Journal of Oilseed Brassica, 14 (1) : 27-32, January 2023

Yield, quality and economics of Indian mustard (*Brassica juncea* L.) as influenced under different sowing date and planting geometries in irrigated condition of eastern Uttar Pradesh

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(Received: 24 August 2022; Revised: 10 December 2022; Accepted: 21 December 2022)

Abstract

A field experiment was carried out at Institute of Agricultural Sciences, BHU, Varanasi to assess the effect of different sowing date and planting geometries on yield, quality and economics of Indian mustard during *Rabi* season of 2015-16. The experiment was laid out in split plot design having three dates of sowing *viz.* D_1: 26th October, D_2: 05th November and D_3: 15th November in main plots and five planting geometry *viz.* S_1: 30 cm × 10 cm, S_2: 30 cm × 20 cm, S_3: 30 cm × 30 cm, S_4: 45 cm × 15 cm and S_5: 45 cm × 30 cm in sub plots. The results revealed significantly higher yield attributes *viz.* siliquae plant^{-1}, seed per siliquae, siliqua length and 1000 seed weight with early sown crop. Crop sown on 26th October recorded 27% and 40% higher seed yield than 5th and 15th November sown crop, respectively. Similarly, the percent increase in stover yield was 27% and 29% in 26th October sown crop over 5th and 15th November sown crop respectively, though the difference between the late sown crops remained comparable. Similar trend was also followed in oil and protein yield. In terms of economics, 26th October sown crop fetched more gross returns (Rs. 61224 ha^{-1}) and net returns (Rs. 43684 ha^{-1}) than 5th and 15th November. Among the different crop geometry, spacing of 30 cm × 10 cm though remained at par with 30 × 20 cm spacing, both recorded significantly higher yield attributes and seed yield over other spacing. The maximum oil yield (596.3 kg ha^{-1}), protein yield (299.8 kg ha^{-1}), gross returns (Rs. 54350 ha^{-1}) and net returns (Rs. 36616 ha^{-1}) was recorded with the spacing of 30 cm × 10 cm over others. Therefore, it would be more appropriate to sow the mustard on 26th October with a spacing of 30 cm × 10 cm for maximum productivity and profitability.

Keywords: *Economics, Indian mustard, planting geometry, protein, sowing date and yield*

Introduction

Rapeseed-mustard crop, the third most important edible oilseed after soybean and groundnut plays a pivotal role in Indian oilseed economy. Rapeseed-mustard shares around 24 % area and 27 % production of total oilseeds in the country (Choudhary *et al.*, 2021). Despite being the third largest producer (11.3%) of mustard after Canada and China in the world, India imports about 57% edible oil, to meet domestic requirements (Jat *et al.*, 2019). In India, rapeseed-mustard is grown over an area of about 6.23 million hectares with an annual production of 9.16 million tons (GOI, 2020). Rapeseed-mustard being a C_3 crop, efficient carbon assimilation response is realized at 15 to 20°C temperature. At this temperature, the plant achieves maximum CO_2 exchange rate which declines thereafter (Singh *et al.*, 2001). But, most of the farmers in India cultivate Indian mustard under late sown condition due to delayed harvesting of *kharif* crops which results in shortening of vegetative and reproductive stage. During the reproductive stage, late-sown Indian mustard is exposed to extreme heat combined with increased evaporative demand of the atmosphere suffer from moisture stress environment, thereby causing forced maturity, accelerated senescence, and low productivity (Porter, 2005). It has also been reported that Indian mustard sown after 30th October resulted in poor seed and oil yield due to limitations in genetic potential (Panda *et al.*, 2004). Therefore, appropriate sowing time is one of the key non monetary inputs which optimizes the highest dry matter accumulation by providing congenial environments for maximum light interception and the best utilization of moisture and nutrients for better plant growth and grain yield (Pattam, 2017).

Planting geometry plays a vital role in the production of rapeseed-mustard under irrigated condition. The competitive ability of mustard plant depends greatly upon the density of plants per unit area (Rajput, 2012) and balance supply of essential nutrients (Nayak *et al.*, 2022). Sub-optimal planting geometry increases inter and intra plant competition leading to poor growth and development. Uniform distribution of crop plants over an area results in efficient use of nutrients, moisture, and suppression of weeds leading to high yield. Proper plant spacing affects interception, penetration, absorption and utilization of incoming solar radiation. Adequate light interception to each leaf strata at optimum crop geometry accelerates photosynthetic rate as well as dry matter accumulation resulting in increased crop yield (Panwar *et. al.*, 2000). Since, not much work has been done on the performance of different dates of sowing and plant geometry to exploit its yield potential; it becomes imperative to identify the optimum date of sowing and spacing. Hence, keeping the above facts in the fore front for developing the hypothesis of the problem at hand, present study was undertaken.

Materials and Methods

Present experiment was conducted at research farm of Institute of Agricultural Sciences, BHU, Varanasi during *rabi* season of 2015-16 under humid sub-tropical condition at an altitude of 80.71 m AMSL. The weather of Varanasi has been classified under moisture deficit zone-4 with moisture deficit index of -20 to -40 per cent and falls in the belt of semi-arid to sub humid climate having hot summer and cold winter. The average annual precipitation (P) of Varanasi is 1100 mm and annual potential evapotranspiration (PET) is about 1525 mm. The weather condition prevailed during the crop growing period is presented in Fig. 1. It is observed that weekly mean maximum and minimum temperature during the experimentation ranged from 30.9°C to 18.6°C and 7.2°C to 19.0°C, respectively. Total precipitation received during the crop period (Oct. 29 to March 24) was 215.1 mm. The weekly maximum relative humidity (RH) ranged between 61 to 94 per cent and minimum RH varied from 26 to 82 per cent during the period of experimentation *i.e.* 44th to 12th standard week. The soil was Gangetic alluvium having was sandy clay loam in texture, pH of 7.42, EC 0.29 (dSm^{-1}), low in organic carbon 0.35% and available N, medium in phosphorus and potassium (Table 1).

The experiment was laid out in split plot design with three replications consisting of three dates of sowing *viz.* D_1: 26th October, D_2: 05th November and D_3: 15th November in main plots and five planting geometry *viz.* S_1: 30 cm × 10 cm, S_2: 30 cm × 20 cm, S_3: 30 cm × 30 cm, S_4: 45 cm × 15 cm and S_5: 45 cm × 30 cm in sub plots. The RGN-73 variety was sown in 22.5 m^2 plot using a seed rate of 5 kg ha^{-1}.

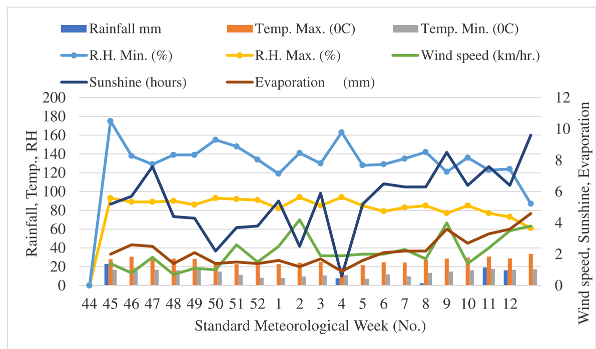

Fig. 1. Meteorological observation during the course of experimentation

Table 1: Mechanical and chemical properties of soil of the experimental plot

Particulars	Values	Method employed
1. Mechanical analysis		
Soil separates (%)		
Coarse sand	8.14	Hydrometric method (Bouyoucos, 1962)
Fine sand	53.58	
Silt	19.87	
Clay	18.87	
Textural class	Sandy clay loam	
Bulk density (g cc^{-1})	1.35	Core sampler (Piper, 1966)
2. Chemical analysis		
Soil pH (1:2.5 soil and water ratio)	7.42	Glass electrode pH meter (Jackson, 1973)
Organic carbon (%)	0.35	Walkley and Black method (Jackson, 1973)
Available nitrogen (kg ha^{-1})	212.42	Alkaline $KMnO_4$ method (Subbiah and Asija, 1956)
Available phosphorus (kg ha^{-1})	21.31	0.5 $NaHCO_3$ (Extractable Olsen *et al.*, 1954)
Available potassium (kg ha^{-1})	187.01	Flame photometric method (Jackson, 1973)
Electrical conductivity (dS m^{-1} at 25°C)	0.29	Systronics electrical conductivity meter (Jackson, 1973)

The recommended doses of fertilizer (120-60-60 kg N-P_2O_5-K_2O per hectare) were applied. Half dose of N and the entire dose of P and K were applied at the time of sowing through urea, di-ammonium phosphate and muriate of potash, respectively. Remaining half dose of N was applied in two equal splits at 30 DAS and 60 DAS according to the recommendation. Two irrigations were applied at 50% flowering and siliqua formation stage as per local recommendation. Plant protection measures were under taken properly to keep the insect pests, diseases and weeds below economic threshold level. Mustard from each net plot in each replication was harvested and dried. The seeds after threshing were weighed and recorded as seed yield per net plot. Further, this net plot seed yield was converted to seed yield per hectare.

Harvest index (HI) was calculated by using the formula (Donald and Hamblin, 1976):

$$\text{Harvest Index (HI) \%} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

Quality parameter such as seed oil content was estimated with the help of soxhlet apparatus using petroleum ether as the extractant (Sankaran, 1966) whereas the seed protein content was calculated by determining the percentage of N in seed using micro Kjeldahl method (Jackson, 1973) and multiplying it by the factor 6.25.

$$\text{Oil content \%} = \frac{\text{Weight of oil}}{\text{Weight of seed sample}} \times 100$$

$$\text{Protein content (\%)} = \text{Seed nitrogen content (\%)} \times 6.25$$

Oil yield and protein yield were calculated by multiplying seed yield with seed oil content and seed protein content, respectively and expressed in kg ha^{-1}

$$\text{Oil yield (kg ha}^{-1}\text{)} = \frac{\text{Oil content (\%)} \times \text{seed yield (kg ha}^{-1}\text{)}}{100}$$

$$\text{Protein yield (kg ha}^{-1}\text{)} = \frac{\text{Protein content (\%)} \times \text{Oil yield (kg ha}^{-1}\text{)}}{100}$$

Data recorded on various parameters of the experiment was subjected to analysis by using Fisher's method of analysis of variance (ANOVA) and interpreted as outlined by Gomez and Gomez (1984). The levels of significance used in 'F' and 't' test was p= 0.05. Critical difference values were calculated where F test was found significant.

Results and Discussion

Yield attributes *viz.* number of siliqua plant^{-1}, siliqua length (cm), number of seeds siliqua^{-1} and 1000-seed weight were significantly influenced by different date of sowing is summarized in Table 2. The present investigation revealed that number of siliquae plant^{-1}, siliqua length (cm), number of seeds siliqua^{-1} and 1000-seed weight were highest in early sown crop (October 26) as compared to delayed sowing (November 05 and November 15). Longer crop growth period coupled with optimum temperature and soil moisture had positive influence on growth and yield attributing characters of mustard. The lowest yield parameters under delayed planting might be ascribed to shorter reproductive and longer vegetative phase which allowed less time for siliqua formation and seed development. The finding of Panda *et al.* (2004) corroborates these results.

The outcomes of the study (Table 3**)** showed that the sowing dates had significant effect on yield as well as quality of mustard. The seed and stover yield were significantly higher in 26th October sown crop followed by 5th and 15th November sown crop. However, stover yield between 5th and 15th November sown crop remained comparable. Moreover, lower values of maximum and minimum temperature under delayed sowing resulted in drastic reduction in the duration of reproductive phase ultimately leading to lower seed and stover yield (Khushu and Singh, 2005). Khichar *et al*. (2000) opined that higher stover yield with early sowing might be credited to higher accrual of growing degree days (GDD) as compared to late sowing dates along with appreciable increase in growth and yield attributes which also reduced with delayed sowing. Similarly, Singh *et al.* (2019) also reported transplanting of mustard on 13th October was found highly superior with respect to growth, physiological parameters, yield and yield attributes compared to transplanting done

Table 2: Effect of sowing dates and planting geometries yield attributes of Indian mustard

Treatment	Siliquae plant^{-1}	Seed Siliquae^{-1}	Siliqua length (cm)	1000 seed weight (g)
Date of sowing				
26 Oct 2015	272.2	12.6	4.84	5.05
05 Nov 2015	190.5	12.5	4.51	4.80
15 Nov 2015	142.7	12.4	4.16	4.75
SEm±	7.07	0.01	0.12	0.07
LSD (p=0.05)	20.1	0.03	0.42	0.19
Planting geometry				
30 cm × 10 cm	149.4	12.4	3.84	4.55
30 cm × 20 cm	184.0	12.3	3.97	4.82
30 cm × 30 cm	212.4	12.6	4.69	4.96
45 cm × 15 cm	193.4	12.2	4.37	4.96
45 cm × 30 cm	269.8	12.9	4.99	5.04
SEm±	7.96	0.04	0.07	0.06
LSD (p=0.05)	23.4	0.12	0.18	0.17

Table 3: Effect of sowing dates and planting geometries on yield and quality of Indian mustard

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Oil content (%)	Oil yield (kg ha^{-1})	Protein content (%)	Protein yield (kg ha^{-1})
Date of sowing							
26th October	1867	6694	21.7	39.8	743.1	27.79	307.9
05th November	1348	4885	21.5	38.3	516.3	20.98	282.8
15th November	1108	4730	19.0	37.1	411.1	14.10	263.3
SEm±	49.2	162.3	0.56	0.44	5.28	0.01	0.59
LSD (p=0.05)	140.4	462.7	1.70	1.26	15.1	0.03	1.74
Planting Geometry							
30 cm × 10 cm	1661	5718	22.1	35.9	596.3	18.05	299.8
30 cm × 20 cm	1533	5772	20.9	38.0	582.5	19.16	293.7
30 cm × 30 cm	1286	5049	20.2	39.0	515.7	19.35	288.1
45 cm × 15 cm	1457	5646	20.5	38.4	559.5	21.73	281.9
45 cm × 30 cm	1267	4996	20.0	40.7	501.5	22.40	275.4
SEm±	57.4	271	0.52	0.66	3.47	0.01	0.58
LSD (p=0.05)	168.6	NS	1.53	1.93	10.2	NS	1.55

on 22nd October and 01st November. The highest harvest index was observed with crop sown on 26th October; however, it was at par with 5th November sown crop. This was due to relatively greater seed yield than 15th November sown crop. Similar results had also been reported by Kumari *et al.* (2012). Among different sowing dates, significantly higher oil and protein content and oil and protein yield was recorded with crop sown on 26th October followed by 05th November and 15 November. This might be due to longer reproductive growth phase of 88 days which had a positive impact on the development of seed and thus, increased oil content and oil yield. These results are inconformity with the earlier findings of Tobe *et al.* (2013).

In terms of economics, among different dates of sowing, 26th October sown crop recorded significantly higher gross returns (Rs. 61224 ha^{-1}) and net returns (Rs. 43684 ha^{-1}) followed by sowing of 5th November and 15th November (Table 4). The highest gross as well as net returns could be attributed to higher grain yield. Similar findings were also recorded by Jat *et al.* (2019).

Crop geometry had also lucid influence on yield attributes, yield and quality parameters of Indian mustard (Table 2 & 3). Among the crop geometries, the highest number of siliqua plant^{-1}, siliqua length (cm), number of seeds siliqua^{-1} and 1000-seed weight were recorded with crop sown at 45 cm × 30 cm spacing as compared to other plant geometries (30 cm x 10 cm, 30 cm x 20 cm, 30 cm x 30 cm and 45 cm x 15 cm). Successive enhancement in yield attributes with widening row spacing could be attributed to minimum exploitation of resources among crops (Shivani and Kumar, 2002). Sowing at a spacing of 30 cm × 10 cm recorded significant higher seed yield over all the treatments except at 30 × 20 cm spacing. However, maximum stover yield obtained with spacing of 30 cm × 20 cm but none of the treatment able to achieve the level of significance. The improvement in seed yield with wider spacing failed to compensate for lower number of plants per unit area. This might be due to higher plant papulation that led to competition for nutrients and light. These findings were in conformity with Kumari *et al.* (2012). In respect to harvest index, treatment 30 cm × 10 cm recorded significantly higher harvest index compared to other

Table 4: Effect of sowing dates and planting geometry on economics of Indian mustard

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})
Sowing Date			
26 Oct 2015	17540	61224	43684
05 Nov 2015	17540	44231	26691
15 Nov 2015	17540	36713	19173
SEm±	-	2562	2612
LSD (p=0.05)	-	7312	7447
Planting geometries			
30 cm × 10 cm	17734	54350	36616
30 cm × 20 cm	17734	50409	32675
30 cm × 30 cm	17734	42391	24657
45 cm × 15 cm	17540	47990	30450
45 cm × 30 cm	17540	41775	24235
SEm±	-	1317	1350
LSD (p=0.05)	-	3869	3966

planting geometries. Significantly greater values of oil and protein content were recorded with spacing of 45 cm × 30 cm and the higher oil and protein yield was due to higher plant density per unit area (Kardgar *et al.*, 2010). Among the spacings, 30 cm × 10 cm being at par with 30 cm × 20 cm fetched significantly higher gross returns (Rs. 54350 ha^{-1}) and net returns (Rs. 36616 ha^{-1}) compared to other treatments (Table 4). The results are in close accordance with Singh *et al.* (2018).

Conclusion

Considering the findings of present investigation, it can be concluded that among dates of sowing, 26th October sown crop recorded significantly higher crop yield, quality attributes, and thereby fetched maximum returns. Crop sown at a spacing of 30 cm × 10 cm also showed distinct superiority over others in terms of seed and stover yield, quality attributes and economics. Thus, Indian mustard cv. RGN- 73 should preferably be sown on 26th October having 30 cm × 10 cm inter and intra row spacing to obtain maximum productivity and profitability.

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