10	63.80	2753	3249
T_9: RDF + Bio-digester liquid 2 % spray	37	2.02	11.05	61.07	2688	3045
T_{10}: RDF through organic source	35	1.78	10.00	52.67	1927	2577
SEm ±	0.60	0.17	0.04	6.84	32.53	52.37
CD (P=0.05)	1.77	0.52	0.13	20.31	96.66	155.59

RDF: 25: 60: 25 NPK kg ha^{-1}

micronutrients on reproductive organs, such as stamens and pollens. These results are in confirmation with the findings of Kumar *et al.,* (2013) in red gram and Ghosh and Joseph (2008) in green gram.

To examine the economic feasibility and viability of the different treatments under investigation during the field experiment, economics of soybean production in terms of gross return, net return and benefit cost ratio were calculated for different treatments of foliar application of nutrients at pod initiation in soybean and the outcome are presented in Table 2. The data revealed that the highest gross return (Rs.75,440 ha^{-1}), net return (Rs.55,808 ha^{-1}), and benefit cost ratio (2.84) were recorded under application of RDF + spray of DAP @ 2 per cent in soybean. The increase in gross and net return are due to higher seed yield. Less input cost and higher economical yield might be resultant in increase the B: C ratio. The highest cost of cultivation (Rs.34,382 ha^{-1}) was recorded under application of RDF + spray of Molybdenum @ 0.5 per cent of soybean among all the different treatments whereas, lowest benefit: cost ratio (0.93) was obtained under treatment of RDF + spray of Molybdenum @ 0.5 per cent in soybean due to scorching on leaves. This was also reported by Kumar *et al*. (2011) and other studies.

Higher oil content (22.01%) was recorded under theapplicationof RDF + DAP 2 per cent spray as compared to the other treatments (Table 3). This might be due to readily availability of nutrients that enhanced the activity of enzymes for biosynthesis of oil through foliar application of nutrients.

Application of RDF+DAP 2 per cent spray recorded maximum protein content (40 %) as compared to the application of RDF through organic sources (35%). The increase in protein content might be due to the fact that the nutrients were readily available to the plant and this was responsible for the structure of enzymes involved in amino acids synthesis and ultimately protein synthesis and thereby protein content

TABLE 2

Economics of soybean as affected by foliar application of nutrients at pod initiation stage

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B : C
T_1: RDF + Water spray	19382	46460	27078	1.39
T_2: RDF + Urea 2 % spray	19452	68620	49168	2.52
T_3: RDF + DAP 2 % spray	19632	75440	55808	2.84
T_4: RDF + MOP 2 % spray	19427	61820	42393	2.18
T_5: RDF + 19:19:19 (NPK) 2 % spray	21632	51620	29988	1.38
T_6: RDF + Molybdenum 0.5 % spray	34382	66500	32118	0.93
T_7: RDF + Boron 0.5 % spray	20922	52020	31098	1.48
T_8: RDF + Zinc chelated 0.5 % spray	21227	55050	33833	1.59
T_9: RDF + Bio-digester liquid spray	19382	53760	34378	1.77
T_{10}: RDF through organic source	19182	38540	19358	1.09

RDF: 25: 60: 25 NPK kg ha^{-1}

TABLE 3

Oil content (%) and Protein content (%) of soybean as influenced by foliar spray of nutrients at pod initiation stage

Treatments	Oil (%)	Protein (%)
T1: RDF + Water spray	19.17	36.30
T2: RDF + Urea 2 % spray	19.97	38.00
T3: RDF + DAP 2 % spray	22.01	40.00
T4: RDF + MOP 2 % spray	21.03	38.60
T5: RDF + 19:19:19 (NPK) 2 % spray	18.87	38.80
T6: RDF + Molybdenum 2 % spray	16.67	37.80
T7: RDF + Boron 0.5 % spray	16.93	37.10
T8: RDF + Zinc chelated 0.5 % spray	17.93	37.60
T9: RDF + Bio-digester liquid spray	19.46	35.60
T10: RDF through organic source	19.15	35.00
SEm±	0.30	0.34
CD (P=0.05)	0.90	1.02

increased. With the readily available nitrogen applied by foliar spray, it increased the protein synthesis and protein content of soybean. Similar findings were also reported by Kumar *et al.* (2013), who also observed higher protein content with the application of RDF+ spray of DAP 2 per cent at pod initiation.

Maximum total nitrogen uptake (302.95kg ha^{-1}) was observed in RDF + DAP 2 per cent spray (Table 4).The significant increase in nitrogen uptake may be due to the synergistic effect of nitrogen and phosphorus. A higher level of phosphorus must have enhanced the root growth, which helped in better absorption of nitrogen through symbiotic nitrogen fixation process as reported by Shashikumar *et al.* (2013).

Significantly higher uptake of total phosphorus was observed in RDF + DAP at 2 per cent spray pod initiation stage (35.42 kg ha^{-1}). The increased phosphorus uptake may be due to the increased dry matter production and the synergistic effect between nitrogen and phosphorus. The similar results were also reported by Mudalagiriyappa *et al.* (2016).

TABLE 4

Effect of foliar spray of nutrients on uptake of nitrogen, phosphorus and potassium by soybean at pod initiation stage

Treatments	Total N (kg ha^{-1})	Total P (kg ha^{-1})	Total K (kg ha^{-1})
T1: RDF + Water spray	172.79	14.82	60.46
T2: RDF + Urea 2 % spray	263.41	27.76	96.39
T3: RDF + DAP 2 % spray	302.95	35.42	108.88
T4: RDF + MOP 2 % spray	242.33	26.38	88.98
T5: RDF + 19:19:19 (NPK) 2 % spray	202.55	20.28	72.54
T6: RDF + Molybdenum 2 % spray	252.29	23.15	88.62
T7: RDF + Boron 0.5 % spray	200.47	18.40	70.49
T8: RDF + Zinc chelated 0.5 % spray	208.91	18.67	73.71
T9: RDF + Bio-digester liquid spray	164.15	14.58	58.97
T10: RDF through organic source	138.32	11.70	50.04
SEm±	3.47	4.01	4.25
CD (P=0.05)	10.43	12.07	12.55

RDF: 25: 60: 25 NPK kg ha^{-1}

Significantly higher total potassium uptake (108.88 kg ha^{-1}) was observed in DAP at 2 per cent spray. This higher uptake might be attributed due to significantly higher dry matter accumulation as a result of the application of other deficient nutrients such as N, P, S and B. The results confirm with the findings of Mudalagiriyappa *et al.* (2016).

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