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Physiological Approaches for Yield Improvement of Blackgram under Rainfed Condition

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A B S T R A C T

Crop productivity of blackgram being low in North eastern dry zone of Karnataka a field experiment was conducted during *kharif,* 2016 at Agricultural Research Station, Kalaburagi, UAS Raichur, to study the effect of foliar nutrition on physiological parameters and yield of blackgram under rainfed condition using TAU-1 variety. Among different sources of nutrients, the highest no. of seeds pod (8.7), pod length (6.1 cm), test weight (55.1 g) and seed yield (1101 kg ha^{-1}) was recorded with foliar spray of pulse magic @ 10g/l along with recommended dose of fertilizers, lower (4.8, 3.6 cm, 48.9 g and 894 kg ha^{-1}, respectively) was obtained in treatment were only recommended dose of fertilizers (25:50 kg N: P_2O_5 ha^{-1}) were applied and the lowest (3.0, 2.2, 16.6 g and 482 kg ha^{-1}, respectively) was obtained in plot were no basal dose of fertilizers were applied and also no foliar spray was given, realizing the importance of nutrition. The yield enhancement might be due to the improvement in physiological traits and yield attributes.

Introduction

Blackgram is an important short duration pulse crop extensively growing in North Eastern Dry Zone of Karnataka. It is widely grown as a grain legume and belongs to the family fabaceae and assumes considerable importance from the point of food and nutritional security. The productivity of the crop is declining over years due to various reasons. Among all the yield limiting factors, fertility management is imperative to ensure better crop production on exhausted soils. Farmers generally take up sowing with basal application of nutrients as recommended and there is no regional recommendation of foliar nutrition during crop growth period. Further, soil application of nutrients is often not enough to meet the growing crop demand particularly in short duration crop like blackgram, as it is basically indeterminate in habit of flowering and fruiting, there is a continuous competition for available assimilates between vegetative and reproductive sinks throughout the growth period. Since, the source is highly limited with lowering translocation of assimilates to the growing reproductive sinks. Hence, higher leaf area index which facilitates higher light interception is an important parameter to obtain higher source in terms of higher assimilation production. Apart from this, major physiological constraints are flower drop and fruit drop (Ojeaga and Ojehomon, 1972). It is usually grown on higher pH soils, it is well known that micro-nutrients as well as some macro-nutrients may hardly be absorbed by roots due to higher ion concentration, which lowers osmotic potential of soil water and consequently the availability of soil water to the plants became a limiting factor (Hirpara *et al.,* 2005), then foliar application is particularly useful (Swietlik and Faust, 1994). Therefore, foliar feeding of nutrients has become an established procedure in crop production to increase yield and quality of crop products (Roemheld and El-Fouly, 1999). Due to this reason, potential productivity is not achieved and hence there is a need to ensure balanced nutrition at right time to the crop through foliar nutrition. Consequently, applications of nutrient elements through foliar spray at appropriate stages of growth become important for their efficient utilization and better performance of the crop as a balanced fertilization with nutrients in plant nutrition is very important in the production of high yield with high quality seeds (Sawan *et al.,* 2001). It has been well established that most of the plant nutrients are also absorbed through the leaves and absorption would be remarkably rapid and nearly complete. Little information is available regarding the response of blackgram to foliar spray of water soluble fertilizers and/ or mixture of fertilizer and plant growth regulator along with soil application. Hence, this study was taken on priority to see the influence of foliar nutrition on blackgram in rainfed condition.

Materials and Methods

The field experiment was conducted during *kharif* 2016 at Agricultural Research Station, Kalaburagi, UAS Raichur under rainfed condition. The experiment was laid out in Randomized Complete Block Design (RCBD) with 13 treatments involving control (only recommended dose of fertilizers), absolute control (no fertilizer and no foliar spray) and pulse magic (product developed and released by UAS, Raichur for increasing the yield of pulse crops. It contains 10 per cent nitrogen, 40 per cent phosphorous, 3 per cent micronutrient and 20 PPM plant growth regulator) and 3 replications using TAU-1 variety with spacing of 30×10 cm. Basal dosage of fertilizer 25:50 kg N: P_2O_5 ha^{-1} was applied to all plots except absolute control. The soil of the experiment site is clayey (Soil pH 8.3; EC 0.21 dSm^{-1}). The available soil nitrogen, phosphorus and potassium were 241, 14.9 and 280 kg ha^{-1}, respectively. Leaf area index (LAI) was worked out by dividing the leaf area per plant by land area occupied by the plant as per Sestak *et al.,* (1971). TDMP of various plant parts was arrived by taking the sum of all the plant parts after keeping the sample in oven at 80^o C for 48 hours. Photosynthetic rate was measured by using infra-red gas analyzer (TPS-2 portable photosynthesis system version 2.01). The measurements were made on the portion of leaves exposed directly to sunlight and it is expressed in μ mol CO_2 m^{-2} s^{-1}. Total chlorophyll content of the leaves was determined by following Dimethyl sulfoxide (DMSO) method devised by Hiscox and Israeistam (1979). The data were analyzed statistically following the method of Panse and Sukhatme (1967). Foliar spray was carried out at flowering stage. The data on growth, yield and yield attributes were statistically analysed and interpreted.

Results and Discussion

All the parameters did not varied significantly before spraying except absolute control (T_{13}) realising the importance of nutrition. Leaf area index is one of the principle factors influencing canopy net photosynthesis of the crop plants (Hansen, 1972). Patra *et al.,* (1995) stated that total dry matter production and pod yield of groundnut were attributed to higher LAI through facilitating efficient interception of light. As observed from the present study the leaf area index was also greatly influenced by various foliar treatments. Higher LAI was maintained at 55DAS (Table 1) with the foliar application of pulse magic @ 10g/l, as combination of both nutrients and PGR has arrested the chlorophyll degradation and enhanced photosynthetic enzyme synthesis resulted in more assimilatory surface area for longer period and thereafter it was declined as crop reaches towards maturity as leaf area declines due to the onset of senescence phenomenon (Kalarani, 1991 and Sujatha, 2001). These results are quite inline with the findings of Surendar *et al.,* (2013) in blackgram due to foliar application of combination of nitrogen and PGR.

The first prerequisite for higher yields is an increase in the total dry matter production (TDM) per unit area and its partitioning to various parts. Dry matter accumulation is an important index reflecting the growth and metabolic efficiency of the plant which ultimately influence the yield of crop. A significant difference in dry matter production was noticed due to foliar application and the highest dry matter production were obtained with foliar application of pulse magic due to the presence of 10 per cent of nitrogen, 40 per cent of phosphorus, 3 per cent of micronutrients and 20 ppm PGR, which governed the various physiological characters that ultimately increased the dry matter production (Table 2) and its partitioning. In blackgram higher TDM was reported by Surendar *et al.,* (2013) due to foliar application of combination of nitrogen and PGR and by Shashikumar *et al.,* (2013) in blackgram due to foliar application of combination of PGR and nutrients. Due to foliar application of various nutrients mixture higher total dry matter was reported by Yadav and Choudhary (2011) in cowpea.

Table.1 Influence of foliar nutrition at flowering stage on Leaf area index at various growth stages in blackgram

Treatments	**Days after sowing**		**At harvest**
	35	**55**	
T_1 - Foliar application of Urea @ 2.0 %	0.92	1.78	0.46
T_2 - Foliar application of Monoammonium phosphate @ 2.0 %	0.93	1.79	0.47
T_3 - Foliar application of Potassium sulfate @ 1.0 %	0.93	1.74	0.45
T_4 - Foliar application of Manganese sulfate @ 0.3 %	0.94	1.73	0.44
T_5 - Foliar application of Magnesium sulfate @ 0.3 %	0.95	1.72	0.43
T_6 - Foliar application of Zinc sulfate @ 0.5 %	0.91	1.80	0.46
T_7 - Foliar application of Boric acid @ 0.02 %	0.93	1.54	0.36
T_8 - Foliar application of Iron sulfate @ 0.5 %	0.94	1.75	0.45
T_9 - Foliar application of Ammonium molybdate @ 0.05 %	0.92	1.56	0.37
T_{10} - Foliar application of 19:19:19 Mixture @ 2.0 %	0.94	1.82	0.48
T_{11} - Foliar application of Pulse magic @ 10 g/l	0.92	1.98	0.53
T_{12} - Control (RDF)	0.91	1.51	0.36
T_{13} - Absolute control	0.62	0.90	0.29
S.Em (±)	**0.03**	**0.04**	**0.01**
C.D. at 5 %	**0.08**	**0.14**	**0.04**

Table.2 Influence of foliar nutrition at flowering stage on dry matter accumulation (g plant^{-1}) and its partitioning at various growth stages in blackgram

Treatments	35 DAS			55 DAS			At harvest			
	Leaf	**Stem**	**Total**	**Leaf**	**Stem**	**Total**	**Leaf**	**Stem**	**Pods**	**Total**
T_1 - Foliar application of Urea @ 2.0 %	3.25	0.27	3.52	6.24	2.03	8.27	1.64	3.85	11.28	16.77
T_2 - Foliar application of Monoammonium phosphate @ 2.0 %	3.26	0.29	3.55	6.28	2.06	8.34	1.65	3.89	11.94	17.48
T_3 - Foliar application of Potassium sulfate @ 1.0 %	3.27	0.28	3.55	6.10	1.94	8.04	1.56	3.73	10.55	15.85
T_4 - Foliar application of Manganese sulfate @ 0.3 %	3.29	0.29	3.58	6.05	1.91	7.96	1.54	3.68	10.02	15.23
T_5 - Foliar application of Magnesium sulfate @ 0.3 %	3.30	0.27	3.57	6.03	1.89	7.92	1.50	3.63	9.90	15.03
T_6 - Foliar application of Zinc sulfate @ 0.5 %	3.18	0.27	3.45	6.30	1.98	8.28	1.61	3.81	10.38	15.80
T_7 - Foliar application of Boric acid @ 0.02 %	3.24	0.26	3.50	5.40	1.65	7.05	1.28	3.21	6.66	11.14
T_8 - Foliar application of Iron sulfate @ 0.5 %	3.28	0.28	3.56	6.13	1.95	8.08	1.58	3.77	9.88	15.23
T_9 - Foliar application of Ammonium molybdate @ 0.05 %	3.23	0.29	3.52	5.49	1.68	7.17	1.31	3.25	6.87	11.42
T_{10} - Foliar application of 19:19:19 Mixture @ 2.0 %	3.30	0.27	3.57	6.39	2.13	8.52	1.68	3.93	12.27	17.89
T_{11} - Foliar application of Pulse magic @ 10 g/l	3.21	0.30	3.51	6.91	2.35	9.26	1.87	4.29	17.58	23.74
T_{12} - Control (RDF)	3.20	0.28	3.48	5.30	1.63	6.93	1.24	3.16	6.33	10.73
T_{13} - Absolute control	2.18	0.14	2.32	3.15	1.02	4.17	1.02	1.96	3.09	6.07
S.Em (±)	**0.10**	**0.02**	**0.11**	**0.17**	**0.06**	**0.23**	**0.05**	**0.11**	**0.86**	**0.89**
C.D. at 5 %	**0.30**	**0.05**	**0.32**	**0.50**	**0.19**	**0.67**	**0.16**	**0.34**	**2.52**	**2.59**

DAS: Days after showing

Table.3 Influence of foliar nutrition at flowering stage on chlorophyll a, b (mg g^{-1} fresh wt.) and a/b ratio at various growth stages in blackgram

Treatments	35 DAS			55 DAS			At harvest		
	Chl.a	**Chl.b**	**a/b ratio**	**Chl.a**	**Chl.b**	**a/b ratio**	**Chl.a**	**Chl.b**	**a/b ratio**
T_1 - Foliar application of Urea @ 2.0 %	1.077	0.380	2.837	2.330	0.917	2.560	0.947	0.380	2.497
T_2 - Foliar application of Monoammonium phosphate @ 2.0 %	1.160	0.373	3.106	2.350	0.913	2.573	0.960	0.363	2.645
T_3 - Foliar application of Potassium sulfate @ 1.0 %	1.153	0.387	3.000	2.287	0.883	2.587	0.930	0.367	2.540
T_4 - Foliar application of Manganese sulfate @ 0.3 %	1.123	0.363	3.095	2.273	0.870	2.626	0.933	0.380	2.460
T_5 - Foliar application of Magnesium sulfate @ 0.3 %	1.103	0.397	2.825	2.310	0.903	2.567	0.963	0.390	2.477
T_6 - Foliar application of Zinc sulfate @ 0.5 %	1.073	0.390	2.766	2.320	0.887	2.618	0.933	0.357	2.659
T_7 - Foliar application of Boric acid @ 0.02 %	1.133	0.360	3.147	1.933	0.747	2.594	0.967	0.373	2.590
T_8 - Foliar application of Iron sulfate @ 0.5 %	1.143	0.323	3.569	2.300	0.893	2.579	0.957	0.353	2.730
T_9 - Foliar application of Ammonium molybdate @ 0.05 %	1.077	0.320	3.548	1.970	0.767	2.578	0.980	0.373	2.640
T_{10} - Foliar application of 19:19:19 Mixture @ 2.0 %	1.123	0.370	3.050	2.373	0.913	2.599	0.927	0.387	2.407
T_{11} - Foliar application of Pulse magic @ 10 g/l	1.127	0.383	2.957	2.587	0.993	2.603	0.940	0.370	2.542
T_{12} - Control (RDF)	1.083	0.390	2.849	1.907	0.740	2.581	0.923	0.380	2.428
T_{13} - Absolute control	0.607	0.220	2.792	1.117	0.443	2.533	0.357	0.177	2.083
S.Em (±)	**0.054**	**0.030**	**0.239**	**0.071**	**0.025**	**0.124**	**0.028**	**0.017**	**0.160**
C.D. at 5 %	**0.159**	**0.08**	**0.698**	**0.208**	**0.074**	**0.361**	**0.082**	**0.050**	**0.468**

DAS: Days after showing

Table.4 Influence of foliar nutrition at flowering stage on photosynthetic rate (µ mol CO_2 m^{-2} s^{-1}) at various growth stages in blackgram

Treatments	Days after sowing		At harvest
	35	55	
T_1 - Foliar application of Urea @ 2.0 %	17.95	26.50	2.77
T_2 - Foliar application of Monoammonium phosphate @ 2.0 %	18.73	26.80	2.53
T_3 - Foliar application of Potassium sulfate @ 1.0 %	18.40	25.10	2.71
T_4 - Foliar application of Manganese sulfate @ 0.3 %	18.56	24.93	2.50
T_5 - Foliar application of Magnesium sulfate @ 0.3 %	18.31	24.44	2.75
T_6 - Foliar application of Zinc sulfate @ 0.5 %	17.93	26.27	2.63
T_7 - Foliar application of Boric acid @ 0.02 %	18.70	21.63	2.79
T_8 - Foliar application of Iron sulfate @ 0.5 %	17.90	25.18	2.47
T_9 - Foliar application of Ammonium molybdate @ 0.05 %	18.36	21.87	2.50
T_{10} – Foliar application of 19:19:19 Mixture @ 2.0 %	18.11	27.30	2.63
T_{11} - Foliar application of Pulse magic @ 10 g/l	17.96	29.70	2.99
T_{12} - Control (RDF)	18.03	21.33	2.82
T_{13} - Absolute control	9.06	9.57	1.30
S.Em (±)	**0.53**	**0.81**	**0.21**
C.D. at 5 %	**1.55**	**2.37**	**0.62**

Table.5 Influence of foliar nutrition at flowering stage on yield components and yield in blackgram

Treatments	No. of seeds pod^{-1}	Pod length (cm)	Test weight (g)	Seed yield (kg ha^{-1})
T_1 - Foliar application of Urea @ 2.0 %	6.9	5.1	51.0	1002
T_2 - Foliar application of Monoammonium phosphate @ 2.0 %	7.0	5.1	49.7	1013
T_3 - Foliar application of Potassium sulfate @ 1.0 %	6.8	5.0	50.5	982
T_4 - Foliar application of Manganese sulfate @ 0.3 %	6.6	4.8	49.4	979
T_5 - Foliar application of Magnesium sulfate @ 0.3 %	6.7	4.9	49.9	976
T_6 - Foliar application of Zinc sulfate @ 0.5 %	6.8	5.0	49.4	986
T_7 - Foliar application of Boric acid @ 0.02 %	4.9	3.6	47.0	909
T_8 - Foliar application of Iron sulfate @ 0.5 %	6.7	4.9	49.7	985
T_9 - Foliar application of Ammonium molybdate @ 0.05 %	5.0	3.7	47.7	913
T_{10} – Foliar application of 19:19:19 Mixture @ 2.0 %	7.1	5.2	51.0	1018
T_{11} - Foliar application of Pulse magic @ 10 g/l	8.7	6.1	55.1	1101
T_{12} - Control (RDF)	4.8	3.6	48.4	894
T_{13} - Absolute control	3.0	2.2	16.6	482
S.Em (±)	**0.5**	**0.2**	**1.3**	**27**
C.D. at 5 %	**1.5**	**0.7**	**4.0**	**80**

Chandrasekhar and Bangarusamy (2003) reported that foliar application of macronutrients along with PGR at flowering stage significantly increased TDM in greengram and this was quite similar with findings of our present results.

Among various biochemical parameters leaf chlorophyll content plays an important role in crop productivity as it helps in harvesting sunlight and transforming its energy into biochemical energy essential for life on earth. Due to this nature it has been designated as "Pigments of life" and it also an indicator of vigour of the plant. In our present studies, the highest chlorophyll content was observed with foliar application of pulse magic @ 10 g/l (T_{11}). The variation in chlorophyll content due to foliar spray may be attributed to decreased chlorophyll degradation and increased chlorophyll synthesis and this was highest in T_{11} (Chl a- 2.587, Chl b-0.993 mg g^{-1} fresh wt.) compared to Control (Chl a- 1.907, Chl b-0.740 mg g^{-1} fresh wt.) at 55 DAS and thereafter declines as crop reached towards maturity due to senescence of leaves (Table 3). This increase in chlorophyll content may be due to presence of nitrogen as it is integral component of chlorophyll molecule (Mitra *et al.,* 1987) and zinc acts as a co-factor for normal development of pigment biosynthesis (Balashouri, 1995) and regulates the chlorophyll content of the leaves. Our results are in conformity with the findings Bhanavase *et al.,* (1994) in soybean and Singh *et al.,* (1988) in groundnut due to foliar application of combination of various nutrients.

The hypothesis that higher leaf photosynthetic rates are necessary for increased yields is still popular (Elmore 1980). Several factors such as light intensity and ambient CO_2 concentration which are known to affect leaf photosynthesis also affect yield in the same direction (Moss and Musgrave 1971). Chandrababu *et al.,* (1985) found significant and positive correlations between leaf photosynthetic rates during the post anthesis period and total dry matter production and pod yield in blackgram. In a similar study Srinivasan *et al.,* (1985) found a significant positive correlation between leaf photosynthesis at the early pod development stage and total dry matter and pod yield in greengram. The photosynthetic rate under a given environmental condition is a function of the various biophysical and biochemical processes which involves diffusion of CO_2 from atmosphere to chloroplast and subsequent enzymatic reactions. In the present experiment, higher photosynthetic rate (Table 4) was observed in foliar spray of pulse magic and it is due to supplying the combination of various nutrients and plant growth regulator (PGR) which may enhances the catalytic units of chloroplast and hence more photosynthetic rate. These findings are similar to the results of Borowski and Michalek (2000), Jla and Hray (2004) in broad bean and in mungbean by Rao *et al.,* (2015) due to influence of nitrogen.

Seed yield governed by number of factors which have direct or indirect impacts. The improvement in seed yield is achieved through improvement in yield attributing characters *viz.*, number of seeds per pod, pod length and test weight. In the present investigation, foliar application of pulse magic @ 10g/l has increased the yield attributing characters and it may be due to the higher leaf area index as it facilitates higher light interception. Foliage applied macro and micronutrients at critical stages of the crop were effectively absorbed and translocated to the developing pods, producing more number of pods and better filling in soybean was reported by Jayabel *et al.,* (1999) in soybean. Similarly, higher number of seeds per pod (8.7) were absorbed in pulse magic foliar spray and it is due to the application of nutrients at reproductive stage has helped in more translocation of photosynthates to the developing pods which has also helped in better filing thus increase in pod length (6.1 cm) and due to the better filling of seeds test weight of the seeds has also increased to the extent of 13 per cent. Due to increase in yield attributing characters final seed yield was increased (Table 5) to the extent of 23 % increment over control, this increment in seed yield was similar to the findings of Teggelli *et al.,* (2016) in pigeonpea due to foliar application of pulse magic.

Based on the above, it could be concluded that foliar application of pulse magic @ 10 g/l during flowering stage along with recommended dose of fertilizers will boost the seed yield in blackgram.

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