Impact of different doses of fertiliser and crop geometry on growth, quality, consumptive water use, water use efficiency and soil moisture extraction in late sown Indian mustard (*Brassica juncea* L.) crop

Abstract

A field experiment was conducted at regional research station, Bawal, CCS HAU, Hisar during Rabi 2015-16 to study the response of late sown Indian mustard (*Brassica juncea* L.) to different dose of fertilizer and crop geometry. The experiment was conducted in split-plot design with four fertilizer dose *viz.* 70% of the recommended dose of fertilizer (RDF), 85% RDF, 100% RDF, 115% RDF in main plot and six crop geometry, *viz.* 30 cm x 10 cm, 25 cm x 15 cm, 30 cm x 15 cm, 25 cm x 20 cm, 30 cm x 20 cm and 25 cm x 25 cm in sub plots. The results revealed that numbers of primary and secondary branches per plant were significantly higher 115% RDF than 70% RDF, but it was at par with 85% and 100% RDF at all stages of crop growth. Wider crop geometry of 25 cm x 25 cm recorded significantly higher number of primary and secondary branches than narrow crop geometry (30 cm x 10 cm) at all growth stages of crop. Highest oil content was obtained in crop geometry of 30 cm x 10 cm along with application of 70% RDF, whereas, highest protein content was recorded in crop geometry of 25 cm x 25 cm along with application of 115% RDF. Late sown Indian mustard at crop geometry of 25 cm x 15 cm along with application of 85 % RDF recorded highest water use efficiency whereas, highest consumptive use of water was recorded in 25 cm x 25 cm crop geometry along with application of 115 % RDF.

Key words: *Crop geometry, quality, water use efficiency and soil moisture extraction*

Introduction

Oilseeds crops are the most important determinant of agricultural economy, next to cereals. India is the world's second largest edible oil consumer after china, meeting more than 50 percent of its annual requirements through imports. Rapeseed-mustard (*Brassica spp*.) is one of the most valuable oilseed crops of the world as well as India. Among the seven edible oilseeds cultivated in India, rapeseed-mustard contributes 28.6% in the total oilseeds production and ranks second after groundnut sharing 27.8% in the India's oilseed economy [1]. Rapeseed-mustard in the world is grown on an area of 33.64 million ha with a production and productivity of 62.84 million tones and 1856 kg/ha, respectively [2]. There was considerable increase in productivity of rapeseed- mustard from 405 kg/ha in 1966-67 to 1856 kg/ha in 2016-17. In India, rapeseed-mustard occupy 5.99 million ha area with production of 6.31 million tones and productivity of rapeseed-mustard in India1053 kg/ha is very less as compared to world's productivity 1856 kg/ha [3]. Rapeseed-mustard spared over India mainly distributed in states of Rajasthan, Haryana, Uttar Pradesh, and Madhya Pradesh. Demand of edible oil has increased with increasing population and improvement in the living standard of the people, resulting thereby in short supply of edible oils which is being met with imports of edible oil costing around Rs. 56,906 crores per annum. Thus, there is need to boost the oilseed production in India as well as Haryana.

Indian mustard (*Brassica juncea* L.) is an important *rabi* oilseed crop of Haryana. Indian mustard (*Brassica juncea* L. Czern) belongs to family Cruciferae, genus *Brassica* and species *juncea* popularly known as rai and cultivated as a cold weather crop. Its seed contains 37 to 49 per cent edible oil (Singh *et al.*, 2009). Under late sown condition, productivity declines primarily due to the shortening of vegetative and reproductive phase. Late sown Indian mustard is exposed to high temperature coupled with high evaporative demand of the atmosphere during the reproductive phase (ripening and grain filling) which consequently results in forced maturity and ultimately low productivity. High temperature in *Brassica* caused flower abortion with appreciable loss in seed yield [4]. Higher doses of fertilizer coupled with narrow crop geometry (inter and intra plant spacing) depleted more soil moisture as compared to lower doses of fertilizer in association with wider plant spacing. Temperature can't be manipulated easily under field conditions but by modifying fertilizer doses and crop geometry of late sown Indian mustard, soil moisture loss may be adjusted to meet out the evaporative demand of the atmosphere during reproductive phase. Uniform distribution of crop plants over an area results in efficient use of nutrients, moisture, and suppression of weeds leading to high yield. In wider row spacing, solar radiation falling within the rows gets wasted particularly during the early stages of crop growth, whereas in closer row spacing upper part of the crop canopy may be well above the light saturation capacity but the lower leaves remain starved of light and contribute negatively towards yield. The dense plant population reduces the yield due to reduction in the photo- synthetically active leaf area caused by mutual shading [1]. The productivity of individual plant is limited under late sown conditions owing to poor growth and development. Hence, higher plant population may compensate for reduction in seed yield [5]. Late planted crop has low productivity due to restricted vegetative growth therefore, selection of appropriate spacing and management of fertilizer doses under late sown condition play an important role in enhancing mustard productivity [6].

MATERIAL AND METHODS

A field experiment was conducted at regional research station, Bawal, CCSHAU, Hisar during the *rabi* season of 2015-16. The experimental site was located at 28º4' N latitude and 76º35' E longitude at an altitude of 266 meters above mean sea level. The soil of experimental field was loamy sand in texture, low in organic carbon (0.46%), low in available N (105.16 kg/ha) and medium available P_2O_5 (10 kg/ha), K_2O (205 kg/ha) and slightly alkaline in reaction pH (7.5). The field experiment comprising of 24 treatment combinations viz. four fertilizer dose F1: 70 % RDF, F2: 85 % RDF, F3: 100 % RDF (Recommended dose of fertilizer i.e. 80 kg N + 30 kg P2O5 + 20 kg K2O + 40 kg S per hectare), F4: 115 % RDF as main plots and six crop geometry as sub plots viz. C1: 30 cm x 10 cm, C2: 25 cm x 15 cm, C3: 30 cm x 15 cm, C4: 25 cm x 20 cm, C5: 30 cm x 20 cm and C6: 25

cm x 25 cm as sub plot treatments was laid out in split plot design with three replications. The experimental site had been used over the years for continuous Clusterbean- Indian mustard cropping. In experiment gross plot size was 6.0 m x 3.0 m with net plot size 4.5 m x 2.0 m. Sowing of Indian mustard variety RH 9801 was done by using seed rates of 5.0, 4.0, 3.3, 3.0, 2.5 and 2.4 kg per ha in flat beds with the help of hand plough in rows as per treatments i.e. 30 cm x 10 cm, 25 cm x 15 cm, 30 cm x 15 cm, 25 cm x 20 cm, 30 cm x 20 cm and 25 cm x 25 cm (inter- row and intra-row plant spacing). Indian mustard variety RH 9801 was sown on 12 th November 2015 at the depth of 4 to 5 cm. The recommended dose of fertilizers as per CCS HAU package of practices were applied at the rate of 80 kg N/ha in the form of urea, 30 kg P_2O_5/ ha in the form of Diammonium phosphate, 20 kg K_2O /ha in the form of Muriate of potash and 40 kg S/ha in the form of gypsum were applied to the crop. Half doses of nitrogen and full basal dose of phosphorus, potassium and sulphur as per treatments were applied at sowing. The remaining half dose of nitrogen was applied after first irrigation. Thinning was done at 21 days after sowing in order to maintain required spacing of plants within the row as per treatment (30 cm x 10 cm, 25 cm x 15 cm, 30 cm x 15 cm, 25 cm x 20 cm, 30 cm x 20 cm and 25 cm x 25 cm) to established plant population of 3.33, 2.66, 2.22, 2.00, 1.66 and 1.60 lakh plants/hectare, respectively. Recommended package of practices was followed for all other operations.

Oil content of seeds was determined by nuclear magnetic resonance (NMR), MKIIIA New Port Analyser. Nitrogen content in seed was determined by colorimetric method and multiplying by 6.25 for calculating the protein content of seed. Soil moisture content on dry weight basis was determined gravimetrically at sowing, before and after each irrigation and at harvest. Soil samples were taken with the help of post-hole auger from different depth. The total consumptive use of water was computed from the soil moisture data by using the equation given by [7].

Water use efficiency (WUE) of different treatments was worked out, dividing the seed yield (kg/ ha) by the total amount of water used (mm) from the respective plots.

$$\textbf{Water use efficiency (kg ha}^{-1}\textbf{ mm}^{-1}\textbf{)} = \frac{\textbf{Seed yield (kg/ha)}}{\textbf{Total consumptive use (mm)}}$$

Soil moisture extraction pattern was worked out layer-wise for three different depths *viz.* 0-30, 30-60 and 60-90 cm, and 90-120 cm for the period between two successive samplings during the entire crop season. The moisture extracted from the different layers during the crop growing seasons was summed up layer wise and total moisture extracted from each layer was worked out. Moisture extraction for each layer was then expressed as percentage of total soil moisture extraction in each period. All the experimental data for various growth, yield and quality parameters were statistically analyzed by the method of analysis of variance (ANOVA) as described by [8].

RESULTS & DISCUSSION

Results of experiment revealed that number of primary branches/plant showed significant variation with change in fertilizer doses. The numbers of primary and secondary branches/plant were significantly higher 115% RDF than 70% RDF, but it was at par with 85% and 100% RDF at all stages of crop growth. Number of primary and secondary branches increased with increased in fertilizer doses 70% to 115% RDF. This increased in growth parameters with increased in fertilizer doses might be due to the better nutrition to the plant resulted more plant height, which resulted in increase number of primary and secondary branches. Similar results are reported by [9] and [10]. Significantly higher number of primary branches/plant were observed in wider crop geometry of 25 cm x 25 cm than narrow crop geometry (30 cm x 10 cm) at all growth stages of crop, though there were observed statistically at par with that of 25cm x 15 cm, 30 cm x 15 cm, 25 cm x 20 cm and 30 cm x 20 cm. Results revealed that oil content decreased with successive increase in fertilizer doses from 70%, to 115% RDF. However, application of 70% RDF had higher values of oil content than other fertilizer doses. The decreasing in oil content with the increase in fertilizer doses due to the utilization of carbohydrates in protein synthesis as reported by [10] and [11]. Application of 115% RDF recorded significantly higher values of protein content over 70%, 85% and 100% RDF. Protein content was increased with the increased in fertilizer dose due to depressing effect of fertilizer doses on oil content since a negative correlation between oil and protein content has been reported by [9] and [12]. Oil content and protein content differed significantly with crop geometry of Indian mustard. Closer spacing (30 cm x 10 cm *i.e.* 3.33 lakh plants/ha) recorded significantly higher oil content over all other crop geometries. Similar result was observed by [13]. While, wider spacing (25 cm x 25 cm *i.e.* 1.60 lakh plants/ha) resulted into significantly higher protein content other crop geometries. This is due to higher nitrogen content which is precursor of protein synthesis in seed. [14] and [15] have also recorded the variability amongst crop geometry of Indian mustard in respect of oil and protein content.

The result presented in Table 1 on seed yield indicated that increasing fertilizer doses application (70%, 85%, 100% and 115% RDF) in late sown Indian mustard significantly enhanced the seed yield. Application of 115% RDF recorded significantly higher seed yield over 70% RDF, however it was statistically at par with 85% and 100% RDF. Application of 115%, 100% and 85% RDF increased in the seed yield to the tune of 10.5%, 9.8% and 7.6% respectively over 70% RDF. This can be attributed to increase in fertilizer doses which improved LAI and might have resulted in higher production of photosynthates and their translocation to sink (yield attributes), which results to the better yield attributes *viz.* number of siliquae plant^{-1} number of seeds siliqua^{-1} 1000 seed weight and seed yield plant^{-1}. The increase in seed yield and its attributes with increase in fertilizer doses have also been observed by [16] and [17]. Crop geometry (25 cm x 15 cm *i.e.* 2.66 lakh plants ha^{-1}) resulted into significantly higher seed yield over all other crop geometries under study. It produced 5.4%, 8.4%, 10.8%, 17.5% and 21.4% higher seed yield over crop geometry of 30 cm x 15 cm (2.22 lakh plants ha^{-1}), 30 cm x 10 cm (3.33 lakh plants ha^{-1}), 25 cm x 20 cm (2.00 lakh plants ha^{-1}), 30 cm x

20 cm (1.66 lakh plants ha^{-1}) and 25 cm x 25 cm (1.60 lakh plants ha^{-1}) respectively. Although the yield attributes per plant were better in case of wider spacing 25 cm x 25 cm but the yield per unit area was less because yield could not be compensated by loss in plant population as reported by [18].

The total consumptive use of water was not influenced markedly by various fertilizer doses. However, it showed a tendency to increase with the increasing fertilizer doses. At 115%, 100%, 85% and 70% RDF, crop consumed 187.8, 185.3, 180.3 and 173.4 mm water respectively. It may be due to increased vegetative growth with higher leaf area index by the application of increasing doses of fertilizer, which is responsible for more loss of water through transpiration. Corroborative finding have also been reported by [19] and [20]. Wider crop geometry of 25 cm x 25 cm utilized higher quantity of water (196.3 mm) as compared to closest plant spacing 30 cm x 10 cm. It may be due to more exposed open area in the crop canopy under wider spacing which enhanced penetration of sunlight with crop canopy, thereby resulting into enhanced evaporation as well as transpiration from the soil surface, which is responsible for more loss of water under spacing as compared to closer spacing. Similar result was reported by [21]. A marked increase in water use efficiency (Table 2) was recorded at 85% RDF than 70% RDF, thereafter it decrease from 100% to 115% RDF. Water use efficiency was highest 7.40 kg per ha-mm in 85% RDF, followed by 100% RDF (7.35 kg/ha/mm), 115% RDF (7.30 kg/ha/mm) and 70% (7.15 kg/ha/mm) RDF. Highest water use efficiency (Table 2) was recorded under crop geometry of 25 cm x 15 cm (8.49 kg/ha/mm) and markedly decreased at 30 cm x 10 cm (7.93 kg/ha/mm), 30 cm x 15 cm (7.83 kg/ha/mm), 25 cm x 20 cm (7.19 kg/ha/mm), 30 cm x 20 cm (6.50 kg/ha/mm) and 25 cm x 25 cm (6.13 kg/ha/mm), respectively. This might be due the fact that the fertilizer doses increased the seed yield under higher proportion then the total consumptive use of water. The present findings are agreement with [21], [22] and [11].

Varying fertilizer doses did not influenced the moisture extraction pattern (Table 2). Soil moisture from deeper layer with increase in the levels of fertilizer doses and reverse trend in the upper soil layer (0-30 cm) during crop season. It may be attributed to extensive proliferation of root system in deeper layers due to fertilizer doses which enables the plant to utilize moisture from deeper soil layers. Moisture extraction pattern was not markedly influenced by crop geometries during crop season. However, the crop showed a tendency to extract more water from 0-30 cm and 30-60 cm soil layer and reverse trend for deeper 60-90 cm and 90-120 cm soil layer during crop season. Corroborative finding have also been reported by [23], [24] and [25].

Table 1: Effect of various treatments on growth, quality and seed yield of late sown Indian mustard

Treatments	Number of primary branches			Number of secondary branches			Oil content (%)	Protein content (%)	Seed yield (Kg/ha)
	70 DAS	95 DAS	Harvest	70 DAS	95 DAS	Harvest			
Fertilizers									
70% RDF	5.21	5.48	5.85	3.46	10.1	11.8	38.8	17.8	1240
85% RDF	5.27	5.53	5.88	3.51	10.4	12.1	38.5	18.3	1334
100% RDF	5.29	5.54	5.90	3.53	10.6	12.3	38.2	18.6	1362
115% RDF	5.30	5.55	5.92	3.54	10.7	12.5	37.9	19.0	1370
CD at 5%	0.07	0.01	0.02	0.06	0.41	0.63	0.57	0.19	70
Crop geometry									
30 cm x 10 cm	5.12	5.41	5.77	3.40	9.4	11.3	39.0	17.8	1348
25 cm x 15 cm	5.21	5.47	5.86	3.48	10.1	12.0	38.9	18.1	1461
30 cm x 15 cm	5.27	5.51	5.88	3.51	10.5	12.2	38.5	18.4	1386
25 cm x 20 cm	5.30	5.56	5.91	3.53	10.8	12.3	38.2	18.6	1318
30cm x 20 cm	5.34	5.58	5.93	3.56	10.9	12.4	37.8	18.8	1243
25 cm x 25 cm	5.35	5.59	5.96	3.59	11.0	12.6	37.7	19.0	1203
CD at 5%	0.15	0.04	0.06	0.11	1.06	0.87	0.32	0.19	61

Table 2: Effect of various treatments on consumptive use, water use efficiency and soil moisture extraction pattern

Treatments	Consumptive use (mm)	Water use efficiency (kg/ha/mm)	Soil moisture extraction pattern (%)			
			0-30 cm	30-60 cm	60-90 cm	90-120 cm
Fertilizers						
70% RDF	173.4	7.15	41.22	28.48	19.13	11.32
85% RDF	180.3	7.40	40.60	28.42	19.47	11.58
100% RDF	185.3	7.35	40.57	28.32	19.49	11.64
115% RDF	187.8	7.30	40.54	27.94	19.58	11.69
Crop geometry						
30 cm x 10 cm	170.1	7.93	40.63	28.06	19.62	11.70
25 cm x 15 cm	172.2	8.49	40.67	28.15	19.53	11.65
30 cm x 15 cm	177.1	7.83	40.70	28.22	19.42	11.64
25 cm x 20 cm	183.3	7.19	40.73	28.33	19.39	11.56
30cm x 20 cm	191.2	6.50	40.78	28.43	19.33	11.47
25 cm x 25 cm	196.3	6.13	40.91	28.54	19.24	11.32

CONCLUSION

Based on one year experimentation it concluded that an inverse relationship was observed between oil content and protein content with respect to increase in fertilizer dose and plant spacing. Late sown Indian mustard at crop geometry of 25 cm x 15 cm along with application of 85 % RDF recorded highest water use efficiency whereas, highest consumptive use of water was recorded in 25 cm x 25 cm crop geometry along with application of 115 % RDF.

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