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Optimization of Intra-Row Spacing for Yield Enhancement in System of Mustard Intensification (SMI) Techniques

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ABSTRACT

The experimental work was carried out during the *rabi* seasons (November to February) of the year 2018 and 2019 at Instructional field of RRS (OAZ), Uttar Banga Krishi Viswavidyalaya, Majhian, Dakshin Dinajpur, West Bengal, India to study the growth and yield performance of different varieties from toria, rapeseed and Indian mustard with three different spacing combinations under System of Mustard Intensification (SMI) technology. The seedlings were raised in micro-pots (2×2.5 cm^2 size) and transplanted in the main plot. The experiment was laid out in a completely randomized block design replicated thrice. The treatments consisted of three levels of plant spacing (25×25 cm^2, 45×45 cm^2, 60×60 cm^2) and included 3 varieties one each from toria, rapeseed and Indian mustard group. Among different treatment combinations, variety Bhagirathi (from Indian mustard group), in combination with spacing of 60×60 cm^2 (S_3V_3) was recorded with highest yield (1348.08 kg ha^{-1}) followed by its rest of the combinations with 25×25 cm^2 (1331.42 kg ha^{-1}) and 45cm×45 cm (1320.67 kg ha^{-1}), i.e. S_1V_3 and S_2V_3, respectively. Plant height (cm) was also recorded highest with S_3V_3 treatment followed by S_2V_3 and S_1V_3. Total chlorophyll (mg 100 g^{-1}) content was recorded highest with the same Bhagirathi variety S1V3 treatment (18.99) followed by S_2V_3 (17.45) and S_3V_3 (17.61). Amongst the yield attributing characters, number of secondary branches, number of siliqua $plant^{-1}$ and total chlorophyll content were recorded highest with the Bhagirathi variety from the Indian mustard group with the spacing of 60×60 cm^2 (S_3V_3).

KEYWORDS: Micro-pot, mustard, spacing, system of mustard intensification, yield

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1. INTRODUCTION

Mustard (*Brassica* spp.) is an important oilseed crops and cultivated almost all place in India next to cereals crops. The area under rapeseed-mustard in India was 6.23 Million hectares, produced about 9.34 million tonnes with 1499 kg ha^{-1} productivity during the year 2018-19 (Anonymous, 2019). The low yield is due to lack of high yielding varieties and improper agronomic practices (Rathour et al., 2021). There is a great scope of increasing yield of mustard by improving management practices. Therefore, modified crop production technologies, which support sustainable crop intensification can be developed and spread among the farmers. One growing concept of sustainable intensification is presently focusing on increasing input use efficiency, adoption of high-tech precision agriculture technologies for field crops, AWD (alternative wetting-and-drying) for irrigated rice production, and integrated pest and nutrient management to reduce and optimize the use of agrochemical inputs in different crops (Anonymous, 2015, Heaton et al., 2013, Anonymous, 2013). System of crop intensification is one of those practices which improve the crop productivity and sustainability by proper management of natural resources. System of crop intensification principles can be applied in wide range of crops like System of Rice Intensification (SRI), System of Wheat Intensification (SWI), System of Sugarcane Intensification (SSI) and System of Mustard Intensification (SMI). Crop intensification provides better root growth by modification of management practices with their better functioning in soil. This makes the soil system better for living and also provides support against biotic and abiotic stress by making the crop healthier (Adhikari et al., 2018). It was found that presence of extensive root system, the interactions between plants and the soil microorganisms was comparatively higher with respect to water and nutrient uptake (Anas et al., 2011, Barison and Uphoff, 2011, Rupela et al., 2006, Thakur et al, 2013). System of Mustard Intensification was a new initiative for increasing mustard yield by some modification of soil, plant, moisture and nutrient management pattern. System of mustard intensification has been successfully done in Bihar and Gujrat Verma, 2013).

Row spacing is one of the very important practices for mustard production (Mondal et al., 1999). Chaudhary et al. (2016) from Pantnagar, reported that transplanting of *Brassica carinata* at 60×60 cm^2 spacing improved its yield potential through root intensification in *tarai* region of Uttarakhand. SMI is the system of transplanting mustard of 8–10 days old seedling at wide spacing provides advantage of proper plant density and allows sufficient aeration, moisture, sunlight and nutrient availability leading to proper root system development from the early stage of crop growth. Spacing between rows of plants is another factor that affects the growth and yield of the crop. Improved varieties of mustard are capable of higher yields when grown under optimum row spacing and good method of planting. The seed yield and maturity of mustard plants are greatly influenced by environmental conditions regardless of proper row spacing. The improper row spacing of mustard decreased seed yield through synchronization of silique filling period with high temperatures, the decrease in assimilates production, drought stress occurrence, shortened silique filling period and acceleration of plant maturity (Mendham et al., 1981). Satapathy (2007) reported that with specific management practices, under system of mustard intensification local mustard varieties of Odisha yielded better than the conventional practice. However, the System of Mustard Intensification along with row spacing information is still lacking. Therefore, the present study was undertaken to find out the suitable row to row spacing for mustard yield enhancement under SMI technology.

2. MATERIALS AND METHODS

2.1. Experimental area

The experiment was conducted in Rabi seasons (November–February) of year 2018 and 2019 at Instructional farm, RRS (OAZ), UBKV, Majhian, Dakshin Dinajpur, W.B, India lying at 26°19'86"N latitude and 89°23'53"E longitude with an average altitude of 43 m above the mean sea level. It comes under Gangetic old alluvial plain of sandy loam soil with acidic in nature. The experimental site is situated under sub-tropical humid region with an average temperature range of 25–37°C during summer to 12–25°C during winter months. Average annual rainfall is about 1535 mm.

2.2. System of Mustard Intensification (SMI) Methodology

2.2.1. Production of seedling in nursery under micropots

For SMI study many micropots (2×2.5 cm^2 size) were purchased from local market. All the micropots were filled up with 1:1 combination of compost and soil. Each variety of mustard was shown by placing of one seed in each micropot in the month of middle October and allows them for seedling growth under natural environment. After 15 days of age at three leaf stage all the seedling under micropots were considered for transplanting in the main field.

2.2.2. Transplanting and yield parameter observation

Nursery raising requires about 200 g seed which may produce about 70,000 seedlings that enough for one hectare. Before transplanting, the main field was ploughed properly and used recommended dose of NPK fertilizers (60:40:40 kg ha^{-1}) and two tonnes of FYM ha^{-1}. Transplanting was done by planting of one seedling from the micropots in field by maintaining planting distance. Irrigation, weeding and all the plant protection measures undertaken whenever required. The soil type of the research plot was sandy loam and pH was 5.52. During entire growth period different yield attributing traits were monitored such as plant height, number of secondary branches, number of siliqua plant^{-1}, number of seeds siliqua^{-1} and seed yield kg ha^{-1}. The leaf chlorophyll content also estimated as per protocol described by Davies (1976).

2.3. Treatment combination

The treatments consisted of three levels of intra spacing (25×25, 45×45, and 60×60 cm^2) among the three different variety of Toria (cv. Agrani), Yellow sarson/ rapeseed (cv. Vinay) and Indian Mustard (cv. Bhagirathi) with plot size of 4×5 m^2. The 9-treatment combination spacing and variety under SMI techniqueswere arranged in following pattern (Table 1).

Table 1: Treatment combination of variety and plant spacing of mustard

Sl. No.	Treatment (Spacing and Variety)	Treatment combination
1.	S_1V_1	25×25 cm^2+Toria (Agrani)
2.	S_1V_2	25×25 cm^2+Rapeseed (Vinay)
3.	S_1V_3	25×25 cm^2+Indian Mustard (Bhagirathi)
4.	S_2V_1	45×45 cm^2+Toria (Agrani)
5.	S_2V_2	45×45 cm^2+Rapeseed (Vinay)
6.	S_2V_3	45×45 cm^2+Indian mustard (Bhagirathi)
7.	S_3V_1	60×60 cm^2+Toria (Agrani)
8.	S_3V_2	60×60 cm^2+Rapeseed (Vinay)
9.	S_3V_3	60×60 cm^2+Indian mustard (Bhagirathi)

2.4. Statistical design and analysis

The experiment was laid out as a randomized complete block design with three replications of each treatment. The statistical analysis of experimental data utilized the ANOVA program was done on SPSS 20.0 software.

3. RESULTS AND DISCUSSION

3.1. Effect of different spacing of SMI

Analysis of variance showed significant difference of yield traits except number of seeds siliqua^{-1} among the treatments (different spacing and variety) studied under SMI practices. The interaction of plant spacing and varieties significantly influenced the plant height. Among the treatment combination maximum plant height was recorded in cv. Baghirathi with spacing of 60×60 cm^2 ie. S_3V_3 (165.32 cm) followed by S_2V_3 161.25 and S_1V_3 (160.54) while minimum height in cv. Agraniwith 25×25 cm^2 S_1V_2 (92.25 cm). On the other hand, S_3V_3 produces maximum yield parameter such as number of primary (9.00), secondary branches (10.82), number of siliqua plant^{-1} (297.45) and number of seeds siliqua^{-1} (13.20), while crop spacing maintain with 25×25 cm significantly reduces these parameters among the varieties (Table 2). The number of seeds siliqua^{-1} found no signification difference among the treatments. The test weight was maximum in S_2V_2 (3.49 g). The total chlorophyll content was recorded maximum in S_1V_3 (18.99 mg 100 g^{-1}) followed by S_3V_3 (17.61 mg 100 g^{-1}) and S_2V_3 (17.45 mg 100 g^{-1}) whereas, minimum in S_2V_2 (14.03 mg 100 g^{-1}) and S_1V_2(14.31 mg 100 g^{-1}). The interaction of plant spacing and varieties significantly influenced the yield. Establishment of an optimum spacing is one of the important factors for securing good yield of mustard. Maximum seed yield in SMI techniques among the varieties was recorded when plant spacing maintain by 60×60 cm^2 (Table 2). Satapathy (2007) reported that with specific management practices along with proper spacing under system of mustard intensification local mustard varieties of Odisha yielded better than the conventional practice.

Among the treatments studied highest seed yield was recorded in S_3V_3 (1348.08 kg ha^{-1}) followed byS_1V_3 (1331.42 kg ha^{-1}) S_2V_3 (1320.67 kg ha^{-1}) while lowest yield obtained from S_3V_1 (935.05kg ha^{-1}). The maximum seed yield under SMI with spacing of row at 60 cm could be due to significantly higher number of branches plant^{-1}, secondary branches, number of siliqua plant^{-1} and number of seeds siliqua^{-1}. This result was in agreement with Singh et al. (2008) and Nautiyal et al. (2020). Maximum yield under wide spacing could be attributed to better growth of plants and maximum planting density and enhanced crop growth rate which might have resulted in efficient metabolism and also provide optimal growing conditions to individual mustard plants so that siliqua is maximized (Sondhiya et al., 2019). The yield enhancement effect of wider spacings between plants has also been reported Mevada et al. (2017) and Chhonkar et al. (2011). Gupta et al. (2018) reported that SMI techniques with sufficient irrigation facility improve oxygen supply to roots, thereby decreasing aerenchyma formation and causing a stronger, healthier root system with potential advantages for nutrient uptake. Previously a detail study on SMI in Bihar state found higher seed yield under transplanting system of mustard (ATMA, 2013). Additionally, the optimum plant spacing ensures proper growth of both aerial and underground parts of the plant through efficient utilization of solar radiation, nutrients and land as well as air spaces and water. The improper row spacing of mustard decreased seed yield through synchronization of silique filling period with high

Table 2: Effect of System of Mustard Intensification (SMI) on three different variety and spacing combination for yield attributing traits

Treatments	Plant height	No. of primary branches	No. of secondary branches	No. of siliqua plant^{-1}	No. of seeds siliqua^{-1}	Test weight (g)	Total Chlorophyll (mg 100 g^{-1})	Seed yield kg ha^{-1}
S_1V_1	126.92	4.02	8.05	124.46	12	3.18	15.37	941.04
S_1V_2	92.25	4.9	6.1	107.16	12.05	3.45	14.31	1232
S_1V_3	160.54	7.37	9.67	270.85	12.78	2.57	18.99	1331.42
S_2V_1	125.39	4.57	8.5	129.41	12.12	3.23	15.49	935.05
S_2V_2	93.83	5.31	5.64	109.75	13	3.49	14.03	1215
S_2V_3	161.25	8.53	10.04	291	12.04	2.72	17.45	1320.67
S_3V_1	135.28	5.19	9.05	133.42	12.01	3.38	16.31	952.08
S_3V_2	111.98	6.77	6.35	117.15	13.05	3.48	14.49	1248.09
S_3V_3	165.32	9	10.82	297.45	13.2	2.86	17.61	1348.08
CD (p=0.05)	3.026	1.09	0.98	2.049	NA	0.47	1.058	4.403
SEm±	1.001	0.361	0.324	0.678	0.233	0.049	0.35	1.456

temperatures and decrease in assimilates production, (Alam et al., 2015).

3.2. Correlation and multiple regression analysis of yield and its attributing traits under SMI

The correlation coefficient analysis of mustard varieties with different planting density under SMI resulted the traits particularly number of secondary branches (r=0.841), number of siliqua plant^{-1} (r=0.931) and total chlorophyll content (r=0.863) were significant and positive associated with seed yield among the varieties (Table 3).

Table 3: Estimation of correlation coefficient for yield attributing traits of System of Mustard Intensification (SMI)

Parameter	PH	NSB	NSP	NSS	TC	TY
NSB	0.970**					
NSP	0.904**	0.843**				
NSS	0.258	0.195	0.418			
TC	0.944**	0.900**	0.894**	0.215		
TY	0.282	0.841**	0.931**	0.594	0.863**	

*: significant at the (p=0.05) level and **: is significant at the (p=0.01) level

On the other hand plant height also found significantly and positively correlated with number of secondary branches (r=0.970), number of siliqua plant^{-1}(r=0.904) and total chlorophyll content (r=0.944) but no significant relation observed with seed yield, this may due to plant height as an important yield traits but because of similar method of practices derived non-significant response to yield. In order to know the predictive abilities under SMI techniques, the multiple regression analysis was carried out by taking seed yield kg ha^{-1} (Y) as dependent variable and yield attributing traits (X) as the independent variable. During the year 2018-19 of SMI studied, the coefficient of multiple determinants (R^2) was 0.950 indicating 95.00% of the variation in yield improvement explained by the set of a variable in the study (Table 4).

Table 4: Multiple regression of SMI

Model	R^2	Adjusted R^2	F value	MSE
Y= 123.47(PH) +7.37 (NSB) +320.35 (NSP) -9.66 (NSS) -99.61 (TC) -28.75 (SY)	0.950**	0.866**	11.33	172.43

*p=0.05; **p=0.01

The best fit of one model over the other has beenattained by comparison of the regression parameter Yintercept (Fried et al., 1979); R^2 (Berger, 1981,Waggoner, 1986).

4. CONCLUSION

Based on intra-raw spacing study under SMI system among the three different varieties we found wide spacing 60×60 cm^2 best for mustard yield. Among the three variety cv. Bhagirathi produces maximum yield and other traits response under wide spacing of System of Mustard Intensification. The character association under this study also revealed positive association of seed yield with number of secondary branches, number of siliqua plant^{-1} and total chlorophyll content.

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7. REFERENCES

Adhikari, P., Araya,H., Aruna, G., Balamatti, A., Banerjee, S., Baskaran, P., Barah, B.C., Behera, D., Berhe, T., Boruah, P., Dhar, S., Edwards, S., Fulford, M., Gujja, B., Ibrahim, H., Kabir, H., Kassam, A., Ram Khadka, B., Koma, Y.S., Natarajan, U.S., Perez, R., Sen, D., Sharif, A., Singh, G., Styger, E., Thakur, A.K., Tiwari, A., Uphoff, N., Verma, A., 2018. System of crop intensification for more productive, resource-conserving, climate-resilient, and sustainable agriculture: experience with diverse crops in varying agroecologies, International Journal of Agricultural Sustainability 16(1), 1–28.

Alam, M.J., Ahmed, K.S., Molla, M.R.A., Tareq, M.Z., Chowdhury, M.M.I., 2015. Effect of spacing on mustard yield at Shibganj and Sadar upazila of bogra district. Journal of Environmental Science and Natural Resources 28, 133–136.

Anas, I., Rupela, O.P., Thiyagarajan, T.M., Uphoff, N., 2011. A review of studies on SRI effects on beneficial organisms in rice soil rhizospheres. Paddy and Water Environment 9(1), 53–64.

Anonymous, 2013. Status report on "*Sri vidhi se sarson – gehu ki khetimenavchar*" (In Hindi). Agriculture Extension Improvement Programme, ATMA, Umaria, Madhya Pradesh, 36.

Anonymous, 2015. Sustainable intensification opportunities with current and future cereal systems of North-West India. Mexico: cereal systems initiative for South Asia. Technical bulletin (Central Soil Salinity Research Institute (Karnal, India), CIMMYT.

Anonymous, 2019. Rajasthan Agricultural Statistics at a Glance. Commissionerate of Agriculture, Jaipur, Rajasthan, 88.

Barison, J., Uphoff, N., 2011. Rice yield and its relation to root growth and nutrient-use efficiency under SRI and conventional cultivation: An evaluation in Madagascar. Paddy and Water Environment 9(1), 65–78.

Berger, R.D., 1981. Comparison of gompertz and logistic equations to describe disease progress. Phytopatholgy 71, 716–719.

Chaudhary, S., Shukla, A., Chandra, B., Negi, M.S., 2016. Assessment of the system of root intensification in rapeseed-mustard (*Brassica* species). Indian Journal of Agronomy 61(1), 119–122.

Chhonkar, D.S., Shroti, S.K., Sharma, B., 2011. Response of cotton varieties to dates of sowing and planting density under semi-arid condition. Annals of Plant and Soil Research 13(1), 62–64.

Davies, B.H., 1976. Carotenoids. In: Goodwing, T.W. (Ed.). Chemistry and Biochemistry of Plant Pigments (2nd Edn.). Academic Press, London, UK, 38–165.

Fried, P.M., Mackenzie, D.R., Nelson, R.R., 1979. Disease progress curves of *Erysiphe graminis*f.sp. *tritici*on chancellor wheat and four multilines. Phytopathology 95, 151–166.

Gupta, G., Dhar, S., Kumar, A., Kambo, N.K., Kumar, V., 2018 System of crop intensification integrated management of crops for improving sustainability and resilience to climate change. Indian Farming 68(4), 14–17.

Heaton, E.A., Schulte, L.A., Berti, M., Langerveld, H., Zagada-Lizavazu, W., Parrish, D., Monti, A., 2013. Managing a second-generation crop portfolio through sustainable intensification: Examples from the USA and the EU. Biofuels, Bioproducts and Biorefining 7(6), 702–714.

Mendham, N.J., Salisbury, P.A., 1995. Physiology: Crop development, growth and yield. In: Kimber, D., McGregor, D.I. (Eds. *Brassica* Oillseeds: Production and Utilization.CAB International, 11–64.

Mevada, K.D., Parmar, B.G., Patel, H.K., Patel, P.D., 2017. Response of linseed to different sowing dates and seed rates under middle Gujarat conditions. Crop Research 52(4&5), 150–154.

Mondal, R.I., Biswas, M., Hydar-Ali, M.K., Akbar, M.A., 1999. Response of rapeseed genotype Dhali to seed rate and seeding date. Bangladesh Journal of Agricultural Research 24(1), 83–90.

Nautiyal, A., Barthwal, A., Saxena A.K., 2020. Growth and yield attributes of mustard (Brassica juncea (L.), Var. pant Brassicca-21 scheduled on irrigation level and row spacing. Journal of Pharmacognosy and Phytochemistry 9(2), 300-303.

Rathour, S., Kumari, M., Swami, S., 2021. Constraints analysis of rapeseed and mustard cultivation in Begusarai district of Bihar. The Pharma Innovation Journal 10(11), 3006–3008.

Rupela, O.P., Gowda, C.L.L., Wani, S.P., Bee, H., 2006. Evaluation of crop production systems based on locally available biological inputs. In: Uphoff, N. (Ed.). Biological Approaches to Sustainable Soil Systems. CRC Press, Boca Raton, FL, 501–515.

Satapathy, P.C., 2007. The system of mustard intensification. SRI-Cornell University. Available at http:// sri.ciifad. cornell.edu. Accessed on 20 April, 2015.

Singh, T., Minhas, K.S., Brar, R.S., 2008. Effect of sowing dates and plant geometry on seed yield of canola

(*Brassica napus* var *Canola*). Research on Crops 9(1), 36–38.
Sondhiya, R., Pandey, R., Namdeo, K.N., 2019. Effect of plant spacings on growth, yield and quality of mustard (*Brassica juncea* L.) genotypes. Annals of Plant and Soil Research 21(2), 172–176.
Thakur, A.K., Rath, S., Mandal, K.G., 2013. Differential responses of system of rice intensification (SRI) and conventional flooded-rice management methods to applications of nitrogen fertilizer. Plant and Soil 370(1–2), 59–71.
Verma, A.K., 2013. SRI in Bihar: From one to 350,000. Farming Matters 29(1), 44–46.
Waggoner, P.E., 1986. Progress curves of foliar diseases: Their interpretation and use. In: Leonard, K.J., Fry, E.W. (Eds.), Plant Disease Epidemiology: Population Dynamics and Management (Volume I). MacMillan Publishing Co., New York, 3–37.