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Growth and biomass production of mustard as Influence by cropping system and nutrient management practices under mustard-based cropping systems

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Abstract
A field experiment was conducted during 2016-17 and 2017-18 at the Research Farm, M G C G V, Chitrakoot Satna (M.P.) to study the evaluation of INM under mustard-based cropping system. Greengram-mustard recorded maximum growth, yield and yield parameters as compared to maize-mustard and sesame-mustard cropping systems. The mustard yield was 12.31 q ha^{-1} higher by 3.43 and 2.0 q ha^{-1} when grown after maize and sesame, respectively. Application of 200% N through FYM ha^{-1} (B_1) and 150% NPK + 5 t FYM ha^{-1} (B_4) resulted in equal seed yield 11.22 to 11.42 q ha^{-1}, respectively and seed oil (39.95 to 39.98%). But net income from mustard was highest (₹40539 ha^{-1}) under B_4 treatment. The total profit was maximum under maize-mustard cropping system (₹84444 ha^{-1} with 4.51 B:C ratio). The second best was greengram-mustard. The total fertilization under B_4 gave highest net income (₹82058 ha^{-1} with 4.50 B:C ratio). The second best fertilization was B_1 (₹ 80195 ha^{-1} with 4.22 B:C ratio). Thus, the greengram-mustard applied with 150% NPK + 5 t FYM ha^{-1} proved the most profitable.

Keywords: Integrated nutrient management, mustard, Biomass Productivity

Introduction
Indian mustard (*Brassica juncea* L.) is an important *Rabi* oilseed crop extensively grown as rainfed crop in India. Mustard oil meets the one third of edible oil requirement of the country, to meet these needs the country highly depends on imports of vegetable oil. Import of vegetable oils during July 2019 is up by 26% to 14.12 lakh tones as compared to 11.19 lakh tones in July 2018, according to data compiled by the Solvent Extractors' Association of India (SEA). There is a need to decrease the Import of vegetable oils by expanding the area under oil seed crops. It is important to increase the yields of mustard crop by improving the available germplasm lines, for that we need to know various yield contributing characters and the relationship among them and with the seed yield. In this experiment, we studied correlation or mutual association among different yield contributing characters and the direct and indirect effects also estimated through path coefficient analysis. The inter-relationship between the yield components will be helpful to a breeder to assess the nature, extent and direction of selection pressure on characters.

Material and Methods
Experiment was conducted at Regional Agriculture Research Station, Polasa, Jagtial during *rabi*, 2020-21. The research plot was laid out in Randomized Block Design (RBD) with two replications and fifty genotypes of Indian mustard including two local checks *i.e.*, NRCHB-101 and Black gold. Each genotype was sown in two rows of three meters length, with inter-row spacing of 45 cm and intra row spacing of 10 cm. Sowing was done by dibbling the seed at 2-3 cm depth. All the standard package of practices were followed during crop growth period. The observations were recorded for twelve yield contributing characters *viz*., days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of siliquae per plant, number of seed per siliqua, siliqua length (cm), 1000 seed weight (g), seed yield per plant (g), harvest index (%) and oil content (%). Data was recorded for five randomly selected plants of each genotype in both the replications. The data was subjected to analysis of variance, phenotypic and genotypic coefficients of variations and other genetic parameters like heritability and genetic advance.

Indian mustard (*Brassica juncea* L.) is the second most important oilseed crop after groundnut sharing 27.8% in India's oilseed economy. However the cultivation of maize/sesame/greengram mustard system is very popular in Kymore Plateau region of madhya Pradesh under rainfed condition. The introduction of *kharif* was found most beneficial than mustard alone succeeding after fallow. Mustard based crop sequences play a significant role in total crop productivity and profitability. Considering the stagnation in productivity, profitability and sustainability of the existing cropping system in the Kymore Plateau, crop diversification through maize, sesame and greengram may be explored. The continuous use of chemical fertilizers is known to degrade physico-chemical properties of soil. On the other hand, the use of organics improves soil properties, its health and fertilizers use efficiency, mitigates short supply of micronutrients, stimulates the proliferation of diverse group of soil micro-organisms and improves the ecological balance of rhizosphere (Sharma *et al.*, 2007) [6]. Judicious management of these organic manures within a crop rotation can have large effects on yields and crop quality (Jat *et al.*, 2018) [2]. Keeping in the above facts and view, the present research was undertaken to find out the suitable cropping system and appropriate dose of organic and inorganic fertilization for mustard based cropping system.

Materials and Methods

The field experiment was conducted during 2016-17 and 2017-18 at the Agriculture Farm, Mahatma Gandhi Chitrakoot Gramoday Vishwa Vidhyalay, Chitrakoot Satna (M.P.). The soil of the experimental field was silty clay-loam having pH 7.5-7.6, electrical conductivity 0.26-0.29 dSm^{-1}, available N 176.6-186.8 kg ha^{-1}, available P 12.5-13.0 kg ha^{-1}, available K 216.6-226.8 kg ha^{-1} and available S 7.75-8.70 mg ha^{-1}. The total rainfall received during 2015-16 and 2016-17 was 744.8 and 844.7 mm, respectively. The treatments comprised three cropping systems (maize-mustard, sesame-mustard and greengram-mustard) and five balance fertilizer treatments (100% N by FYM, 100% NPK, 100% NPK + S, 75% NPK + 5 t FYM and 50% NPK + 5 t FYM/ha in *kharif* season and 100% NPK by FYM, 0, 50, 75 and 100% NPK in *rabi* season). The experiment was laid out in RBD (factorial) with three replications. Mustard cv. Pusa Mahak was sown on 04/11/16 and 28/11/17 at a spacing of 45cm.X15cm during two years. The recommended dose of NPK of mustard was estimated @ 120:60:40 kg/ha as per treatment. All the crops were grown as per recommended package of practices. The *rabi* (mustard) crop was harvested on 10/03/17 and in two respective years. The observation related to growth parameters and biomass productivity of mustard were measured as per standard procedure. Biomass productivity was expressed in term of biological yield.

Results and Discussion

Growth parameters

The growth parameter *viz* plant height, branches/plant and dry matter weight/plant were recorded significantly higher under greengram-mustard cropping system as compared to maize-mustard or sesame-mustard. The improvement in growth parameters might be owing to preceding crop greengram giving multifarious advantages to enrich the soil associated with physico-chemical and biological properties. The findings are in accordance with those of Kumpawat *et al.* (2010), Kumar *et al.*(2012) and Jat *et al.* (2018) [2].

Application of 100% N equivalent through FYM in kharif and 100% N equivalent through in mustard (B1) followed by B4 (75% NPK + FYM 5t. in kharif and 75% NPK in mustard) and B5 (50% NPK+ FYM 5t. in kharif and 100% NPK in mustard) recorded significantly greater growth parameters *viz* plant height at harvest, dry weight/plant and branches/plant.

On the other hand, application of 100% NPK in kharif and no any addition of NPK in mustard produced lowest growth parameters (117.20 cm plant height, 21.87 branches $plant^{-1}$ and 26.0 g dry weight /plant. The increased supply of nitrogen in B_1, B_4 and B_5 fertility treatments encouraged the plant foliage and boosted plant growth because it is an integral part of the chlorophyll, proteins, enzymes and structural materials. Due to higher N supply, the more rapidly synthesized carbohydrates are converted to proteins and protoplasm thereby increasing the size of cells. Similar results had also been reported by Meena *et al.*, (2013); Sharma *et al.*, (2017) [6] and Kumar and Singh, (2019).

Table 1: Growth and yield-attributing parameters of mustard as influenced by cropping systems and balance fertilization (Pooled for 2 years)

	Treatments		Plant height (cm) at harvest	Dry weight/ $plant^{-1}$ (g)	Branches $plant^{-1}$
	Cropping systems				
C_1	Maize-Mustard		120.24	28.00	25.56
C_2	Sesame-Mustard		128.02	32.46	28.04
C_3	Greengram-Mustard		132.32	35.98	32.90
	S.Em+		0.030	0.048	0.020
	C.D. (5%)		0.085	0.134	0.055
	Balance Fertilization				
	Kharif	**Rabi**			
B_1	100% N by FYM/ha	100% N by FYM/ha	134.97	39.86	34.52
B_2	100% NPK (120:60:30)	0% NPK (120:60:30)	117.20	26.00	21.87
B_3	100%NPK+ S_{20}	50% NPK	122.95	28.37	28.33
B_4	75%NPK + 5t FYM/ha	75%NPK	131.25	35.16	31.09
B_5	50% NPK + 5t FYM/ha	100% NPK	127.94	31.37	28.37
	S.Em+		0.039	0.061	0.025
	C.D. (5%)		0.110	0.173	0.071

Table 2: Yield and biomass productivity of mustard as influenced by cropping systems and balance fertilization during 2016-17 and 2017-18

Treatments			Seed yield (q/ha)			Straw yield (q/ha)			Total biomass (q/ha)		
			2016-17	2017-18	Mean	2016-17	2017-18	Mean	2016-17	2017-18	Mean
	Cropping systems										
C_1	Maize-Mustard		8.46	9.30	8.88	31.08	34.46	32.77	39.54	43.76	41.65
C_2	Sesame-Mustard		9.80	10.80	10.30	34.55	37.79	36.17	44.35	48.59	46.47
C_3	Greengram-Mustard		11.78	12.83	12.31	39.18	42.66	40.92	50.96	55.49	53.23
	S.Em+		0.134	0.035	0.085	0.067	0.133	0.100	0.201	0.168	0.21
	C.D. (5%)		0.380	0.100	0.240	0.190	0.377	0.284	0.57	0.477	0.60
	Balance fertilization										
	Kharif	**Rabi**									
B_1	100% N by FYM/ha	100% N by FYM/ha	10.92	11.91	11.42	37.81	41.28	39.55	48.73	53.19	50.96
B_2	100% NPK (120:60:30)	0% NPK (120:60:30)	8.56	9.53	9.05	30.93	34.45	32.69	39.49	43.98	41.735
B_3	100% NPK+ S_{20}	50% NPK	9.85	10.64	10.25	35.14	36.75	35.95	44.99	47.39	46.19
B_4	75% NPK + 5t FYM/ha	75%NPK	10.71	11.73	11.22	36.05	40.72	38.39	46.76	52.45	49.605
B_5	50% NPK + 5t FYM/ha	100% NPK	10.04	11.06	10.55	34.76	38.32	36.54	44.8	49.38	47.09
	S.Em+		0.173	0.045	0.109	0.087	0.172	0.130	0.26	0.22	0.24
	C D (P=0.05)		0.490	0.128	0.309	0.245	0.487	0.366	0.74	0.62	0.68
	Interactions		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.

Yield of mustard

The greengram-mustard recorded significantly higher seed yield (12.31 q/ha) and straw yield (40.92 q ha^{-1}) as compared to sesame-mustard and maize-mustard cropping system. The significantly lowest seed yield (8.88 q ha^{-1}) and stover yield (32.77 q ha^{-1}) were obtained from maize-mustard cropping system. This could be described due to grater growth parameters of mustard which enhanced the formation of more reproductive primodia and produce high seed and straw yield. These results are in close conformity with the observations made by Kumpawat *et al.* (2010), Devi *et al.* (2014) and Jat *et al.* (2018) [2].

The treatment having 200% N through FYM (100% N through FYM in Kharif and 100% N through FYM in mustard) resulted in the maximum seed yield (11.42 q ha^{-1}) and straw yield (39.55 q ha^{-1}). This was followed by the treatments having equal 150% NPK + 5 t FYM ha^{-1} B_4 (75% NPK+5t. FYM/ha in Kharif +75% NPK in Rabi) and B_5 (50% NPK+ FYM 5t./ha in Kharif +100% NPK in Rabi). The lowest seed and straw yield (9.05 and 32.69 q ha^{-1}, respectively) was recorded from the minimum fertilization having 100% NPK only in kharif and no NPK in mustard (B_2). The higher productivity in treatments, B_1, B_4 and B_5 was on account of increased growth parameters in these treatments. The result are in the line of Rundala *et al.*, (2013); Jat *et al.*, (2018) [2] and Kumar and Singh., (2019).

Biomass productivity

Biomass productivity in term of biological yield was noted significantly higher under greengram – mustard over maize – mustard and sesame – mustard system. This was because of superior grain and stover yield of mustard. Application of 100% N equivalent through FYM in kharif and 100% N equivalent through FYM in mustard (200% N equivalent through FYM) produced significantly greater biological yield over rest of the treatment. The treatment B4 (75% NPK+FYM 5t./ha in kharif and 75% NPK in mustard) and B5 (50% NPK+ FYM 5t./ha in kharif and 100% NPK in mustard) gave 50.96 and 49.60 kg/ha biological yield in intermediate order. This might be because of more residual effect of FYM applied in kharif to the rabi mustard.

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