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Research Paper

Assessment of yield and profitability of Indian mustard (*Brassica juncea*) with foliar fertilization under rainfed condition

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2018–19, 2019–20 and 2020–21 at Dryland Agriculture Research Farm of the Chaudhary Charan Singh, Haryana Agricultural University, Hisar, to study the effect of various foliar sprays on yield and profitability of rainfed Indian mustard [*Brassica juncea* (L.) Czernj.]. The experiment was laid out in a randomized block design with 3 replications, comprising 7 foliar nutrition treatments, viz. control (no spray), water-spray, urea @ 1%, urea @ 2%, water-soluble complex fertilizer (18: 18: 18) @ 0.5%, 0.5% $ZnSO_4$ spray, water-soluble complex fertilizer (18: 18: 18) @ 0.5% + 0.5% $ZnSO_4$. The experimental results revealed that, the growth and yield attributes, viz. plant height at harvesting, dry-matter accumulation at harvesting, number of siliquae/plants, number of branches/plant and number of seeds/siliqua, were significantly influenced by different foliar nutrition treatments except water spray. Among different foliar spray treatments, foliar spray of water-soluble complex fertilizer (18: 18: 18) @ 0.5% + 0.5% $ZnSO_4$ resulted in significantly higher plant height at harvesting (226.1 cm), dry-matter accumulation at harvesting (99.3 g/plant), siliquae/plant (426.0), branches/plant (32.6) and seeds/siliqua (15.2). Further, the data showed that, foliar spray of water-soluble complex fertilizer (18: 18: 18) @ 0.5% + 0.5% $ZnSO_4$ increased the seed and stover yield of Indian mustard by 30.6 and 21.1% compared with the control with higher net returns (₹121,300/ha), benefit: cost ratio (4.98) and rainwater-use efficiency (75.6 kg/ha-mm).

Key words: Economics, Foliar fertilization, Indian mustard, Yield attributes, Yield

In India, Indian mustard [*Brassica juncea* (L.) Czernj.] is grown in an area of 8.74 million ha, with the production of 10.95 million tonnes and average productivity of 1,270 kg/ha (MoA & FW, GoI, 2022). Indian mustard seed has 28–36% protein content with high nutritive value. It is a winter (*rabi*) season crop that requires relatively cool temperature, a fair supply of soil moisture during the growing season and a dry harvest period (Banerjee *et al*., 2010). Indian mustard oil, considered to be an important constituent of the Indian diet, is used as a cooking medium especially in northern parts of India. Major area in our country is under rainfed dryland conditions where the crop is widely grown and consequently suffers from lack of soil moisture during critical growth stages leading to poor growth and yield. The yield varies from state to state with varying rainfall and soil type. The productivity imbalance is due to unusual distribution of rainfall and erratic rains. Foliar application of nutrients for increasing and exploiting genetic potential of the crop is also considered as an efficient and economic method of supplementing the nutrient requirement. Foliar supply of nutrients has been found to increase the photosynthetic efficiency by delaying the onset of senescence of leaves. Application of fertilizer in right amount at right time may even not be efficient due to soil moisture. Integrated use of chemical fertilizers (N, P and K) through foliar feeding has been accepted as an effective way to compensate soil deficiency and inability of soil to transfer nutrients to the plants to maintain high productivity of undernourished crop (Rundla and Bairwa, 2018).

It is also important to develop low-input technology for increasing production of Indian mustard under rainfed condition. Method of fertilizer application is a non-monetary input which influences growth and consequently the yield of crop. Foliar application of major as well as micronutrients helps rapid translocation of nutrients when compared to soil application which is very pertinent in mitigating stress in plants. Foliar spray technique supports the nutrients to compass the site of food synthesis directly, leading no wastage and immediately supply of food and thereby reduce the requirement of fertilizers (Das and Jana, 2015).

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Instead of soil application, foliar fertilization may be the best technique for alleviating of the nutrient deficiencies with special emphasis on nitrogen deficit under moisture-stress condition (Banerjee *et al*., 2019). 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 large number of proteins such as transcription factors and enzymes (Singh and Kumar, 2009). Therefore, the present investigation was carried out to adjudge the effect of foliar sprays on growth, yield attributes, seed yield and economics of Indian mustard var. 'RH 725' in sandy loam soil of Haryana under rainfed condition.

MATERIALS AND METHODS

A field experiment was conducted at Dryland Agriculture Research Farm of the Chaudhary Charan Singh Haryana Agricultural University, Hisar (29° 10' N, 75° 46' E and 215.2 m above mean sea-level). The soil of the experimental field was sandy loam, low in organic carbon (0.37%) and in available nitrogen (136 kg/ha), medium in available phosphorus (14.8 kg/ha), potassium (260 kg/ha) and Zn (0.52 ppm). The experimental site falls under semi-arid and subtropical climate with hot, dry and desiccating winds during summer and severe cold during the winter season. The experiment was laid out in randomized block design with 3 replications, comprising 7 foliar nutrition treatments, viz. control (no spray), water spray, urea @ 1%, urea @ 2%, water-soluble complex fertilizer (18 : 18 : 18) @ 0.5%, 0.5% $ZnSO_4$ spray, water-soluble complex fertilizer (18: 18: 18) @ 0.5% + 0.5% $ZnSO_4$.

The crop was sown on 19 October, 18 October, 24 October and harvested on 25 March, 20 March and 21 March during 2018–19, 2019–20 and 2020–21, respectively. The seeds of Indian mustard var. 'RH 725' (136–143 days) were sown at 45 cm (row to row) × 15 cm (plant to plant) spacing in the plots of size 6.0 m × 4.5 m. Nitrogen and phosphorus @ 40 and 20 kg/ha at the time of sowing in the form of urea and single superphosphate, respectively, across all treatments, was considered as recommended dose of fertilizer (RDF). The crop was grown with all recommended package of practices during all the 3 years. The foliar application was done 60 days after sowing of the crop. Rainfall (November-March) and other climatic data were recorded during the experimentation (Table 1 and Fig. 1). Rainwater-use efficiency (RWUE) was calculated by dividing the seed yield (kg/ha) by cumulative effective rainfall (mm) from sowing to harvesting. The RWUE (kg/ha-mm) indicates yield attained by a treatment per millimeter of rainwater received during the cropping period. Since there is no irrigation to the crop other than rainwater, RWUE would indicate the water productivity or water-use efficiency of a treatment under rainfed condition.

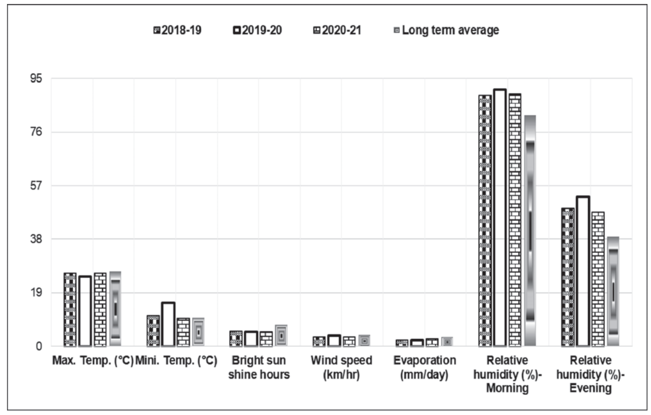

Fig. 1. Average climatic data during crop season of Indian mustard

Observations on plant height and number of branches/plants were recorded manually on 5 random plants from each plot of each replication separately as well as yield and yield-attributing characters were recorded as per the standard method. The economics of the treatments was worked out considering the prevailing cost of inputs and outputs (₹4,425/100 kg for Indian mustard seed and ₹75/100 kg for mustard stover/stalk). To find out the most profitable treatment, economics of different treatments were worked out in terms of net returns of the crop. Treatment-wise benefit: cost (B: C) ratio was calculated to ascertain economic viability. All the results were analyzed statistically for drawing conclusion using Analysis of variance (ANOVA) procedure.

Table 1. Effective rainfall during the crop growing season

Month	Effective rainfall (mm)				Normal rainfall (mm)
	2018–19	2019–20	2020–21	Mean	
November	–	17.5	17.6	11.7	3.2
December	–	6.0	–	2.0	4.4
January	28.0	12.9	7.8	16.2	11.4
February	11.5	11.5	6.5	9.8	14.0
March	6.7	15.5	–	7.4	13.0
Winter season (November–March)	46.2	63.4	31.9	47.1	54.9

RESULTS AND DISCUSSION

Weather and climate

The data on rainfall were recorded by the rainguage located at the experimental site (Table 1). The total effective rainfall received during the crop-growth period was 46.2, 63.4 and 31.9 mm during 2018–19, 2019–20 and 2020–21, respectively, with average value of 47.1 mm, which was 14.2% deficit from the mean normal rainfall (54.9 mm). Month-wise, it was 265.6 and 42.1% higher in November and January and 54.5, 30.0 and 43% deficit in December, February and March compared to the mean monthly normal rainfall respectively. More or less variations among the rest of the climatic data compared to long-term average were also observed (Fig. 1). During all the seasons, the mean maximum and minimum temperature ranged from 24.8 to 25.9 and 9.9 to 15.5°C respectively. The relative humidity varied from 47.5 to 53% in the evening to 89 to 91% in the morning. The average wind speed ranged from 3.3 to 3.7 km/h. The bright sun-shine hours ranged from 5.1 on a cloudy day to 5.5 on a clear day. Evaporation from open pan evaporimeter ranged between 2.2 and 2.6 mm/day.

Soil-moisture status

Soil-moisture status at the time of sowing as well as harvesting of the crop increased with the increase in soil depth during all the 3 years of experimentation (Table 2). The soil moisture was 187.3, 198.0 and 176.7 mm/120 cm soil depth at the time of sowing which receded to 111.3, 139.8 and 120.8 mm/120 cm soil depth at the time of harvesting of the experiment during 2018–19, 2019–20 and 2020–21 respectively.

Growth and yield attributes

Different foliar sprays brought about significant improvement in plant height over the control except water spray (Table 3). Foliar fertilization of water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% + 0.5% $ZnSO_4$ resulted in significantly highest plant height (226.1 cm) among all the treatments. The lowest plant height (188.7 cm) was observed at no foliar spray. Greater height of plant receiving adequate and balanced nutrition might be owing to better metabolic activities performed by the crop (Katiyar *et al*., 2014; Gour *et al*., 2019). Among all the treatments, significantly highest dry-matter accumulation at harvesting (99.3 g/plant) was recorded with foliar spray of water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% + 0.5% $ZnSO_4$. Presence of N, P and K in water-soluble complex fertilizer helped in better growth and development of the crop. Sarkar *et al*., (2021) reported higher dry-matter accumulation at harvesting with foliar spray of N : P : K (19 : 19 : 19) @ 1% in Indian mustard.

Table 2. Soil-moisture status (mm) at the time of sowing and harvesting of Indian mustard

Soil depth (cm)	2018–19		2019–20		2020–21	
	At sowing	At harvesting	At sowing	At harvesting	At sowing	At harvesting
0–15	15.5	6.1	18.2	12.3	15.1	6.5
15–30	19.8	8.5	21.6	13.5	19.2	11.5
30–60	42.7	27.9	43.8	33.4	40.3	30.2
60–90	48.1	33.7	49.9	37.9	43.5	35.1
90–120	61.2	35.1	64.5	42.7	58.6	37.5
Total	187.3	111.3	198.0	139.8	176.7	120.8

Table 3. Effect of foliar fertilization on growth and yield attributes of Indian mustard (pooled data of 3 years)

Treatment	Plant height at harvesting (cm)	Dry-matter accumulation at harvesting (g/plant)	Siliquae/ plant	Branches/ plant	Seeds/ siliqua	1000-seeds weight (g)
Control (no spray)	188.7	76.7	324.0	24.4	13.5	4.78
Water spray	193.3	78.2	329.2	25.1	13.8	4.80
Urea @ 1%	205.5	86.4	359.0	28.5	14.2	4.84
Urea @ 2%	208.6	88.7	373.7	29.1	14.3	4.87
Water-soluble complex fertilizer (18 : 18 : 18) @ 0.5%	214.5	91.6	401.0	30.6	14.9	4.94
0.5% $ZnSO_4$ spray	201.6	85.5	351.5	28.2	14.0	4.82
Water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% + 0.5% $ZnSO_4$	226.1	99.3	426.0	32.6	15.2	4.98
SEm±	3.3	2.4	5.2	0.5	0.3	0.06
CD (P=0.05)	10.2	7.4	16.2	1.5	0.8	NS

The yield attributes like siliquae/plant and branches/plant were significantly influenced by different foliar spray treatments over the control except water spray. The maximum siliquae/plant (426.0) and branches/plant (32.6) were achieved by foliar spray of water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% + 0.5% $ZnSO_4$ among all the treatments. Seeds/siliqua were significantly influenced by different foliar nutrition treatments. The highest number of seeds/siliqua (15.2) was recorded in the plot where foliar application of water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% + 0.5% $ZnSO_4$ was done and it was statistically at par with water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% foliar spray. The lowest number of seeds/siliqua (13.5) was obtained from the control plot (no spray). The 1000-seed weight was not significantly influenced by different foliar nutrition treatments, as it is a genetically governed character. Increase in growth and yield-attributing characters owing to foliar fertilization could be ascribed to the overall improvement in plant growth, vigour and production of photosynthates because of increased availability, absorption and translocation of nutrient in plants. Kaur *et al.,* (2019) also reported that, improvement of growth and yield-attributing characters was associated with foliar fertilization.

Yield

The final seed yield is the expression of the effects of various yield components developed under the particular set of environmental conditions. The foliar spray of water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% + 0.5% $ZnSO_4$ resulted in significantly highest seed yield (3.28 t/ha) among all the foliar spray treatments (Table 4). Adequate crop nutrition improved the vegetative and reproductive growth, as was evident from taller and vigorous plants having more dry-matter accumulation and thus, the plant can attain a greater number of siliquae/plant, seeds/siliqua and yield-contributing parameters and ultimately the seed yield (Mondal *et al*., 2018). Stover yield (9.01 t/ha) was found higher in foliar spray of water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% + 0.5% $ZnSO_4$, followed by water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% spray. Further monthly rainfall distribution pattern during experimentation showed that, comparatively higher rainfall was received in November and January commensurate vegetative and flowering stage of crop; however, very limited rainfall was received in December and February commensurate vegetative and siliquae-formation stage. This indicates that higher values of seed and stover yield is owing to foliar fertilization which contributed significantly in increasing the seed yield of the crop under normal range of climatic conditions for the growth of Indian mustard (Fig. 1). These results confirm findings of Sarkar *et al*., (2021) and Hardasbhai (2022).

Economics

Foliar spray of water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% + 0.5% $ZnSO_4$ showed the highest cost of cultivation (30.6 × 10^3 ₹/ha), net returns (121.3 × 10^3 ₹/ha) and B : C ratio (4.98), closely followed by foliar application of water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% (Table 4). Application of foliar spray of urea @ 2% was the third highest in order of magnitude in terms of net returns (1,08.5 × 10^3 ₹/ha) and B : C ratio (4.59). The per cent increase in net returns and B : C ratio was 39.0 and 25.4 with foliar spray of water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% + 0.5% $ZnSO_4$ over the control. Singh *et al*., (2021) and Gayathri and Singh (2021) also reported similar results.

Rainwater-use efciency

The rainwater-use efficiency (RWUE) was the highest (75.6 kg/ha-mm) in the treatment of foliar spray of water-

Table 4. Effect of foliar fertilization on seed yield and economics of Indian mustard (pooled data of 3 years)

Treatment	Seed yield (t/ha)	Stover yield (t/ha)	Cost of cultivation (× 10^3 ₹/ha)	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio	RWUE (kg/ha-mm)
Control (no spray)	2.51	7.44	29.4	87.3	3.97	57.9
Water spray	2.57	7.59	30.1	89.4	3.98	59.3
Urea @ 1%	2.89	8.37	30.2	104.5	4.46	66.8
Urea @ 2%	2.99	8.58	30.2	108.5	4.59	68.9
Water-soluble complex fertilizer (18 : 18 : 18) @ 0.5%	3.10	8.86	30.4	113.8	4.74	71.7
0.5% $ZnSO_4$ spray	2.84	8.30	30.3	102.4	4.38	65.6
Water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% + 0.5% $ZnSO_4$	3.28	9.01	30.6	121.3	4.98	75.6
SEm±	0.05	0.16	–	–	–	–
CD (P=0.05)	0.16	0.51	–	–	–	–

RWUE, Rainwater-use efficiency

soluble complex fertilizer (18 : 18 : 18) @ 0.5% + 0.5% $ZnSO_4$ followed by water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% foliar spray (Table 4). This indicated the better use of rainwater under this treatment than 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.

Nutrient status

After harvesting of crops, available soil nitrogen and phosphorus were influenced significantly by different foliar spray treatments (Table 5). Soil potassium was not significantly influenced by different foliar spray treatments. Foliar application of urea @ 2% resulted in higher soil-available nitrogen (142.2 kg/ha), whereas foliar application of water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% + 0.5% $ZnSO_4$ resulted in higher soil-available phosphorus (17.4 kg/ha) than rest of treatments. These results confirm findings of Sarkar *et al.,* (2021).

It can be concluded from the study that, an integration of recommended dose of fertilizer (N : P_2O_5 @ 40 : 20 kg/ha) along with foliar spray of water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% + 0.5% $ZnSO_4$ at 60 days after sowing proved beneficial for getting higher yield and profitability of Indian mustard under rainfed condition of sandy-loam soils in arid/semi-arid regions.

Table 5. Effect of foliar fertilization on soil status after experimentation with Indian mustard

Treatment	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)
Control (no spray)	135.2	15.2	254.8
Water spray	136.5	15.7	255.2
Urea @ 1%	139.8	15.8	254.9
Urea @ 2%	142.2	16.1	254.1
Water-soluble complex fertilizer (18 : 18 : 18) @ 0.5%	138.1	16.8	256.3
0.5% $ZnSO_4$ spray	137.3	15.9	254.9
Water-soluble complex fertilizer (18 : 18 : 18) @ 0.5% + 0.5% $ZnSO_4$	139.4	17.4	256.7
SEm±	1.2	0.4	1.2
CD (P=0.05)	3.8	1.1	NS

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