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Effect of Sowing Dates and Spacing on Alternaria Blight of Mustard and Economics of Cultivation

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ABSTRACT: Leaf blight of mustard incited by *A. brassicae* (Berk.) Sacc., is a devastating disease prevalent everywhere in India and the world which causes up to 47 % yield loss without any confirmed source of transferable resistance till date. This disease damages mostly foliage and pods of the brassica crop resulting into severe deterioration in yield of seed and oil content both, which ultimately lowers the farmers income and contribute into shortage of the edible oil in the country. Considering its seriousness and non-availability of resistant variety, the present investigations were accomplished to study the effect of cultural methods viz. Sowing dates and spacings on the disease severity, yield and economics of cultivation during two consecutive crop season of Rabi 2020-21 and 2021-22. The study was conducted at TCA Dholi under split plot design with three replicates accommodating four dates of sowing from 15th October to 15th November at 10 days interval as main plots and four spacings *viz.* 30 × 10 cm, 30 × 20 cm, 45 × 20 cm and 60 x 20 cm as sub plots. The result revealed that delayed sowing resulted into rapid enhanced of the disease severity, reduction of test weight of seed and seed yield. Widening of spacing resulted into slight reduction of the disease severity, enhancement of test weight of seed but decreased the seed yield of mustard crop due to large reduction of optimum plant density. The maximum yield (1865.50 kg ha^{-1}) was obtained in 15th October sown crop at 30 × 10 cm spacing followed by (1831.50 kg ha^{-1}) at 30 × 20 cm spacing both of which were at par, and the minimum yield (936.50 kg ha^{-1}) was obtained in 15th November sown at 60 × 20 cm^2, but yield of 1043 kg ha^{-1} was obtained in 15th November sown crop at 30 × 10 cm spacing. The successive 10 days delay in sowing of mustard from 15th October to 15th November, increased the days to attain 50 % flowering by 8 days from 58 days to 66 days but shortened the days to attain physiological maturity by 12 days from 148 to 136 days, thereby reducing the reproductive phase by 20 days from 90 to 70 days which coupled with increased disease severity on leaves as well as on pods at the most vulnerable stage of crop, lead into heavy reduction of yield (from 1866 to 1043 kg/ha), net return (from Rs. 87620 to Rs. 38010 per ha) and Benefit: Cost ratio (from 3.04 to 2.09).

Keywords: Sowing dates, Spacing, Alternaria blight, Mustard, PDI, B:C Ratio.

INTRODUCTION

Rapeseed-Mustard are globally known as "Oilseed brassica", which holds the status of the third most important oilseed crop after soyabean and palm with the production of about 72 MT from about 35 m ha area. In terms of area and production, India stands third place after Canada and China, and fifth place in terms of productivity after Germany, France, Canada and China (Jat *et al*., 2019). It is grown all over India in both tropical and subtropical regions covering 6.23 m ha of area producing 9.34 MT with 1499 kg/ha average productivity. In India, Rajasthan stands the first in its production covering the area of 2.37 m ha producing 4.08 MT with the average productivity of 1720 kg/ha. Bihar produces 0.11 MT from an acreage of 0.08 m ha with average productivity of 1305 kg/ha (Anonymous, 2019). In India, rapeseed mustard shares 23.5% area and 24.2% production of total oilseeds in the country. Despite being the third largest producer (11.3%) of oilseed brassica in the world, India meets 57% of the domestic edible oil requirements through imports and ranked 7th largest importer of edible oils in the world (Jat *et al*., 2019). Rapeseed-mustard is the major source of income especially to the marginal and small farmers in rainfed areas. This group of oilseed crops is gaining wide acceptance among the farmers because of adaptability for both irrigated as well as rainfed areas and suitability for sole as well as mixed cropping. Since these crops are cultivated mainly in the rain-fed and resource scarce growing regions of the country, their contribution to livelihood security of the small and marginal farmers in these regions is also highly significant.

Indian mustard (*Brassica juncea* L.) is widely cultivated in Indian sub-continent due to its inherent high yield and edible oil content potential besides its relative tolerance to bioticandabiotic stresses. Productivity of the crop, in the country is low due to a number of foliar diseases, *viz*., Alternaria blight, white rust, downy mildew and powdery mildew, among which, Alternaria blight incited by *Alternaria brassicae* (Berk.) Sacc. is the most important and devastating disease. It has been reported to cause variable losses in yield, depending upon disease severity. Yield loss tothe extent of 47 per cent has been reported (Chattopadhyay *et al.*, 2005; Meena *et al.,* 2010). Alternaria blight disease caused by *A. brassicae* are found everywhere in rape seed-mustard cropping are as and decrease15-71percentinproductivity, 14-36 percent in oil content (Meena *et al.,* 2010). The fungus, not only leads to yield reduction by causing foliar damage to the crop, but also damages siliqua in pod formation stage, severely deteriorating both seed and oil yield. (Choudhary *et al.*, 2018).

A number of fungicides have been recommended for effective control of this disease but the spraying of fungicides in standing crop is practically difficult, uneconomical and no teco-friendly. Identification of suitable sowing dates and spacing can be a better cultural method to minimize the yield loss by escaping the disease and maximizing the yield.

In the context of paramount importance of this disease of mustard crop, indiscriminate use of pesticide causing environmental pollution and pesticide residue in the food, urgent need of non-chemical method to avoid or minimize the disease severity at most susceptible age of crop, the present investigation, focused to evaluate the effect of sowing dates and spacings on these verity of Alternaria blight disease on leaf and pod, test weight, yield and economics of cultivation of Indian mustard has been conducted. Relationship between the period of reproductive phase of the crop with disease severity, seed yield and benefit: cost ratio, has also been worked out.

MATERIALS AND METHODS

The field experiment for management strategies of the Alternaria blight disease were carried in the experimental field of the Department of Plant Pathology at Tirhut College of Agriculture (T C A) Dholiunder Dr. Rajendra Prasad Central Agricultural University Pusa, Bihar during two consecutive Rabi crop season of 2020-21 and 2021-22. Geographically, the Dholi farm is located between 25°98′ north latitude and 85°60′ east longitude in the Indo- Gangetic plain of Bihar at an altitude of 52.18 meters above mean sea level. The experimental plot had a fairly uniform topography and the soil was deep, fertile, sandy loam, light, low in organic carbon, available nitrogen and potassium, and medium in phosphorus and well drained. Widely and popularly grown, Varuna variety of Indian mustard (*Brassica juncea* L.) highly susceptible to Alternaria leaf blight was used.

The experiments were laid out in split plot design with 3 replicates employing four spacings *viz.* 30 × 10 cm (S_1), 30 × 20 cm (S_2), 45 × 20 cm (S_3) and 60 × 20 cm (S_4) and four dates of sowing *viz*., 15th October (D_1), 25th October (D_2), 5th November (D_3) and 15th November (D_4). Within a replicate, the four sowing dates were considered as main plots and within such a main plot, the four spacings were treated as sub plots. Sowing dates were randomized first followed by randomization of spacing within a sowing date. Thus, each replicate had represented by four sowing dates columns and subplots represented by four spacings, providing a total of 48 (3 × 4 × 4) plots. The size of each plot measured 1.5 m × 5 m. Each spacing was maintained in a separate subplot within the main plot. The thinning operation to get desired spacing, plant density and plant geometry was done after 21 days of sowing. The weeds were removed by long tine hoe at 30 and 60 days after sowing during crop growth period.

The recommended dose of fertilizer of N_{80}, P_{40}, and K_{40}kg/ha for the crop was applied in the form of Urea, Single Super Phosphate and Muriate of Potash uniformly. Full dose of P and K with half dose of nitrogen fertilizers were drilled just before the sowing as a basal application, and remaining half dose of nitrogen were applied at 25 DAS after thinning operation. Need need-based irrigation was given. Lower to moderate infestation of mustard aphid was observed which was managed through insecticide spray.

The disease severity in term of percent disease intensity (PDI) on leaf at 90 DAS (at 50% pod formation stage) and PDI on pod at 120 DAS (at physiological maturity stage) were recorded. After harvesting and threshing, seed yield (kg ha^{-1}), test weight of one thousand seed (in gram), cost of cultivation (C_3), gross return (on the market price of Rs. 70/Kg), net profit and B:C ratio were calculated for different treatment. Other valuable parameters like days to attain 50 % flowering, physical maturity age, period of reproductive phase of the crop were also recorded.

The severity of disease was recorded on leaves at 90 days after sowing at 50 % pod formation stage and on pods at 120 DAS at physiological maturity stage, following 0–5 scale of Sharma and Kolte (1994) where, 0=nosymptoms; 1=1-10% leaf area damaged; 2 = 11-25%; 3 = 26-50%, 4 =51-75%; and 5 ≥ 75% leaf/pod are a damaged.

The severity Index (SI) was then calculated in terms of PDI as:

Percent Disease Index (PDI) =

$$\frac{\text{Sum of all numerical ratings}}{\text{Total no. of leaf/pod observed} \times \text{Maximum rating}} \times 100$$

All recorded data, were analysed as the standard analysis of variance (ANOVA) technique prescribed for a split plot design (Syndecor and Cochran 1967) and the treatment means for both years were compared individually and was pooled at the 5% level of significance (P=0.05) using least significant difference (LSD) and hence results based on pooled analysis were presented to draw logical inferences.

RESULTS

The effect of four different sowing dates viz. D_1 (Oct. 15), D_2 (Oct. 25), D_3 (Nov. 05) and D_4 (Nov. 15) as well as four plant spacings *viz.* S_1 (30 × 10 cm^2), S_2 (30 × 20 cm^2), S_3 (45 × 20 cm^2) and S_4 (60 × 20 cm^2) on disease severity as percent disease intensity (PDI) on leaves and PDI on pods, test weight (1000 seed grain weight) and seed yield were recorded significant (Table 1, 2 and 3). Days to attain 50% flowering, physiological maturity, period of reproductive phase, net profit and B:C ratio for different sowing dates were summarised (Table 3).

Effect of Sowing dates: Pooled mean data of two years for different sowing dates D_1 (Oct. 15), D_2 (Oct. 25), D_3 (Nov. 05) and D_4 (Nov. 15) for PDI on leaf were 19.53, 24.54, 34.09 and 55.39; for PDI on pods were 10.45, 23.49, 35.10 and 48.79; for test weight of seed in gram were 5.50, 5.28, 5.09 and 4.55; for seed yield in kg ha^{-1} were 1810.50, 1618.90, 1340.80 and 996.10 respectively (Table 1 & 2). This data clearly revealed that delayed sowing resulted into rapid enhanced of the severity of Alternaria blight on leaves and pod and thereby gradual reduction of test weight of seed and seed yield of mustard crop. Rapid increase of disease severity in delayed sowing may be due to favourable environmental condition and advancing susceptible crop age. Decrease in test weight and seed yield in delayed sowing dates might be due to increased disease severity, delayed germination and enhancing temperature which shortened days of crop maturity therefore getting less time and leaf area site for biomass accumulation through carbon fixation before seed formation which in turn resulting into finally low net return and B:C Ratio (Table 3).

Effect of plant spacing: The pooled mean data of two years for different plant spacings S_1 (30 × 10 cm^2), S_2 (30 × 20 cm^2), S_3 (45 × 20 cm^2) and S_4 (60 × 20 cm^2) for PDI on leaf were 36.67, 34.93, 31.92 and 30.03; for PDI on pods were 32.35, 30.53, 28.44 and 26.51; for test weight in gram were 5.03, 5.08, 5.13 and 5.19; for seed yield in kg ha^{-1} were 1488.50, 1458.00, 1328.90 and 1390.90 respectively (Table 1 & 2) which revealed that widening of spacing resulted into, however slight reduction of the severity of leaf blight and pod blight and thereby slight enhancement of test weight of seed but decrease in seed yield of the crop. This data under different plant spacings for changes in the disease severity on leaf as well as pod, test weight, seed yield, net profit and B:C Ratio might be due to differences in plant immunity, plant growth factors viz., nutrients uptake and availability of light, moisture, space and aeration in differed share by individual plants.

Table 1: Effect of different sowing dates and plant spacing on Alternaria blight severity of mustard during 2020-21 and 2021-22.

Treatments	PDI on Leaf at 90 DAS			PDI on Pods at 120 DAS		
	2020-2021	2021-2022	Pooled	2020-2021	2021-2022	Pooled
D_1 (Oct. 15)	19.53	19.54	19.53	9.85	11.05	10.45
D_2 (Oct. 25)	24.42	24.66	24.54	22.43	24.55	23.49
D_3 (Nov. 05)	34.03	34.15	34.09	34.63	35.58	35.10
D_4 (Nov. 15)	55.22	55.56	55.39	48.93	48.65	48.79
SEm(±)	0.62	0.39	0.42	0.54	1.04	0.52
CD (p=0.05)	1.52	0.95	1.03	1.31	2.54	1.28
S_1 (30 × 10 cm)	36.56	36.78	36.67	31.75	32.95	32.35
S_2 (30 × 20 cm)	34.65	35.22	34.93	30.13	30.93	30.53
S_3 (45 × 20 cm)	32.03	31.81	31.92	27.93	28.95	28.44
S_4 (60 × 20 cm)	29.95	30.10	30.03	26.03	27.00	26.51
SEm(±)	0.52	0.49	0.45	0.76	0.66	0.46
CD (p=0.05)	1.08	1.02	0.92	1.57	1.35	0.95
$D_1 \times S_1$	23.17^{hij}	23.47^{gh}	23.32^{hi}	11.50^{j}	13.50^{h}	12.50^{i}
$D_1 \times S_2$	21.67^{ij}	22.40^{gh}	22.03^{i}	10.40^{jk}	11.20^{hi}	10.80^{ij}
$D_1 \times S_3$	18.30^{k}	17.03^{i}	17.67^{j}	9.20^{jk}	10.30^{i}	9.75^{jk}
$D_1 \times S_4$	14.97^{l}	15.27^{i}	15.12^{k}	8.30^{k}	9.20^{i}	8.75^{k}
$D_2 \times S_1$	26.87^{g}	27.00^{f}	26.93^{f}	25.30^{g}	26.50^{f}	25.90^{g}
$D_2 \times S_2$	25.47^{gh}	26.13^{f}	25.80^{fg}	24.00^{gh}	25.20^{fg}	24.60^{g}
$D_2 \times S_3$	23.93^{hi}	24.00^{g}	23.97^{gh}	21.30^{hi}	24.00^{fg}	22.65^{h}
$D_2 \times S_4$	21.40^{j}	21.50^{h}	21.45^{i}	19.10^{i}	22.50^{g}	20.80^{h}
$D_3 \times S_1$	38.73^{d}	38.60^{c}	38.67^{c}	38.60^{d}	39.20^{d}	38.90^{d}
$D_3 \times S_2$	35.53^{e}	35.60^{d}	35.57^{d}	35.50^{de}	37.20^{d}	36.35^{e}
$D_3 \times S_3$	31.80^{f}	31.83^{e}	31.82^{e}	33.00^{ef}	33.80^{e}	33.40^{f}
$D_3 \times S_4$	30.03^{f}	30.57^{e}	30.30^{e}	31.40^{f}	32.10^{e}	31.75^{f}
$D_4 \times S_1$	57.47^{a}	58.07^{a}	57.77^{a}	51.60^{a}	52.60^{a}	52.10^{a}
$D_4 \times S_2$	55.93^{ab}	56.73^{a}	56.33^{a}	50.60^{ab}	50.10^{ab}	50.35^{a}
$D_4 \times S_3$	54.07^{bc}	54.37^{b}	54.22^{b}	48.20^{bc}	47.70^{b}	47.95^{b}
$D_4 \times S_4$	53.40^{c}	53.07^{b}	53.23^{b}	45.30^{c}	44.20^{c}	44.75^{c}
For the same level of Sowing						
SEm(±)	1.05	0.98	0.89	1.5201	1.31	0.92
CD (p=0.05)	2.16	2.03	1.84	3.14	2.71	1.90
For The different levels of Sowing						
SEm(±)	1.10	0.94	0.88	1.42	1.54	0.95
CD (p=0.05)	2.40	1.99	1.89	3.01	3.44	2.07

Performance of individual plants in terms of disease severity on leaf and pod were observed better along with growth and yield attributing characteristics like test weight of seed in wider plant spacings, but due to decrease in plant density from the optimum level, seed yield, net return and B:C ratio got decreased (Table 3).

Effect of sowing dates × plant spacing: The pooled mean data of two consecutive years for the interaction between sowing dates and plant spacings revealed that maximum disease intensity on leaf, that on pod and minimum test weight were with 57.77%, 52.10 % and 4.47 gram respectively in $D_4 \times S_1$ (Table 1 & 2). The minimum disease on leaf, that on pod and maximum test weight of seed were 15.12%, 8.75 % and 5.61 gram respectively in D1 × S4. However, the maximum yield (1865 kg ha^{-1}) was obtained in $D_1 \times S_1$ followed by (1831.50kg ha^{-1}), however statistically at par in $D_1 \times S_2$ and (1791.00kg ha^{-1}) in $D_1 \times S_3$. The maximum disease on leaf, that on pod and minimum test weight of seed were 57.77 %, 52.10 % and 4.47 gram respectively in D4 × S1. However, the minimum yield (936.50 kg ha^{-1}) was obtained in $D_4 \times S_4$ followed by (991.50 kg ha^{-1}) in $D_4 \times S_3$ and (1013.50 kg ha^{-1}) in $D_4 \times S_2$ (Table 1 & 2).

Table 2: Effect of sowing dates and spacings on test weight and yield of mustard cv. Varuna during 2020-21 and 2021-22.

Treatments	Test weight (g)			Seed yield (kg ha-1)		
	2020-2021	2021-2022	Pooled	2020-2021	2021-2022	Pooled
D_1 (Oct. 15)	5.49	5.51	5.5	1814.80	1806.20	1810.50
D_2 (Oct. 25)	5.27	5.3	5.28	1625.70	1612.00	1618.90
D_3 (Nov. 05)	5.08	5.1	5.09	1349.00	1332.50	1340.80
D_4 (Nov. 15)	4.55	4.56	4.55	1007.00	985.30	996.10
SEm(±)	0.02	0.02	0.02	30.51	31.86	30.94
CD (p=0.05)	0.05	0.05	0.05	74.64	77.96	75.71
S_1 (30 × 10 cm)	5.01	5.04	5.03	1497.00	1480.00^{a}	1488.50
S_2 (30 × 20 cm)	5.07	5.09	5.08	1464.00	1452.00^{ab}	1458.00
S_3 (45 × 20 cm)	5.13	5.14	5.13	1437.00	1420.80^{bc}	1428.90
S_4 (60 × 20 cm)	5.18	5.20	5.19	1398.50	1383.30^{c}	1390.90
SEm(±)	0.03	0.02	0.02	16.66	18.83	17.10
CD (p=0.05)	0.06	0.04	0.05	34.39	38.87	35.29
$D_1 \times S_1$	5.39^{bc}	5.42^{cd}	5.41^{cd}	1874.00^{a}	1857.00^{a}	1865.50^{a}
$D_1 \times S_2$	5.47^{b}	5.48^{bc}	5.48^{bc}	1839.00^{ab}	1824.00^{ab}	1831.50^{ab}
$D_1 \times S_3$	5.50^{ab}	5.51^{b}	5.51^{b}	1796.00^{bc}	1786.00^{ab}	1791.00^{bc}
$D_1 \times S_4$	5.60^{a}	5.61^{a}	5.61^{a}	1750.00^{cd}	1758.00^{bc}	1754.00^{cd}
$D_2 \times S_1$	5.20^{ef}	5.23^{gh}	5.22^{fg}	1674.00^{de}	1665.00^{cd}	1669.50^{de}
$D_2 \times S_2$	5.26^{de}	5.27^{fg}	5.27^{ef}	1641.00^{ef}	1631.00^{de}	1636.00^{ef}
$D_2 \times S_3$	5.30^{cde}	5.32^{ef}	5.31^{e}	1608.00^{ef}	1593.00^{de}	1600.50^{ef}
$D_2 \times S_4$	5.33^{cd}	5.36^{de}	5.35^{de}	1580.00^{f}	1559.00^{e}	1569.50^{f}
$D_3 \times S_1$	5.00^{h}	5.02^{k}	5.01^{i}	1385.00^{g}	1367.00^{f}	1376.00^{g}
$D_3 \times S_2$	5.06^{gh}	5.08^{jk}	5.07^{hi}	1360.00^{gh}	1342.00^{f}	1351.00^{gh}
$D_3 \times S_3$	5.12^{fg}	5.14^{ij}	5.13^{gh}	1339.00^{gh}	1326.00^{f}	1332.50^{gh}
$D_3 \times S_4$	5.15^{fg}	5.17^{hi}	5.16^{gh}	1312.00^{h}	1295.00^{f}	1303.50^{h}
$D_4 \times S_1$	4.46^{k}	4.48^{n}	4.47^{l}	1055.00^{i}	1031.00^{g}	1043.00^{i}
$D_4 \times S_2$	4.51^{jk}	4.53^{mn}	4.52^{kl}	1016.00^{ij}	1011.00^{g}	1013.50^{i}
$D_4 \times S_3$	4.58^{ij}	4.59^{lm}	4.59^{jk}	1005.00^{ij}	978.00^{gh}	991.50^{ij}
$D_4 \times S_4$	4.63^{i}	4.65^{l}	4.64^{j}	952.00^{j}	921.00^{h}	936.50^{j}
For the same level of Sowing dates						
SEm(±)	0.05	0.04	0.04	33.33	37.66	34.20
CD (p=0.05)	0.11	0.08	0.09	68.78	77.73	70.58
For The different levels of Sowing dates						
SEm(±)	0.05	0.04	0.04	41.99	45.60	42.83
CD (p=0.05)	0.11	0.08	0.09	95.16	102.63	96.96

Table 3: Effect of sowing dates on attaining different growth stages and economics of cultivation.

Sowing dates	Growth stages (days)				Economics of cultivation			
	50% flowering	50% Pod formation	Physiological maturity	Period of reproductive phase	Yield (Kg/ha)	Gross cost (C3) in (Rs/ha)	Net Return (Rs/ha)	B: C Ratio
D_1(Oct.15)	58	92	148	90	1866	43000	87620	3.04
D_2(Oct.25)	60	94	145	85	1670	41000	75900	2.85
D_3(Nov.05)	64	95	142	78	1376	39000	57320	2.47
D_4(Nov.15)	66	98	136	70	1043	35000	38010	2.09

Effect of sowing dates on growth stages and economics: Result revealed that successive 10 days delay in sowing of mustard from 15[th] October to 15[th] November increased the days to attain 50 % flowering from 58 days to 66 days but shortened the days to attain physiological maturity from 148 to 136 days, thereby reducing the reproductive phase from 90 to 70 days which coupled with increased disease severity on leaves as well as on pods, lead into drastic reduction of yield (from 1866 to 1043 kg/ha), net return (from Rs. 87620 to Rs. 38010 per ha) and Benefit: Cost ratio (from 3.04 to 2.09).

DISCUSSION

Our experimental results are in close proximity with the findings of some other researchers *viz.,* Prasad *et al.* (2003), Ayub (2001); Shivani and Kumar (2002); Mahapatra and Das (2015); Keerthi *et al*. (2016); Singh *et al*. (2018); Jat *et al*. (2019); Sohi *et al*. (2020); Lalruatfeli *et al*. (2021).

Lalruatfeli *et al*. (2021) also observed similar results from Nagpur, Maharastra that delay in sowing after first week of November reduced the yield, but in terms of spacing they found 45 × 10 cm as the best which differed from our result, which may be due to regional variation in climatic condition. Prasad *et al*. (2003) reported that the early sowing reduced the disease severity. Ayub, (2001) also suggested to adjust the sowing time of Indian mustard as the basic techniques to reduce the Alternaria blight incidence. Shivani and Kumar (2002) reported that seed yield decreased progressively with delay in sowing date and widening of spacing. They also found 30 cm as optimum row spacing for Indian mustard sown after 5^{th} October. Khatun *et al.* (2011) also found 21^{st} October sowing as the best along with lower disease percentage on leaf and silique. Mahapatra and Das (2015) also reported that disease severity gradually increased with delay in sowing. Keerthi *et al*. (2016) also reported similar results from Gujarat, regarding decrease of reproductive phase, seed yield, and B:C ratio with successive delay in sowing from 15^{th} October to 15^{th} November. Singh *et al*. (2018) from Dholi, also found similar effect on seed yields, net return and B: C ratio by different sowing dates and crop geometry. They reported that sowing on 14^{th} and 24^{th} November resulted in % reductions in seed yield by 23.3 and 43.3, net return 32.2 to 59.8 and B: C ratio 23.4 to 55.8 per cent as compared to sowing on 4^{th} November. They also observed the reductions caused due to different crop geometry was to the extent of 11.12 to 31.08 per cent in seed yield, 10.92 to 30.44 per cent in net return and 15.71 to 50 14 per cent in B: C ratio as compared to the crop geometry of 30 cm × 10 cm. Jat *et al*. (2019) also found similar results of significant higher seed yield, (1882 kg/ha) and corresponding higher net return (Rs. 46737/ha) and B:C ratio (3.04) from sowing of mustard crop in the second fortnight of October and that of 1895 kg/ha, Rs. 46448/ha and 2.96 from the spacing of 30 cm × 10 cm. Sohi *et al.* (2020) also found increasing disease severity of Alternaria blight of mustard with delay in date of sowing.

CONCLUSION

The result clearly revealed that delayed sowing resulted into rapid enhanced of the severity of Alternaria blight on leaves and pod at the most susceptible stage of crop and thereby gradual reduction of test weight of seed and seed yield, and widening of spacing resulted into slight reduction of the disease severity, enhancement of test weight of seed but decreased the seed yield of mustard crop. The maximum yield (1865.50 kg ha^{-1}) was obtained in 15^{th} October sown crop at 30 × 10 cm spacing followed but at par by (1831.50 kg ha^{-1}) at 30 × 20 cm spacing and minimum yield of 1043 kg ha^{-1} was obtained in 15^{th} November sown crop at 30×10 cm spacing. Result also indicate that successive 10 days delay in sowing of mustard from 15^{th} October to 15^{th} November increased the days to attain 50 % flowering from 58 days to 66 days but shortened the days to attain physiological maturity from 148 to 136 days, thereby reducing the reproductive phase from 90 to 70 days which coupled with increased disease severity on leaves as well as on pods during the most vulnerable stage of crop, lead into heavy reduction of yield (from 1866 to 1043 kg/ha), net return (from Rs. 87620 to Rs. 38010 per ha) and Benefit: Cost ratio (from 3.04 to 2.09).

FUTURE SCOPE

Effect of different sowing dates with different spacing in different soil and weather conditions using different variety for minimizing disease severity and maximum yield may be highly useful to develop recommendation for mustard growing farmers for enhancing their profit.

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