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PRODUCTIVITY AND PROFITABILITY OF OILSEED *BRASSICA* SPECIES UNDER SYSTEM OF MUSTARD INTENSIFICATION

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ABSTRACT

A system of mustard intensification (SMI) is conceptualized as a system of formulated principles for producing rapeseed and mustard rather than technical practices of technology. A field experiment was conducted during winter (*rabi*) seasons of 2017-18 and 2018-19 at Banaras Hindu University, Varanasi to assess the system of mustard intensification in *Brassica* species under different methods of cultivation. The experiment was designed insplit-plot arrangement taking three oilseed *Brassica* species (*Brassica juncea* 'Giriraj', *B.carinata* 'PC-6' and *B. napus* 'GSC-7') in main-plots and three methods of cultivation (SMI prepared seedlings transplanted at 60 cm × 60 cm and 45 cm × 45 cm, and conventional line sowing at 30 cm × 10 cm) in sub-plots with 3 replications. Transplanting of *Brassica juncea* seedling at 60 cm × 60 cm spacing recorded significantly higher growth attributes *viz.* plant height, stem diameter and dry-matter accumulation with almost all yield-attributing characters and yields, except number of branches/plant and number of siliquae / plant which were significantly higher in *Brassica carinata*. The SMI seedling transplanting at 60 cm × 60cm and 45 cm × 45 cm increased the seed yield by 24.39% and 2.91% over conventional sowing. Similarly, SMI planting at 60 cm × 60 cm of *Brassica juncea* also gave significantly maximum profit in respect to net return (`55,512/ha) and benefit cost ratio (2.06) over normal sowing of *Brassica napus*. Thus, it could be concluded that transplanting of *Brassica juncea* at 60 cm × 60 cm spacing can prove a step ahead in realizing the yield potential of the crop through system of mustard intensification.

Key words : *Brassica*, Genotype, Intensification, Spacing, Transplanting.

Introduction

Oilseed production in world is in downward trend and following 1.4% growth per annum relative to last decades except soybean growth which was 4.1% per annum (FAO, 2019). Though, India is fourth largest producer of the oilseed but today it is one of the largest importers of edible oils followed by China and United States. Approximately 55.10% of vegetable oil are imported to meet the demand of growing population in which government invest India's nearly ¹ 156800 crore on vegetable oil import in the year 2021-22 (DAOFW, GOI 2022-23). Total production of oilseed in year 2021-22 is only to 37.7 million tons and at present, average monthly consumption rate of oilseed is 1.82 million metric tonnes, which is 26% less than the domestic minimum needs (GoI, 2017).

In Indian oil economy, oilseed *Brassica* has noteworthy contribution approximately 23.5% of the total oilseed production, however average yield (1184 kg/ha) is lower as compared to another developed countries (GoI, 2021). *Brassica* is the second largest vegetable oilseed crop after groundnut sharing 27.8% in the India's oilseed economy. *Brassicaceae* or rapeseed-mustard family is the largest angiosperm of plant kingdom having 338–360 genera with 3,709 species, which is globally dispersed except Antarctica (Al-Shehbaz *et al.*, 2006). Among the 37 species of *Brassica* family, five species are included in rapeseed and mustard grown for vegetable oil (Gómez-Campo, 1980). These are *Brassica napus* L., *Brassica rapa* (*campestris*), *Brassica juncea* (L.) Czernj and Cosson, *Brassica carinata* A. Braun and *Eruca sativa* (Mill.) (ISO, 2002). According to "triangle of U" the three amphidiploids derivatives *i.e*. *B. carinata*, *B. juncea* and *B. napus* are derived by hybridization and polyploidization of any two diploid species *B. nigra*, *B. oleracea* and *B.rapa* (*campestris*) (Abdeta *et al*., 2022). Since majority of oilseed are confined to marginal land under rainfed area only, so there is significant deceleration in oilseed production was observed (Pant *et al*., 2019). Indian mustard [*Brassica juncea* (L.) Czernj and Cosson] comprises 75% of the total rapeseed-mustard cropped area in the country (AICRP-RM, 2015). Gobhi sarson (*B. napus* L. spp. *Oleferia* DC. var. annua) and Karan Rai (*Brassica carinata* A. Braun.) are the new promising oilseed crops having high yield potential, wider adaptability and high oil content, butit has limited area of cultivation in India. Yield is combined output of genetic inheritance, weather condition and its agronomic management and practices (Robertson *et al*., 2004). After yellow revolution in India, there is huge gap between demand and supply of oilseed due to stagnant yield under conventional system of planting. Another reason for declining in the yield of mustard is delayed planting due to late harvest of rice, which minimizes the interval of vegetative to reproductive phase of the crop. Seedling transplanting is better choice for resolving problems of delayed crop sowing, poor germination and poor establishment of seedling, water scarcity and weed problem (Rameeh *et al*., 2019).

After green revolution intensification symbolizes the greater use of external inputs, but in another approach in terms of sustainability is most productive use of resources. System of root intensification provides opportunity for early establishment of crop with better root proliferation in water stress condition (Tyagi *et al*., 2017). Meanwhile, SRI in mustard enhances the yield by mitigating the competition among individuals for light, nutrient, space, water etc. under changing climate, but it requires further standardization before recommendation.

Materials and Methods

A field experiment was conducted at Agricultural Research Farm of Banaras Hindu University, Varanasi (25°18' N, 83°03'E and 75.7 m above the mean sea level) during *rabi* seasons of 2018-19 and 2019-20. The soil of experimental site was sandy clay loam in texture (Order- Inceptisol, Type- Ustochrept) with homogenous fertility having pH 7.6, electrical conductivity 0.20 dS/m, organic carbon 0.38%, available N 209.23kg/ha, available P 10.56 kg/ha and exchangeable K 202.32 kg/ha. The trial was arranged in split-plot design with three replications. The experiment consisted of 9 treatments, having three genotypes in main plots *i.e. Brassica juncea* cv.'Giriraj', *B. carinata* cv. 'PC 6' and *B. napus* cv. 'GSC 7' with three spacings such as 60 cm × 60cm transplanting, 45 cm ×45 cm transplanting and 30 cm × 10 cm as conventional planting in sub-plots.

Seedling are grown in plastic bags from sprouted seeds which was treated with jaggery, cow urine and vermicompost slurry for 15 days. Water was sprinkled frequently after emergence of crop without causing any water stress. Manually seedlings were transplanted in the field as per proposed geometry after removal of plastic bags from each plant in first fortnight of November during both years. The recommended fertilizer dose of 120, 60, 60 kg N, P_2O_5 and K_2O/ha was used and 50% N along with a full dose of P_2O_5 and K_2O were applied as basal at the time of final land preparation and the rest amount of nitrogen was applied at 35 days after sowing (DAS). Others appropriate cultural managements like intercultural operations; weeding/hoeing, plant protection measures etc. were followed as per package of practices of rapeseed and mustard. Yield parameters like siliquae/plant was counted on five tagged plants in net plot area and averaging them. The seeds/siliqua and siliqua length were recorded from five random places in each selected plant and mean was computed. The seed yield and stover yield were recorded after threshing and converted it into kg/ ha after applying conversion factor. Economics of different treatments were worked out in terms of cost of cultivation, net return and benefit-cost ratio based on prevailed market prices of the input and outputs.

The data collected were tabulated and then statistically analyzed as per the standard analysis of variance (ANOVA) procedure for split-plot design (Corchan and Cox, 1957) and the significance was verified by F-test. Treatments means were compared at by Fisher's protected least significant difference at a significance level of 5% probability.

Results and Discussion

Growth parameters

Plant height of transplanted crop was significantly more than the conventional planting during both the years (Table 1). *B. juncea* (Giriraj) exhibited height increases of 14% and 9% in the first year, and 10.4% and 6.8% in the second year, respectively, surpassing the heights attained by *B. carinata* (PC 6) and *B. napus* (GSC 7). This may happen due to that *B. carinata* and *B. napus* has lengthy rosette period at initial stage, however early bolting achieved in *B. carinata* than canola (Seepaul *et al*., 2016). The highest plant height was observed in 60 cm × 60 cm spacing during both years and it was statically at par with the transplanting at 45 cm × 45 cm during second year. The lowest height was achieved in conventional planting system (30 cm ×10 cm). This may be attributed that wider spacing in transplanted crop provide more room to each plant for above and below ground growth causing more root density and vigorous growth compared to conventional system (Abraham *et al*., 2014; Sushma *et al*., 2023).

The number of branches has major role in increasing seed yield and it was significantly affected by genotypes (Table 1). Among genotypes, *Brassica carinata* cultivar 'PC 6' was able to be produced highest number of primary (16.8) and secondary (31.26) branches per plant over the rest of the two genotypes during both years. However, the number of branches in cultivar Giriraj (*B. juncea*) did not differ with the cultivar GSC 7 (*B.napus*). Plant density had shown significant influence in number of branches per plant. Transplanted crop at 60 cm × 60 cm recorded maximum number of primary (13.4) and secondary (23.06) branches followed by transplanting at 45 cm × 45 cm. This may be due to vigorous growth of root and profuse stem diameter that promotes branching from the basal part responsible for change in canopy architecture and branching patterns. Less number of branches/plants obtained with conventionally sown crop (30 cm × 10 cm) during both years. The observed phenomenon may be attributed to limited lateral space, leading to increased competition among plants for sunlight, moisture, and nutrients in narrow spacing as compared to wider spacing. These finding corroborate with the result of Oad *et al.* (2001).

Yield attributes

The yield attributes like siliquae/plant, siliqua length, seeds/siliqua and 1,000-seed weight was influenced significantly by the planting methods and the genotypes (Tables 1 and 2). The different planting geometry significantly influenced the number of siliquae/plant of Ethiopian mustard but not of Indian mustard (*B.juncea*) and canola oilseed rape (*Brassica napus*). Ethiopian mustard acquired 34% and 43% more number of siliquae/plant than *Brassica napus* and *Brassica juncea*, respectively during both the years. The highest value for number of siliquae/plants was obtained in Ethiopian mustard and it was lowest for *Brassica juncea*. This can be explained that siliquae per plant is proportional to number of branches per plant and Ethiopian mustard had higher number of primary secondary and tertiary branches. Similarly, during both years, increasing spacing causing more siliqua per plant and the differences among transplanting at 60 cm × 60 cm, 45 cm × 45 cm and conventional sowing was significant. This happened due to higher root-shoot ratio indicate higher yield potential under minimum supply of water and nutrient. Satpathy (2009) also reported the higher siliquae/plant at wider spaced mustard.

At maturity, *B. napus* cv. 'GSC 7 recorded maximum siliqua length as compared to 'Giriraj' and 'PC 6' in both the year. The difference among these species was might bedepend on their genetic makeup, nutrient uptake capacity and climatic conditions of the experimental sites (Iqbal *et al*., 2008). However, siliqua length is not significantly influenced by spacing geometry with respect to plant geometry. However, maximum siliqua length was witnessed in transplanting at 60 cm × 60 cm, but the differences among the planting geometry are non-significant.

The impact of transplanting on *Brassica* spp. was much more pronounced and gave better result on seeds/siliquaduring the first year in comparison to second year. Under different genotypes, *B. napus* cv. 'GSC 7' was significantly higher followed by 'Giriraj' and 'PC 6', respectively. Among plant geometries, the transplanting at 60 cm × 60 cm irrespective of other spacings found to be numerically and significantly better than 45 cm × 45 cm and conventional sowing under same management practices. Similar results were reported by Oad *et al.* (2001).

Analysis of thousand seed weight in both the year indicted that the seeds of different *Brassica* genotypes varied significantly in weight (Table 2). The higher test weight was noted with *Brassica juncea' Giriraj*' (7.05 and 7.75 g), which was significantly at par with both genotypes while lowest weight was recorded with *B. carinata* cv. 'PC 6'(4.88 and 4.77 g) in year 2017-18 and 2018-19, respectively. These results are in line with those of Angadi *et al*. (2003), who revealed that thousand seed weight is the most stable part of yield and not affected by plant density fluctuations. Similarly, transplanting at 60 cm × 60 cm was also recorded 17.25 and 13.37% higher test weight over transplanting at 45 cm × 45 cm. This may be attributed that under SMI system with proper irrigation management improves the oxygen supply in roots which leads to decrease in aerenchyma formation and promoting a healthier root system having potential advantage of nutrient uptake (Gupta *et al*., 2018). The yield enhancement under wider row spacing also illustrated by Mevada *et al*. (2017) and Sondhiya *et al*. (2019). The significant lower test weight was achieved with conventional at 30 cm × 10 cm. This is probably happened due to more plant inter competition for space which restrict the mobilization of photosynthates material to the seed which lowers the seed weight.

Table 1 : Effect of different genotypes and planting patterns on several agronomic traits of *Brassica* spp.

Treatment	Plant height (cm)		Primary branches		Secondary branches		Siliquae/plant		Siliqua length (cm)		Seeds/siliqua	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
***Brassica* species**												
Brassica carinata	161.00	172.24	16.35	6.78	25.06	37.62	679.52	691.75	4.87	4.96	13.47	11.83
Brassica napus	170.19	177.90	7.27	8.04	11.28	11.80	382.36	389.24	7.01	7.24	20.67	22.85
Brassica juncea	184.76	190.78	9.09	8.62	9.39	10.23	527.66	537.16	5.29	5.55	17.81	17.00
SEm±	1.82	1.35	0.43	0.40	0.84	1.11	26.78	27.26	0.28	0.26	0.46	0.51
CD (p=0.05)	7.13	5.29	1.7	1.57	3.30	4.35	105.16	107.05	1.10	1.07	1.82	1.99
Crop geometry												
Conventional at 30 cm × 10 cm	166.49	175.75	8.19	8.89	13.60	16.70	402.77	410.02	5.69	5.36	15.14	15.72
Transplanting at 45 cm × 45 cm	171.61	183.41	11.15	11.10	14.91	18.60	546.48	556.32	6.2 7	6.04	18.99	16.96
Transplanting at 60 cm × 60 cm	177.85	187.76	13.35	13.44	17.22	24.35	640.29	651.82	7.02	6.36	17.83	19.00
SEm±	1.44	1.50	0.44	0.50	0.43	0.80	20.47	20.84	0.20	0.21	0.40	0.36
CD (p=0.05)	4.45	4.61	1.37	1.54	1.33	2.45	63.08	64.22	NS	NS	1.25	1.10

*NS – Non significant.

Table 2 : Effect of different genotypes and planting patterns on yield and economics of *Brassica* spp.

Treatment	Test weight (g)		Seed yield(kg/ha)		Stover yield (kg/ha)		Net return(` /ha)		B:C ratio	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
***Brassica* species**										
Brassica carinata	2.54	2.59	1649.17	1682.16	4551.54	4597.06	40,611	44,140	1.56	1.65
Brassica napus	3.14	3.17	1246.60	1271.54	3281.67	3314.48	20,298	24,048	0.78	0.90
Brassica juncea	3.62	3.66	1967.28	2006.62	5490.97	5545.88	49,565	51,564	1.90	1.93
SEm±	0.11	0.12	48.76	49.73	133.80	135.14	93.02	96.32	0.03	0.04
CD (p=0.05)	0.43	0.44	191.45	195.28	525.38	530.64	365.24	443.12	0.13	0.21
Crop geometry										
Conventional at 30 cm × 10 cm	2.62	2.66	1446.62	1475.55	3958.92	3998.51	24,210	25,467	0.54	0.81
Transplanting at 45 cm × 45 cm	3.13	3.18	1669.37	1702.76	4564.24	4609.88	47,756	47,914	1.21	1.60
Transplanting at 60 cm × 60 cm	3.55	3.60	1747.06	1782.01	4801.02	4849.03	48,810	48,202	1.41	1.75
SEm±	0.12	0.12	40.45	41.26	158.95	160.54	95.21	98.45	0.03	0.04
CD (p=0.05)	0.38	0.38	124.64	127.14	489.77	494.67	293.37	312.34	0.12	0.14

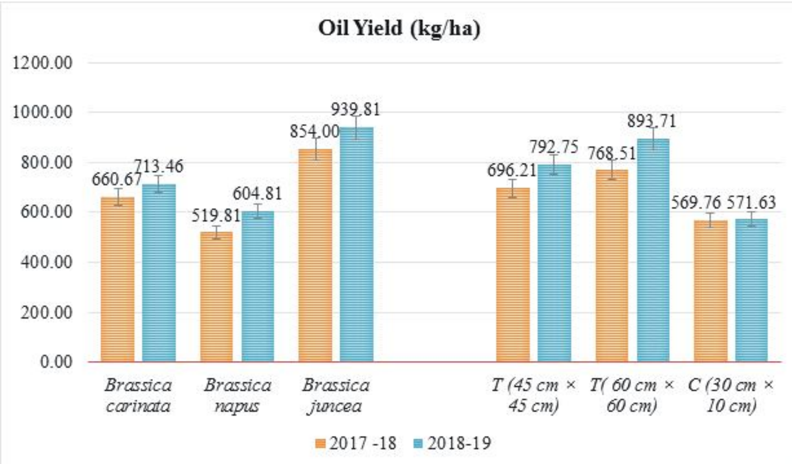

Fig. 1 : Effect of different genotypes and planting patterns on oilyield of *Brassica* spp.

Yields

Data indicated that genotype and spacing had significant effect on seed yield and stover yield (Table 2). Means comparison showed that *Brassica juncea* 'Giriraj' produced significantly superior seed yield and stover yield out of other two species during both years. Ethopian mustard (*B. carinata* cv. 'PC 6') also remained significantly higher over the *Brassica napus* cv. 'GSC 7', which recorded lowest produced among three genotypes. This might be due to *B.juncea* is known to be more shattering resistance, drought tolerance and greater environment adaptability in semi-arid regions, which provide more improve source to sink relation than both species (Woods *et al*., 1991; Getinet *et al*., 1996). In spacing, seed yield and stover yield were highest at the transplanting of 60 cm × 60 cm, which was significantly superior over rest of the two methods of planting during both the years. The higher seed yield achieved under SMI with 60 cm row spacing can be attributed to a notable increase in the number of primary and secondary branches/plant, siliqua/ plant, and seeds/siliqua and test weight (Nautiyal *et al*., 2020). However, the lowest yield was observed in conventional planting method. Our results confirm those of Tyagi *et al*. (2017), Pandit *et al*. (2022).

Under different planting geometries, the oil yield was found to be maximum in transplanting at 60 cm × 60 cm and minimum in conventional planting method. However, transplanting at 45 cm × 45 cm remained on par and significantly superior over conventional planting. Amongst different genotypes, irrespective of management practices the *B. juncea* 'Giriraj' gave significantly and numerically higher value than *B. Carinata* 'PC 6' and *B. napus* cv. 'GSC 7 during both years.

Economics

Net return and benefit: cost ratio was affected by *Brassica* genotypes and crop establishment methods during both years (Table 2). Transplanting of *Brassica* spp. was profitable with improved productivity along with increased return as compared to conventional sowing method. The highest net return (` 50564/ha) and B: C ratio (1.91) was recorded with cultivar 'Giriraj', which acquired 19.32% more profitable compared to 'PC-6'. Nevertheless, the lower yield remained associated with genotype *Brassica napus* 'GSC-7' causing the lowest net return (` 22173) and B: C ratio (0.84). Transplanting at 60 cm × 60 cm gave maximum net return (` 4349/ha) and higher B: C ratio (1.58).

Thus, it can be concluded that transplanting of *Brassica juncea* "Giriraj" at 60cm × 60 cm could realize the higher yield advantage and efficiently utilize the resource through root intensification.

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