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Impact of Foliar Application of Nutrients on Yield and Economics of Cluster Bean (*Cyamopsis tetragonoloba* L.) under Dryland Condition

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ABSTRACT

Field experiments were carried out at CCS Haryana Agricultural University, Hisar during *kharif* season of 2018 to 2020 to find out the impact of foliar spray of nutrients on yield and economics of cluster bean (*Cyamopsis tetragonoloba* L.) under dryland condition. The experiment was laid out in Randomized Block Design with three replications comprising of nine treatments viz. RDF ($N:P_2O_5$ @ 20:40 kg/ha), RDF + water spray at flower initiation, RDF + water spray at pod formation, RDF + NPK (0:0:50) 1% spray at flower initiation, RDF + NPK (0:0:50) 1% spray at pod formation, RDF + 0.5% $ZnSO_4$ spray at flower initiation, RDF + 0.5% ZnSO4 spray at pod formation, RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at flower initiation and RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at pod formation. The results indicated that yield attributes, viz. plant height at harvesting, number of branches/plant, number of pods/plant and test weight, were significantly influenced by different foliar nutrition treatments except water spray. Among different treatments, RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at flower initiation recorded highest plant height at harvesting (75.8 cm), number of branches/plant (11.4), number of pods/plant (70.4) and test weight (31.3 g). Further, the data showed that, RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at flower initiation increased the seed and straw yield of cluster bean by 38.8 and 47.8% compared with RDF alone (control) with higher net returns (₹ 21139/ha), benefit: cost ratio (2.08) and rainwater-use efficiency (4.52 kg/ha-mm).

Keywords Cluster bean, Dryland, Economics, Foliar spray, Nutrients, Yield.

INTRODUCTION

The aberrant nature of rainfall is often faced in dryland regions and reduces crop productivity because of either untimely onset of monsoon or early withdrawal of monsoon and associated dry spell (s) at any stage in the crop season (Verma and Singh 2017). Cluster bean (*Cyamopsis tetragonoloba* L.) is a deep-rooted crop grown for feed, fodder, green manure and vegetable purpose. Being a legume crop, it has the capacity to fix atmospheric nitrogen by its effective root nodules (Kumhar *et al.* 2012). It is highly adaptable towards erratic rainfall and have multiple industrial uses. It

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is an important crop in cropping system for farmers of arid areas. Under drought stress, reduced nutrient availability is an important factor for limiting plant growth. Foliar application offers numerous advantages, including satisfying the nutritional need of crop grown in moisture deficient soils in rainfed condition. In India, the area under cluster bean was 2.71 million ha and production of 1.30 million tonnes with the average productivity of 481 kg/ha during 2020-21 (MoA *et al.* 2022).

Potassium is an important nutrient for improving the crop yield per unit area. Potassium is vital for physiological processes, water availability, photosynthesis, transportation of assimilates and activation of enzyme with a direct effect on crop production. Potassium checks the water requirement of crop during water stress conditions since potassium plays an important role in the opening and closing of stomata, through which transpiration occurs from the leaves and CO_2 enters into leaf tissues. Stomatal activity reduces and loss of transpiration increases under inadequacy of potassium. Grain yield increases by enhancing the uptake of potassium under the arid condition (Damon and Rengel 2008). Foliar application of nutrients is the quickest and efficient utilization of nutrients which eliminates the losses through leaching, fixation and helps in regulating the uptake of nutrients by the plants (Manomani and Srimathi 2009). Foliar application of NPK shall be more effective than soil application and also avoiding the depletion of these nutrients in leaves, thereby resulting in an increased photosynthetic rate, better translocation of these nutrients from the leaves to the developing grains. Zinc is important for plant growth, as plants require a proper balance of all the essential nutrients for normal growth and optimum yield. It is required as a structural component of a greater number of proteins such as transcription factors and enzymes (Singh and Kumar 2009). Therefore, the present investigation was carried out to adjudge the impact of foliar application of nutrients on yield and economics of cluster bean var. 'HG 563' in sandy loam soil of Haryana under dryland condition.

MATERIALS AND METHODS

A field experiment was conducted at Dryland Agriculture Research Farm of the Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India (29010' N latitude, 75046' E longitude and 215.2 m altitude). The soil of the experimental field was sandy loam in texture, low in organic carbon (0.28%), low in available nitrogen (119 kg/ha), medium in available phosphorus (12.4 kg/ha), potassium (266 kg/ha) and Zn (0.52 ppm). The experiment was laid out in Randomized Block Design with three replications comprising of nine treatments viz. RDF ($N:P_2O_5$ @ 20:40 kg/ha), RDF + water spray at flower initiation, RDF + water spray at pod formation, RDF + NPK (0:0:50) 1% spray at flower initiation, RDF + NPK (0:0:50) 1% spray at pod formation, RDF + 0.5% $ZnSO_4$ spray at flower initiation, RDF + 0.5% $ZnSO_4$ spray at pod formation, RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at flower initiation and RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at pod formation. The crop was sown on 4, 22 and 15 July and harvested on 10, 15 and 12 October during 2018, 2019 and 2020, respectively. The seeds of cluster bean var HG 563 were sown at 45 cm spacing in the plots of size 6.0 m × 4.5 m. Nitrogen and phosphorus at 20 and 40 kg ha^{-1} at the time of sowing in the form of urea and DAP, respectively across all the treatments was considered as recommended dose of fertilizer (RDF). The crop was grown with all recommended package of practices during all the three years. Other climatic data except rainfall were also recorded during the course of experimentation (Fig. 1). Rainwater-use efficiency (RWUE) was calculated by dividing the grain yield (kg/ha) to cumulative effective rainfall (mm) from sowing to harvest. RWUE (kg/ha-mm) indicates the water productivity or water use efficiency of a treatment under dryland condition.

The observations on yield attributing characters were recorded manually on five randomly selected representative plants from each plot of each replication separately. The economics of different treatments was calculated considering the current cost of inputs and outputs (₹ 4066/q for cluster bean seed and ₹ 223/q for cluster bean straw) in terms of net returns of the crop to find out the most profitable treatment. Treatment-wise benefit: cost (B: C) ratio was calculated to ascertain economic viability. All the results were analyzed statistically for drawing conclusion using online statistical analysis tools (OPSTAT).

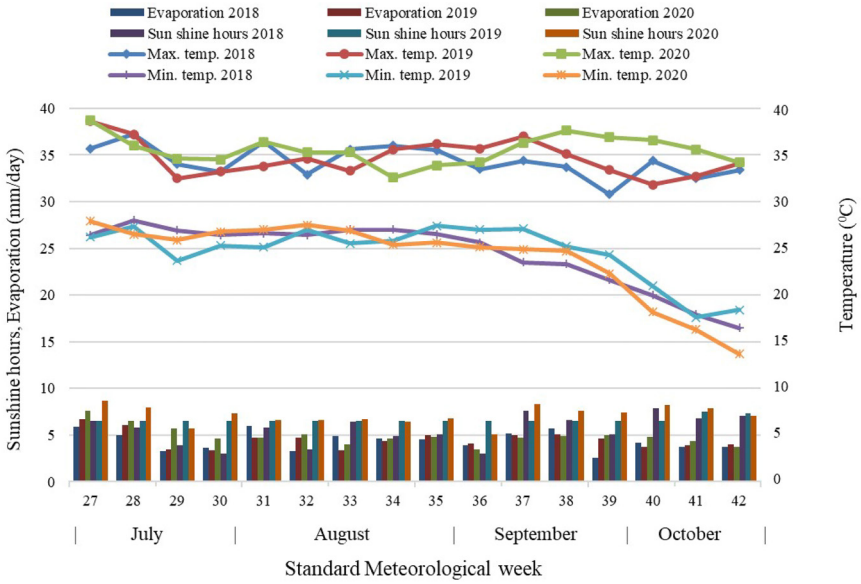

Fig. 1. Weather parameters during crop season.

RESULTS AND DISCUSSION

Weather and climate

Table 1 depicts the data on rainfall recorded by the rainguage located at the experimental site. The total rainfall occurred during the season was 381.6, 305.9 and 314.0 mm during 2018, 2019 and 2020, respectively, with average value of 333.8 mm, which was 1.2 % deficit from the mean normal rainfall (337.8 mm). However, total effective rainfall occurred during the cluster bean growing period was 311.6, 133.0 and 238.5 mm during 2018, 2019 and 2020, respectively. Month-wise, it was 3.47 and 1.43 % higher in June and September and 3.84 and 35.3 % deficit in July and August compared to the average monthly normal rainfall, respectively. All the climatic data except rainfall showed the more or less variations during all the 3 years (Fig.1). The mean maximum and minimum temperature ranged from 32.6 to 38.7 and 16.5 to 27.3°C, respectively during all the seasons. The bright sun-shine hours ranged from 3.0 on a cloudy day to 8.7 on a clear day while evaporation from open pan evaporimeter ranged between 2.6 and 7.6 mm/day.

Table 1. Rainfall during the period of experimentation.

Season	Actual rainfall (mm)				Normal rainfall (mm)
	2018	2019	2020	Mean	
June	47.0	98.7	33.2	59.6	57.6
July	193.5	104.2	151.9	115.1	119.7
August	23.2	85.7	94.2	67.7	104.7
September	117.9	17.3	34.7	56.6	55.8
Kharif (Jun-Sep)	381.6	305.9	314.0	333.8	337.8

Soil moisture status

Soil moisture status at sowing as well as harvesting of the crop increased with the increase in soil depth during all the 3 years of experimentation (Table 2).

Table 2. Soil moisture status (mm) at sowing and harvesting of experiment.

Soil depth (cm)	2018		2019		2020	
	At sowing	At harvesting	At sowing	At harvesting	At sowing	At harvesting
0-15	13.5	6.9	16.1	8.2	15.1	7.8
15-30	19.3	12.6	18.1	9.3	17.2	8.3
30-60	39.2	18.5	26.5	11.4	27.0	10.3
60-90	40.3	34.8	42.5	30.2	41.2	28.4
90-120	56.3	46.7	58.0	41.0	54.3	39.2
Total	168.6	119.5	161.2	100.1	154.8	94.0

Table 3. Effect of treatments on yield attributes of cluster bean (Three years pooled data).

Treatments	Plant height at harvesting (cm)	Number of branches per plant	Number of pods per plant	Number of seeds per pod	Test weight (g)
RDF (N:P_2O_5 @ 20:40 kg/ha)	67.2	7.7	55.6	37.2	25.8
RDF + water spray at flower initiation	69.2	7.9	58.3	37.8	26.6
RDF + water spray at pod formation	68.5	8.1	57.7	37.4	26.4
RDF + NPK (0:0:50) 1 % spray at flower initiation	72.5	10.0	60.2	38.6	27.5
RDF + NPK (0:0:50) 1 % spray at pod formation	70.3	9.3	60.0	37.5	27.2
RDF + 0.5% $ZnSO_4$ spray at flower initiation	74.1	10.6	65.3	39.3	28.6
RDF + 0.5 % $ZnSO_4$ spray at pod formation	73.9	10.4	64.1	38.7	28.4
RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at flower initiation	75.8	11.4	70.4	42.3	31.3
RDF + NPK (0:0:50) 1 % + 0.5% $ZnSO_4$ spray at pod formation	75.3	11.2	68.2	41.8	30.5
SEm ±	0.9	0.2	1.3	1.2	0.7
CD (p=0.05)	2.7	0.7	4.1	NS	2.3

The soil moisture was 168.6, 161.2 and 154.8 mm/120 cm soil depth at sowing which receded to 119.5, 100.1 and 94.0 mm/120 cm soil depth at harvesting of the experiment during 2018, 2019 and 2020, respectively.

Yield attributes

The data presented in Table 3 revealed that different foliar sprays along with RDF brought about significant improvement in plant height over RDF alone except RDF + water spray. RDF + NPK (0:0:50) 1 % + 0.5% $ZnSO_4$ spray at flower initiation produced significantly highest plant height (75.8 cm) among all the treatments except treatments receiving RDF + 0.5% $ZnSO_4$ at flower initiation, RDF + 0.5% $ZnSO_4$ at pod formation and RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ at pod formation. The lowest plant height (67.2 cm) was obtained with RDF alone. The highest plant height might be due to the better nutrition, which plays a vital role in cell division and growth of the plant. The results are in conformity with the findings of Chavda *et al.* (2020). RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at flower initiation recorded significantly higher number of branches per plant, number of pods/plant and test weight of cluster bean compared to all other treatments and was at par with RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at pod formation. Different foliar application of nutrients along with RDF did not affect significantly the number of seeds per pod. Increase in yield attributing parameters due to foliar application of nutrients could be ascribed to the overall improvement in plant growth, vigour and production of photosynthates owing to increased availability, absorption and translocation of nutrient in plants. Pavithra *et al.* (2017) also reported that improvement in yield attributing parameters were associated with foliar fertilization in cluster bean.

Yield

The final seed yield is the expression of the effects of various yield components developed under the particular set of environmental conditions. The data presented in Table 4 indicated that RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at flower initiation recorded significantly highest grain yield (904 kg ha^{-1}) compared to other treatments except treatment receiving RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at pod formation. This might be due to enhancement of yield attributing characters like number of branches per plant, number of pods per plant and test weight of cluster bean. Straw yield (1799 kg ha^{-1}) was found higher in RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at flower initiation followed by RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at pod formation. During experimentation, comparatively similar to normal rainfall was received during July and September commensurate vegetative and maturity stage of crop, this indicates that higher values of seed and straw yield is due to foliar sprays which contributed

Table 4. Yield and economics of cluster bean as influenced by foliar fertilization (Three years pooled data).

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	B: C ratio	RWUE (kg/ ha-mm)
RDF (N:P_2O_5 @ 20:40 kg/ha)	651	1217	18800	10444	1.55	3.25
RDF + water spray at flower initiation	689	1323	19100	11899	1.62	3.45
RDF + water spray at pod formation	677	1293	19100	11399	1.60	3.39
RDF + NPK (0:0:50) 1% spray at flower initiation	749	1453	19450	14263	1.73	3.75
RDF + NPK (0:0:50) 1% spray at pod initiation	725	1421	19450	13271	1.68	3.62
RDF + 0.5 % $ZnSO_4$ spray at flower initiation	837	1633	19250	18592	1.97	4.21
RDF + 0.5 % $ZnSO_4$ spray at pod formation	824	1623	19250	17880	1.93	4.14
RDF + NPK (0:0:50) 1% + 0.5 % $ZnSO_4$ spray at flower initiation	904	1799	19550	21139	2.08	4.52
RDF + NPK (0:0:50) 1 % + 0.5 % $ZnSO_4$ spray at pod formation	883	1748	19550	20309	2.04	4.44
SEm ±	16	18				
CD (p=0.05)	49	55				

significantly in increasing the seed yield of the crop under normal range of climatic conditions for the growth of cluster bean (Fig.1). These results are conformity with the findings of Sunil *et al.* (2017) and Chetana *et al*. (2020).

Economics

Highest cost of cultivation (₹ 19550/ha), net returns (₹ 21139/ha) and B: C ratio (2.08) were recorded in treatment RDF + NPK (0:0:50) 1 % + 0.5% $ZnSO_4$ spray at flower initiation, closely followed by RDF + NPK (0:0:50) 1 % + 0.5% $ZnSO_4$ spray at pod formation (Table 4). RDF + 0.5% $ZnSO_4$ spray at flower initiation was the third highest in order of magnitude in terms of net returns (₹ 18592 /ha) and B: C ratio (1.97). These results are in the vicinity with those reported by Chavda *et al*. (2020) and Chetana *et al.* (2020).

Rainwater-use efficiency (RWUE)

The RWUE was recorded highest (4.52 kg/ha-mm) in the treatment RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at flower initiation followed by RDF + NPK (0:0:50) 1% + 0.5% $ZnSO_4$ spray at pod formation. This indicated the better use of rain water under this treatment compared to rest of treatments. Sarma *et al.* (2015) also reported higher rainwater-use efficiency in toria by foliar application of potassium under rainfed upland situation of Assam.

CONCLUSION

The present study exhibited that an integration of RDF (N:P_2O_5 @ 20:40 kg/ha) along with foliar spray of NPK (0:0:50) 1% + 0.5% $ZnSO_4$ at flower initiation proved beneficial for getting higher yield and profitability of cluster bean under dryland condition**.**

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