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Effect of planting geometry on growth and yield of mustard [*Brassica juncea* (L.)] varieties

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Abstract
A field experiment was conducted during *rabi season* of 2014 on the topic entitled "Effect of planting geometry on growth and yield of mustard [*Brassica juncea* (L.)] Varieties" in sandy loam soil of N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.). The experimental comprised of three planting geometry *viz*., 40×15cm, 40×20cm, 40×25cm and three varieties *viz*., Varuna, Vardan and NDR-8501. Results revealed that planting geometry of 40×15cm produced significantly higher growth yield.

Keywords: mustered, planting geometry, dry matter accumulation, yield and yield attributes

Introduction
Indian mustard (*Brassica juncea* L.) is an important oilseed crop belong to family cruciferae, the oilseed crop play an important role in agriculture economy of India. Our country is the largest oil economy in the world after the U.S. China and Brazil in term of vegetable oil. India occupies the second position in area after China and third position in production in the world after China and Canada. In India, during year 2012-2013, the area of Rapeseed-mustard was 67.17 lakh ha. With the production of 72.62 lakh mt. and productivity of 10.81 quintal/ha. In U.P during the year 2012-2013 the area of rapeseed-mustard was 8.00 lakh ha. With the production of 10.00 lakh mt. and productivity of 12.5 quintal/ha (Anonymous, 2012-13) [1]. However during 2013-14 the area of rapeseed-mustard was 6.5 lakh ha. With the production of 7.8 lakh mt. and productivity of 12.08 quintal/ha (Anonymous, 2013-14) [2]. Indian mustard is sown late due to delay in harvesting of rainy season crops like cluster bean, cotton and rice (Kumar *et al.* 2013) [10]. 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 which consequently results in forced maturity, increased senescence and low productivity (Porter, 2005) [14]. The rise in temperature, even by a single degree beyond the threshold level is considered as heat stress in the plants 2 (Hasanuzzaman *et al.* 2013, Wahid *et al*. 2005) [6, 17]. The global mean surface air temperature increased by 0.5 °C in the twentieth century and is expected to increase a further 1.5-4.5 °C by the late twenty-first century (IPCC, 2012) [7]. Climate change has increased the intensity of heat stress and heat stress due to increased temperature is an agricultural problem in many areas in the world as well as in India (Beck *et al*. 2007) [4]. Transitory or constantly high temperatures cause an array of morphological, physiological and biochemical changes in plants (Serraj *et al*. 1999, Moradshahi *et al*. 2004) [16, 13]. Heat stress affects plant growth throughout its ontogeny, though heat-threshold level varies considerably at different developmental stages. For instance, during seed germination, high temperature may slow down or totally inhibit germination and at later stages, high temperature may adversely affect photosynthesis, respiration, water relations and membrane stability, enhanced expression of a variety of heat shock proteins and production of reactive oxygen species (ROS) constitute major plant responses to heat stress (Wahid *et al*. 2007, Camejo *et al*. 2005) [18, 5]. High temperature in *Brassica* enhanced plant development and caused flower abortion with appreciable loss in seed yield (Alam *et al.* 2014, Lallu & Dixit, 2008, Lobell & Asner, 2003) [11, 12]. Kumar & Srivastava, (2003) [9] reported that under late sown conditions there is reduced chlorophyll stability index, poor harvest index and consequently decreased seed yield. Extreme temperature leads to accumulation of certain organic compounds (Osmolytes) like sugars, polyols, proline and glycine betaine (Kavikishor *et al.* 2005, Sairam & Tyagi, 2004) [5, 15].

Materials and Methods

The present investigation entitled “Effect of planting geometry on growth and yield of mustard [*Brassica juncea* (L.)] Varieties” was conducted at Instructional Farm of Narendra Deva University of Agriculture and Technology Kumarganj, Faizabad (U.P.) during rabi season of 2014. The farm is located 42 Km away from Faizabad city on Faizabad-Raebareli road at 26˚47 N latitude and 82˚12 E longitude and about 113 meters above the mean sea level. The experiment was conducted in Randomized Block Design (RBD). The different growth parameters studied were measured as Initial Plant Population (m^{-2}), Plant height (cm), Leaf area index, Dry matter accumulation, Days to flower initiation, Days to maturity, Yield and yield attributes.

Results

Initial Plant Population (m^{-2}) Data pertaining to initial plant population recorded at 20 DAS as influenced by planting geometry and varieties have been presented in (Table-1). Maximum plant population (15.5 plant m^{-2}) was recorded under planting geometry on 40×15 cm followed by 40×20 cm of Indian mustard. It is evident from the data that Varuna variety exhibited maximum initial plant population (12.4) followed by NDR-8501 (12.2).

Plant height (cm) Data pertaining to plant height of Indian mustard recorded at various growth stages as affected by planting geometry and varieties have been presented in (Table-2). Plant height increased successively with age of crop. It is evident from the data that planting geometry and variety influenced plant height significantly at all the growth stages except 30 DAS. Taller plants were obtained at planting geometry of 40×15 cm which was significant over rest both of planting geometry. Shorter plants were recorded under wider planting geometry (40×25 cm.) sowing. Varieties had significant variation on Plant height at all the stages except 30 DAS. It is quite evident from the data that higher plant height was obtained in NDR-8501 which was at par with Varuna at all the stages while significantly superior over Vardan variety. Data also showed that Vardan variety recorded smaller height of Plant at all the stages.

Leaf area index as affected by planting geometry have been presented in (Table-3) LAI increased successive till 75 DAS and there after declined. It is quite obvious from the data that the LAI was significantly affected due to planting geometry at all the stages. Significantly higher leaf area index was obtained at planting geometry (40×25cm) as compared to sowing done on 40×20cm planting geometry, 40×15cm planting geometry proved lowest LAI at all the stages of crop. Leaf area index was affected significantly at all the stages due to varieties. Highest leaf area index (2.35) was recorded in NDR-8501 variety. Data also revealed that Vardan variety recorded lowest (2.01) leaf area index at all the growth stage. The relationship of Thermal unit and Radiation use efficiency with Leaf area index depicted on Fig. 4.1 to 4.4. of NDR-8501 variety.

Dry matter accumulation as influenced by planting geometry and varieties has been presented in (Table-4). It is quite obvious from the data that dry matter accumulation varied significantly due to planting geometry at all the stages of mustard. It was recorded higher under the treatment when mustard was sown on 40×15 cm which was at while significantly superior over rest both of the planting geometry. Wider planting geometry recorded lowest dry matter at all the stages. Dry matter accumulation was affected significantly at all the stages due to varieties. Highest dry matter accumulation was recorded in NDR-8501 variety which was at par with Varuna while significant over Vardan at all the stages of Indian mustard. Data also revealed that Vardan variety recorded lowest dry matter accumulation at all the growth stages. The relationship of Thermal unit and Radiation use efficiency with Leaf area index depicted on Fig. 4.1 and 4.4. of NDR-8501 variety.

Days to flower initiation as affected by planting geometry and varieties have been presented perusal of data showed that in (Table-5) different planting geometry influenced significantly to flower initiation. Maximum days taken to flower initiation (45.2 days) were recorded when crop was sown on 40×25 cm planting geometry which was superior over 40×20 cm and 40×15 cm sowing spacing. The minimum days taken to flower initiation was recorded at 40×15 cm planting geometry. Days to flower initiation were affected by different varieties. The maximum days taken to flower initiation were recorded with NDR-8501 (48.2 Days) variety followed by Varuna (46.7 Days) and then Vardan (38.9 Days).

Days to maturity as affected by planting geometry and varieties have been presented in (Table-5). A perusal of data showed that different planting geometry influenced significantly to flower initiation. Maximum days taken to maturity (131.3 days) were recorded when crop was sown on 40×25 cm planting geometry which was superior over 40×20 cm and 40×15 cm sowing spacing. The minimum day taken to maturity was recorded (130 days) at 40×20 cm planting geometry. Days to maturity were affected by different varieties. The maximum days taken to maturity were recorded with NDR-8501 (136 Days) variety followed by Varuna (133.9 Days) and then Vardan (119.6 Days).

Yield and yield attributes

Seed yield (kg ha^{-1}) as affected by planting geometry and varieties have been presented in (Table-6). A perusal of data showed that different planting geometry influenced significantly to the Seed yield. Maximum Seed yield (2100) was recorded when crop was sown on 40×15 cm which was significantly superior over 40×20 cm and 40×25 cm planting geometry. The minimum Seed yield (1570) was recorded when sowing was done at 40×25 cm planting geometry. The Seed yield (kg ha^{-1}) was significantly affected by different varieties. Maximum Seed yield (1988.3) was recorded with NDR-8501 variety followed by Varuna (1840) and then Vardan.

Straw yield (kg ha^{-1}) as affected by planting geometry and varieties have been presented in (Table-6). A perusal of data showed that different planting geometry influenced significantly to the Straw yield. Maximum Straw yield (7511.6) was recorded when crop was sown on 40×15 cm which was significantly superior over 40×20 cm and 40×25 cm planting geometry. The minimum Straw yield (5410) was recorded when sowing was done at 40×25 cm planting geometry. The Straw yield (kg ha^{-1}) was significantly affected by different varieties. Maximum Straw yield (6913.3) was recorded with NDR-8501 variety followed by Varuna (6428.3) and then Vardan.

Biological yield (kg ha^{-1}) as affected by planting geometry and varieties have been presented in (Table-6). A perusal of data showed that different planting geometry influenced significantly to the Biological yield. Maximum Biological yield (9611.6) was recorded when crop was sown on 40×15 cm which was significantly superior over 40×20 cm and 40×25 cm planting geometry. The minimum Biological yield (6980) was recorded when sowing was done at 40×25 cm planting geometry. The Biological yield (kg ha^{-1}) was significantly affected by different varieties. Maximum Biological yield (8901.6) was recorded with NDR-8501 variety followed by Varuna (8268.3) and then Vardan.

Harvest index (%) as affected by planting geometry and varieties have been presented in (Table-6). A perusal of data showed that different planting geometry influenced none significantly to the Harvest index. Maximum Harvest index (22.4) was recorded when crop was sown on 40×20 cm which was equal to 40×25 cm and superior to 40×15 cm planting geometry. The minimum Harvest index (21.8) was recorded when sowing was done at 40×15 cm planting geometry. The Harvest index (%) was affected by different varieties. Maximum Harvest index (22.3) was recorded with NDR-8501 variety followed by Varuna (22.2) and then Vardan.

Table 1: Initial plant population (m^2) at 20 DAS of Indian mustard as affected by planting geometry and varieties.

Treatments	Initial plant population (m^2)
Planting geometry	
40×15 cm	15.5
40×20 cm	11.6
40×25 cm	9.6
SEm±	0.15
CD at 5%	0.46
Varieties	
Varuna	12.4
Vardan	12.2
NDR- 8501	12.2
S. Em ±	0.15
CD at 5%	NS

Table 2: Plant height (cm) of Indian mustard as affected by planting geometry and varieties.

Treatments	Plant height (cm)						
	30 Das	45 Das	60 Das	75 Das	90 Das	105 Das	At harvest
Planting geometry							
40×15 cm	21.6	45.5	73.3	102.7	128.1	146.5	154.1
40×20 cm	21.8	42.6	68.7	92.7	115.6	132.2	139.1
40×25 cm	22.3	35.8	57.7	88.3	110.2	126.1	132.6
S. Em ±	0.41	0.76	1.29	1.79	2.22	2.62	2.77
CD at 5%	NS	2.23	3.79	5.23	6.50	7.64	8.10
Varieties							
Varuna	21.9	42.5	68.5	95.8	119.5	136.7	143.8
Vardan	21.4	36.8	59.3	88.5	110.3	126.2	132.8
NDR-8501	22.4	44.6	71.9	99.5	124.1	141.9	149.3
S. Em ±	0.41	0.76	1.29	1.79	2.22	2.62	2.77
CD at 5%	NS	2.23	3.79	5.23	6.50	7.64	8.10

Table 3: Leaf area index of Indian mustard as affected by planting geometry and varieties.

Treatments	Leaf area index						
	30 Das	45 Das	60 Das	75 Das	90 Das	105 Das	At harvest
Planting geometry							
40×15 cm	1.55	2.83	4.05	4.45	3.57	2.68	1.00
40×20 cm	1.70	3.03	4.32	4.74	3.80	2.86	1.10
40×25 cm	1.75	3.34	4.75	5.22	4.19	3.12	1.31
S. Em ±	0.03	0.05	0.08	0.08	0.07	0.06	0.04
CD at 5%	0.09	0.17	0.24	0.25	0.20	0.16	0.12
Varieties							
Varuna	1.65	2.98	4.25	4.67	3.75	2.81	2.05
Vardan	1.60	2.91	4.15	4.57	3.65	2.73	2.01
NDR-8501	1.75	3.30	4.71	5.15	4.15	3.12	2.35
S. Em ±	0.03	0.05	0.08	0.08	0.07	0.05	0.04
CD at 5%	0.09	0.17	0.24	0.25	0.20	0.16	0.12

Table 4: Dry matter accumulation of Indian mustard as affected by planting geometry and varieties.

Treatments	Dry matter accumulation (g/m^2)						
	30 Das	45 Das	60 Das	75 Das	90 Das	105 Das	At harvest
Planting geometry							
40×15 cm	52.48	100.91	155.25	345.00	530.77	707.70	876.41
40×20 cm	47.09	90.56	139.32	302.60	476.32	635.09	786.49
40×25 cm	44.24	85.07	130.88	290.83	447.44	696.58	738.80
S. Em ±	0.91	1.821	2.803	6.047	8.992	12.509	14.606
CD at 5%	2.630	5.315	8.128	17.65	26.247	36.510	42.633
Varieties							
Varuna	49.04	94.31	145.10	322.44	496.06	661.41	819.08
Vardan	42.01	80.79	124.29	276.20	424.92	566.56	701.62
NDR-8501	52.75	101.44	156.06	346.81	533.55	711.40	880.99
S. Em ±	0.907	1.821	2.803	6.047	8.992	12.509	14.606
CD at 5%	2.630	5.315	8.128	17.65	26.247	36.510	42.633

Table 5: Days to flower initiation and Maturity of Indian mustard as affected by planting geometry and varieties.

Treatments	Days to flower initiation	Days to maturity
Planting geometry		
40×15 cm	43.8	128.2
40×20 cm	44.8	130.0
40×25 cm	45.2	131.3
Varieties		
Varuna	46.7	133.9
Vardan	38.9	119.6
NDR-8501	48.2	136.0

Table 6: Yield and yield attributes of Indian mustard as affected by planting geometry and varieties.

Treatments	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Planting geometry				
40×15 cm	2100.0	7511.6	9611.6	21.8
40×20 cm	1768.3	6116.6	7885.0	22.4
40×25 cm	1570.0	5410.0	6980.0	22.4
S. Em ±	33.79	126.23	154.94	0.42
CD at 5%	98.64	368.54	452.23	NS
Varieties				
Varuna	1840.0	6428.3	8268.3	22.2
Vardan	1610.0	5696.6	7306.6	22.0
NDR- 8501	1988.3	6913.3	8901.6	22.3
S. Em ±	33.79	126.23	154.94	0.42
CD at 5%	98.64	368.54	452.23	NS

Conclusion

This experiment concluded that the Seed yield (kg ha^{-1}) was significantly affected by different varieties. Maximum Seed yield (1988.3 kg) was recorded with NDR-8501 variety followed by Varuna (1840 kg) and then Vardan. Seed yield (kg ha^{-1}) was significantly affected by planting geometry. Significantly higher seed yield (2100 kg) was obtained when crop was sown on 40×15cm which has significant superior over crop sown on 40×20 cm and 40×25cm planting geometry.

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