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Effect of plant spacings on growth, yield and quality of mustard (*Brassica juncea* L.) genotypes

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ABSTRACT

A *field experiment was carried out during winter seasons of 2017-18 and 2018-19 at the Private Research Farm, Benda-Semaria Road, Rewa (M.P.) to study the effect of plant spacings on growth, yield and quality of mustard genotypes. Amongst the mustard genotypes, Five types and four spacings were evaluated in factorial randomized block design with three replications. Swarn Jyoti proved the most suitable genotype with respect to growth parameters, yield attributes, seed yield and its quality as well as monetary gain per hectare of production. Thus, this genotype (Swarn Jyoti) gave the maximum seed yield (15.75 q ha^{-1}), net income upto Rs.44399 ha, oil content in seed (41.56%) and seed protein (19.01%). The most optimum plant spacing was 30 x 15 cm which yielded upto 15.02q ha^{-1} giving highest net income of Rs.40706 ha^{-1} but lower oil content (39.81%) and seed protein (17.44%). The combined impact of Swarn Jyoti grown with 30 x 15 cm plant spacing further encouraged all these parameters significantly i.e. grain yield (18.40 q ha^{-1}), net income Rs.(57938 ha^{-1}), oil content (41.38%) and seed protein 918.37%).*

Key words: Plant spacings, quality, mustard, genotypes, yield

INTRODUCTION

Mustard (*Brassica juncea* L.) belongs to the family Crucifereae. It is an important oilseed crop in winter season of north India. Mustard is the second most important edible oilseed crop after groundnut which accounts nearly 30% of the total oilseeds produced in India. In India, mustard is grown in an area of 5.60 M ha with the production of 6.84 M t, accounting for a productivity of 1159 kg ha^{-1}. The average productivity of rapeseed and mustard in the Madhya Pradesh is 1147 kg ha^{-1}. Planting patterns play an important role in enhancing overall productivity of crops as it is likely to affect interception, absorption, penetration and utilization of incoming solar radiation. Plant density is another important character, which can be manipulated to attain the maximum production from per unit land area. The optimum plant density with proper geometry of planting is dependent on variety, its growth habit and agro-climatic conditions. It is also a fact that specified varieties do not exhibit the same phenotypic characteristics in all the environmental conditions. Improved cultivar is an important tool, which have geared production in many countries of the world. In addition to many other factors, cultivars with higher yield potential and a wide range of adaptability to edaphic and climatic conditions is essential for increasing yield per unit area, ultimately boosting up total production (Kaur and Singh, 2011). Several new varieties have been developed which needs location specific evaluation with regard to agro-input management in which plant spacing is the most important factor. Such information is lacking under the existing agro-climatic conditions of Kymore plateau. Keeping the above facts in view, the present investigation was carried out using mustard as test crop.

MATERIALS AND METHODS

The field experiment was conducted at the Private Agriculture-Research Farm, Benda-Semaria Road, Rewa (M.P.) during 2017-18 and 2018-19. The soil of the experimental field was silty-clay-loam having pH 7.5, electrical conductivity 0.32 dS m^{-1}, organic carbon 0.86 %, available N, P_2O_5 and K_2O 230,13.8 and 372 kg ha^{-1}, respectively. The rainfall received during the rainy season was 772 mm. The treatments comprised five genotypes (Pusa Tarak, Swarn Jyoti, Pusa Jai Kisan, Pusa Agrani and JTC-1) and four plant spacings (30 x 15, 40 x 15, 50 x 15 and 60 x 15 cm). Thus, the twenty treatment combinations were laid out in the field in a factorial randomised block design keeping three replications. The mustard genotypes were sown

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on 25 and 15 November in 2017 and 2018, respectively @ 6 kg ha^{-1}. The common dose of 40 kg N, 30 kg P_2O_5 and 20 kg K_2O ha^{-1} was applied in all the treatments. The crop was raised as per recommended package of practices. The genotypes were harvested on 9 April, 2018 and 29 March, 2019 yield attributes and seed yield were recorded at harvest. The oil per cent in seed was determined by Soxhlet's extraction method. The seed protein was determined by multiplying the per cent N-content in seed with 6.25.

RESULTS AND DISCUSSION

Growth parameters

The data (Table 1) reveal that amongst the genotypes, KTC-1 attained the significantly maximum height (166.1 cm), branches (32.36 plant^{-1}) and leaves (63.09 plant^{-1}) at 97 days stage. This was followed by Swarn Jyoti and then Pusa Jai Kisan. The significantly minimum growth parameters were recorded in case of Pusa Agrani genotype of mustard at 97 DAS stage of observations. The significant variation of all these traits among the different genotypes might be due to attainment of variable growth characters which are genetically controlled in different genotypes developed from different parental origins. The remarkable increase in plant height in case of genotype JTC-1, Swarn Jyoti and then Pusa Jai Kisan may be acceleration of cell elongation and cell division (Chaudhary and Bhogal 2017). Due to maximum increase in leaves formation per plant in case of JTC-1, the photosynthetic surface area of the leaves per plant was eventually highest in this genotype. The second best genotype was Swarn Jyoti with respect to photosynthetic leaves area. In fact, plant leaf is the factory for the conservation of solar energy into the chemical by the process of photosynthesis. The water and CO_2 in the presence of sunlight give rise to the chlorophyll formation in which nitrogen is also a constituent. Thereby, in the adequate nitrogen supply conditions, the chlorophyll formation is an optimum. Moreover by virtue of varied genetic constitution, the varieties also differ in their chlorophyll formation. Therefore, the chlorophyll content was found in the higher range in case of JTC-1 and Swarn Jyoti genotypes over others at every stage of plant growth. Consequently, both these genotypes recorded equally highest dry matter production (44.32 to 45.01 g plant^{-1}).

Table 1: Growth and yield-attributing parameters of mustard as influenced by genotypes and plant spacings (Pooled for 2 years)

Treatments	Plant height (cm) 97 DAS	Branches plant^{-1} 97 DAS	Leaves plant^{-1} 97 DAS	Siliquae plant^{-1}	Length of siliqua (cm)	Seeds siliqua^{-1}	1000-seed weight (g)	Seed yield plant^{-1} (g)
Genotypes								
Pusa Tarak	156.8	24.27	49.97	287	5.54	14.93	6.80	12.89
Swarn Jyoti	165.5	27.98	58.86	339	6.22	18.09	7.70	15.10
Pusa Jai Kisan	165.3	24.95	52.02	302	5.66	15.18	7.22	13.98
Pusa Agrani	145.8	17.83	44.91	274	4.89	14.20	6.15	12.30
JTC-1 (Karan Rai)	166.1	32.36	63.09	332	6.11	17.34	7.62	14.36
CD (P=0.05)	0.16	0.45	0.32	2.64	0.13	0.17	0.14	0.09
Plant spacings (cm)								
30 x 15	145.1	22.56	47.26	254	5.49	15.04	6.48	12.30
40 x 15	154.5	24.84	50.69	286	5.60	15.57	6.96	13.43
50 x 15	163.8	26.30	55.79	318	5.73	16.26	7.31	14.22
60 x 15	176.1	28.19	61.31	369	5.90	16.91	7.62	14.95
CD (P=0.05)	0.14	0.40	0.28	2.36	0.12	0.16	0.12	0.08
Interaction	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.

Thus, the formation of mustard leaves per unit area thereby per plant was the remarkable feature observed in case of JTC-1 and Swarn Jyoti genotypes. This may be due to the fact that these genotypes promoted plant growth by ensuring higher number of greener leaves with increased photosynthesis as a result of (i) increased metabolism of the absorbed plant nutrients (ii) influencing cell membranes of leaves (iii) forming longer and stronger roots to absorb water and nutrients, and (iv) as a result of acting on dividing cells in roots and shoots. Profuse root development ensured more absorption of minerals, nutrients and soil moisture from the deeper soil layers. These favourable soil conditions brought about efficient utilization of plant nutrients accompanied by activating plant enzymes. Such type of variability in growth characters of mustard and soybean genotypes has also been observed by many research workers (Sheykhlou *et al.*, 2012; Raut *et al.*,,2013; Patel *et al.*,2015; Choudhary and Bhogal,2017 and Chauhan, 2017).

As regards with the plant spacings, all the growth parameters (viz., plant height, number branches and leaves per plant) were increased significantly at every growth stage due to increased (wider) plant spacings upto 60 x 15 cm as compared to the closer spacings. At 97 DAS, the widest (60 x 15 cm) spacing brought about significantly higher plant height (176.1 cm), number of branches (28.19 plant^{-1}) and leaves (61.31 plant^{-1}), chlorophyll content (1.96 mg g^{-1}) and dry matter/plant (45.62 g). On the other hand, the lowest values of all these growth parameters under closest (30 x 15 cm) spacing were 145.1 cm plant height, 22.56 branches plant^{-1}, 47.26 leaves plant^{-1}, chlorophyll content (1.39 mg g^{-1}) and dry matter (38.21 g plant^{-1}). The significant increase in all these parameters under widest (increased) plant spacing sulphur might be due to the fact that the increased spacing between plants resulted in enhanced space, sun-light, nutrients and soil moisture for increased photosynthesis, metabolic activities, growth and development. These findings corroborate with those of many researchers (Sharma *et al.*, 2009; Chhonkar *et al.*, 2011 and Mevada *et al.*, 2017).

Yield-attributing parameters

Amongst the mustard genotypes, Swarn Jyoti resulted in significantly higher number of siliquae (339 plant^{-1}), suliqua length (6.22 cm), seeds (18.09 siliqua^{-1}), 1000-seed weight (7.70 g) and seed yield (15.10 g plant^{-1}). The second and third best genotypes were JTC-1 and Pusa Jai Kisan, respectively with respect to yield-attributes. This was followed by Pusa Tarak and the significantly lowest yield attributes were recorded in case of Pusa Agrani genotype of mustard. All these yield-attributing characters among the genotypes are genetically governed although the agro-climatic changes are also involved. Thus, the genotypes differed in their growth and yield-attributing potential depending upon the many physiological processes which are controlled by both genetic make up and the agro-climatic environment. The different genotypes of mustard have been found to differ significantly in the yield-attributing characters. This fact has also been observed by several researchers (Sheykhlou *et al.*, 2012; Raut *et al.*, 2013; Singh *et al.*, 2015; Saxena and Bisen, 2017; Kanaujia *et al.*, 2017 and Sahu *et al.*, 2017).

Table 2: Yield and quality of mustard as influenced by genotypes and plant spacings (Pooled for 2 years)

Treatments	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)	Oil content (%)	Oil yield (kg/ha)	Protein content (%)	Protein yield (kg ha^{-1})
Genotypes							
Pusa Tarak	12.25	20.93	37.01	39.02	477.5	17.42	213.0
Swarn Jyoti	15.75	25.97	37.69	41.56	654.1	19.01	298.4
Pusa Jai Kisan	13.05	22.45	36.74	39.94	520.6	17.89	233.0
Pusa Agrani	10.10	19.30	34.34	38.98	393.1	16.90	170.0
JTC-1 (Karan Rai)	14.46	23.75	37.88	41.18	595.6	18.72	270.0
CD (P=0.05)	0.04	0.07	0.063	0.07	0.69	0.13	1.05
Plant spacings (cm)							
30 x 15	15.02	25.20	37.16	39.81	600.8	17.44	263.6
40 x 15	13.64	23.59	36.54	40.03	547.8	17.81	244.5
50 x 15	12.50	21.61	36.56	40.23	504.5	18.18	228.6
60 x 15	11.32	19.49	36.67	40.46	459.5	18.50	210.8
CD (P=0.05)	0.03	0.06	0.057	0.06	0.62	0.12	0.94
Interaction	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.

The widest spacing upto 60 x 15 cm increased all the yield-attributes of mustard upto significant extent over the closer plant spacings (30 x 15 to 50 x 15 cm). Under the widest spacing between rows, the highest number of silique/plant, siliqua length, seeds siliqua^{-1}, 1000-seed weight and seed yield plant^{-1} may be attributed to the reduced competition between plants for space, light, nutrients and soil moisture. This had significant role in regulating the photosynthesis, enhanced the metabolic activities promoting chlorophyll formation and photosynthesis at one hand and root development coupled with accelerated nutrients absorption on the other. Moreover, this has resulted in higher uptake of nutrients and maintained better harmony between photosynthesis and translocation, and ultimately given rise to higher yield-attributing parameters of mustard. The beneficial effect of wider spacings between plants has also been reported by Sharma *et al.* (2009), Chhonkar *et al.* (2011) and Mevada *et al.* (2017).

Productivity of mustard

Amongst the mustard genotypes, Swarn Jyoti recorded maximum seed yield (15.75 q ha^{-1}), straw yield (25.97 q ha^{-1}) and harvest index (37.69%). Out of these, seed yield and straw yield were found significantly higher in case of Swarn Jyoti. The second best genotype was, of course, JTC-1 and then Pusa Jai Kisan (Table 2). The higher productivity parameters in case of Swarn Jyoti and JTC-1 genotypes might be attributed to increased vegetative growth, thereby yield-attributing characters viz., number of silique plant^{-1}, siliqua length, 1000-seed weight, number of seeds siliqua^{-1} and weight of grains plant^{-1} in these genotypes. The yield obtained from both the genotypes was higher than those of other genotypes which might be due to their physiological role in increased synthesis and partitioning of the biomass. This was followed by the third best genotype Pusa Jai Kisan based on all these yield-attributing characters. The yield variations among the mustard genotypes have also been reported by several research workers (Raut *et al.*, 2013; Singh *et al.*, 2015; Patel *et al.*, 2015; Choudhary and Bhogal, 2017; Saxena and Bisen, 2017 and Chauhan, 2017).

Mustard requires appropriate space between plants for proper yield. In the present experiment, seed and straw yield as well as harvest index of mustard were found to increase significantly with the closer 30 x 15 cm spacing between plants. The increase in grain, straw yield and harvest index was mainly due to increase in the plant population per unit area due to closer spacing between plants. Although wider spacings rose the yield attributes where the plants received increased space, light, nutrients and moisture. The higher harvest index indicates that the it enhanced the transformation of biomass into seed. The closest (30 x 15 cm) spacing caused proportionately greater increase in grain than in non-grain parts which resulted in higher harvest index of mustard. The interactions between genotypes x closest spacing were found to be positive and significant in increasing the seed and straw yield as well as harvest index. This showed the synergistic relationship between high-yielding genotypes with applied closest (30 x 15 cm) plant spacing between rows. It is quite apparent that the wider plant spacing having less number of plants per unit area could not compensate the yields obtained under the closer plant spacings having higher number of plants per unit area. The present results are in conformity with those of many research workers (Sharma *et al.*, 2009; Chhonkar *et al.*, 2011 and Mevada *et al.*, 2017).

Nutritional seed quality

The genotype Swarn Jyoti resulted in significantly higher oil content in seed (41.56%) and oil yield (654.1 kg ha^{-1}). Protein content in seed (19.01%) and protein yield (294.4 kg ha^{-1}). The second and third best genotypes were JTC-1 and Pusa Jai Kisan, respectively with respect to nutritional quality of seed. The Pusa Tarak and Pusa Agrani attained the fourth and fifth position, respectively. Thus, the Pusa Agrani recorded the lowest oil content (38.98%), oil yield (393.1 kg ha^{-1}), protein content (16.90%) and protein yield (170.0 kg ha^{-1}). The variation in grain protein content among these genotypes might be owing to the differences in the synthesis of protein through amino acids as a result of N-metabolism. In case of variation in grain oil content among the genotypes might be due to variation in the synthesis of fatty acids and their esterification by accelerating biochemical reactions in glyoxalate cycle.

Seed oil and seed protein percentage both were found to enhance upto significantly extent due to increasing plant spacings upto 60 x 15 cm. The increase in oil content in mustard due to plant spacing upto 60 x 15 cm could be due to the fact that wider spacings helped in the synthesis of fatty acids and their esterification by accelerating biochemical reactions in glyoxalate cycle (Dwivedi and Bapat, 1998). The increase in oil content in soybean with S application might be due to the fact that S helped in oil synthesis by enhancing the level of thioglucosides (Dwivedi and Bapat, 1998). The increase in oil content on addition of S was probably due to the increase in glycosides. Similar increases in protein and oil contents in mustard due to increasing plant spacing have been supported by many research workers (Tripathi *et al.*, 2010; Patel *et al.*, 2015; 2017; Saxena and Bisen, 2017 and Kanaujia *et al.*, 2017).

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