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Growth and Yield of a Chickpea (*Cicer arietinum*) and Mustard (*Brassica juncea*) as Influenced by Row Ratio and Liquid Manures

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Authors' contributions

This work was carried out in collaboration among all authors. Author DT designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author VS managed the analyses of the study. Author AKV managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during 2018 and 2019 at the crop research farm, Department of Agronomy, Shuats, Prayagraj (Uttar Pradesh) to study the effect of intercrop row ratio and liquid manures on chickpea and mustard intercropping system. The treatments consisted of five intercropping systems viz. Sole chickpea, sole mustard, chickpea + mustard (1:1), chickpea + mustard (2:1), chickpea + mustard (3:1) row ratios in replacement series and four liquid organic manures viz. control (no spray), panchagavya 3%, cow urine 10% and vermiwash 10% were tested in split plot design with planting ratio as the main plots and liquid manures as the sub plot with 3 replications**.** Results revealed that maximum growth attributes in both crop were recorded under chickpea + mustard (3:1). However maximum, yield attributes and yield were recorded under sole stand of both crop. Among liquid manures maximum growth, yield attributes and yield were recorded under foliar application of panchagavya 3% at branching and flowering stage in both crop and vermiwash10% found at par.

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1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) and rapeseed (*Brassica juncea* L.) are grown in sole as well as in mixed stands because of their diverse morphology, growth rhythm and similar climatic requirements. Chickpea area in the country has risen from 7.57 million 'ha' in 1950-51 to 9.44 million hectare in 2018-2019. Chickpea production increased from 3.65 million tonnes to 10.13 'mil' tonnes during same 2018-2019, while the production of chickpea crop in Uttar Pradesh was 0.73 'mil' tonnes from 0.57 million hectare (Ministry of Agriculture, 2019). and mustard area of the country has risen from 2.07 'mil' 'ha' in 1950-51 to 6.23 'mil' 'ha' in 2018-2019.Mustard production increased from 0.76 'mil' tonnes to 9.34 'mil' tonnes during same 2018-2019, while the production of mustard crop in Uttar Pradesh was 0.75 million tonnes from 1.12 'mil' 'ha' [1].

Intercropping is an effective approach for boosting the production and quality productivity of crop agricultural practices are cultivating of two or more economic dissimilar crop species in distinct row combinations simultaneously on the same piece of land.Conceptually, intercropping system helps for risk avoidance from epidemic of insect-pest and disease, and overcome the effect of adverse environmental conditions in agro-climatologically unstable regions along with better utilization of solar radiation and inputs like fertilizer and water compared to crops in sole system. It is a practice that increases diversity in the cropping system [2].

Foliar application is credited with the advantage of quick and efficient utilization of nutrients, elimination of losses through leaching and fixation and regulating the uptake of nutrients by plant [3] and Chaudhary et al. [4]. Further liquid manures meet the nutrient requirement of crops during standing condition with greater nutrient use efficiency [5]. If the recommended row ratio of chickpea with oilseeds like rapeseed-mustard for a specific area is adopted then farmers could utilize applied and available resources more efficiently and effectively. Keeping these in view, an experiment was undertaken to improve the productivity and profitability of chickpea and mustard intercropping system with optimum row ratio and liquid manures.

2. MATERIALS AND METHODS

A Field experiment was conducted during rabi season of 2018 and 2019 at Crop Research farm of Department of Agronomy, Sam Higginbottom University of Agriculture Technology and Sciences Prayagraj, Uttar Pradesh, India. The soil of the experimental field was sandy loam in texture, low in organic carbon (0.45 and 0.44) and nitrogen (118 and 120 kg/ha), medium in phosphorus (26.5 and 28 kg/ha) and high in potassium (312 and 316 kg/ha) during 2018 and 2019 respectively. The mean maximum and minimum temperatures during the *rabi* season of 2018-2019 were 41.63^0 C and 6.0^0 C and during the *rabi* 2019-2020 were 35.31^0 C and 9.26^0C (Table 3.3.1 and 3.3.2). The relative humidity ranged from from 95.14% and 30.43% in 2018-2019 and 94.00% to 45.29% and total rainfall 5.83 mm and 4.10 mm were received during study period of 2018-2019 and 2019-2020, respectively. The treatments consisted of five intercropping systems viz. Sole chickpea, sole mustard, chickpea + mustard (1:1), chickpea + mustard (2:1), chickpea + mustard (3:1) row ratios in replacement series and four liquid organic manures viz. control (no spray), panchagavya @ 3%, cow urine @ 10% and vermiwash @ 10% were tested in split plot design with planting ratio as the main plots and liquid manures as the sub plot with 3 replications**.**. The fertilizers in sole stands of both crops and in intercropping system were applied at the rate of 20 kg N/ ha^{-1}, 40 kg. 20 kg ha^{-1} and 80 kg N/ ha^{-1}, 40 Kg/ ha^{-1} and 40 ha^{-1} in chickpea and mustard crops respectively. The sources of fertilizer were urea (46% N), single super phosphate (16% P) and murate of potash (60% K). The crops of chickpea and mustard were sown in the 05 Nov, 2018 and 05 Nov 2019 during first and second year respectively. Crop was raised under irrigated condition and a total two irrigations were applied at critical growth stages. The foliar spray of panchagavya 3%, vermiwash 10%, cow urine 10 % and water spray (control) were sprayed at two times, one at branching stage and another at flowering stage as per the treatment combination. Crop protection measure were followed as when required. Harvesting of mustard was done on 02 March 2019 and 05 march 2020. while chickpea was harvested on 05 April 2019 and 08 April 2020 in two year study. The data collected on growth parameters, yield components and yields were analysed following the method of analysis

for split plot design as described by Gomez and Gomez. The significance of different sources of variation was tested at probability level of 0.05.The standard error of mean (SE) and the value of Critical difference were indicated in the tables to compare the difference between the mean values. Statistical analysis of data was analysed on excel.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes of Chickpea (Main Crop)

3.1.1 Intercropping system

Results (Table 1.) indicate sole chickpea recorded lower plant height, number of nodules per plant and dry weight per plant at all experiment year except in case of plant height during second year. Non-significant difference was noticed among all the intercropping system treatments. Maximum plant height (72.65, 73.14 and 72.90 cm), number of nodules (11.74, 10.91and10.39 per plant) and dry weight per plant (27.66, 28.05 and 27.86 g per plant) was observed in first, second year and in pooled data in the treatment of intercropping combination chickpea + mustard (3:1) row ratio during first, second and pooled data respectively. However, lowest plant height (71.31, 71.20 and 71.33 cm), number of nodules (9.44, 8.84 and 9.44 per plant) and dry weight (26.36, 26.76 and 26.56 g per plant) was observed in sole crop of chickpea in first year, second year as well as in pooled data except in case of plant height chickpea + mustard (1:1) recorded lowest plant height (cm) during second year of experiment.

3.1.2 Liquid manures

The results of experiment indicated significant influence on growth attributes viz. plant height and dry weight by recommended dose of fertilizer and liquid manures Table 1. Foliar application of panchagavya 3% recorded significantly higher plant height (81.55, 81.96 and 81.75 cm), number of nodules (13.91, 13.91 and 13.91 per plant) and dry weight (30.60, 30.80 and 30.70 g per plant) of chickpea which was at par with foliar application of vermiwash 10% during first, second year as well as in pooled data respectively. Increase plant height may be due to increased protein synthesis and growth regulators such as IAA, and GA3, in panchagavya may enhance cell division, cell multiplication and cell enlargement which favoures increased internodal length. The lower plant height was observed in control may be due to inadequate nutrient supply during the crop growth stages. Confirmity of results also by Gunasekar et al. [6].

The increase in number of nodules per plant and dry weight of nodules per plant might be due to the better availability of nutrients. The IAA and GA present in panchgavaya when applied as foliar spray could have created stimuli in the plant system and increased the production of growth regulators in cell system and the action of growth regulators in plant system ultimately stimulated the necessary growth and development. These findings are accordance with Panchal et al. [7].

Panchgavya contains N, P, K, S, Fe, Zn Gunasekar et al. [6]. Thus, balanced nutrition might have resulted in better development and robust growth panchagavya is also known to contain beneficial microorganism such as azospirilum azotobacter phosphobacteria and pseudomonas besides lactobacillus which promotes the plant growth parameter. Similar trends of results also reported by Chongre et al. [8].

3.2 Growth Attributes of Mustard (Component Crop)

3.2.1 Intercropping system

In respect of intercropping systems, mustard in sole stand recorded minimum plant height and dry weight Table 2. Plant height and plant dry weight of mustard was not influenced significantly among different intercropping system. Maximum plant height (172.33, 173.05 and 172.69 cm) and dry weight (34.30, 35.02 and 34.66 g per plant) of mustard was recorded under chickpea + mustard with 3:1 row ratio intercropping system. However minimum plant height (168.03, 168.75 and 168.39 cm) and dry weight (32.58. 33.15 and 32.86 g per plant) recorded under sole stand of mustard during all experimental year respectively.

3.2.2 Liquid manures

Table 2 revealed that foliar application of liquid manures significantly higher plant height and dry weight was recorded during all experimental year. Maximum plant height (179.56, 180.02 and 179.78 cm) and maximum dry weight (37.72, 37.96 and 37.84 g per plant) of mustard was

recorded through foliar application of panchagavya 3% which was at par with foliar application of vermiwash 10% during first, second year as well as in pooled data respectively. The panchagavya considered to be the most effective bio-enhancer, which might have enhance photosynthesis and portioning of photosynthates to various metabolic sink and resultant more growth and yield components. Results of present experiment also confirmed by Patel et al. [9].

3.2.3 Interaction effects of intercropping system and liquid manures

Interactive effects of the of chickpea and mustard both crop, non significant difference was noticed among intercropping system and liquid manures in growth attributes of both crop.

3.3 Yield Attributes and Yield of Chickpea (Main Crop)

3.3.1 Intercropping system

The data of chickpea for 2018, 2019 and pooled are presented in Table 3 clearly indicates that the yield attributes and yield of chickpea was higher in sole crop treatment than in the intercropping treatments. Yield attributes viz. seed index (g) was not influenced significantly among different intercropping system, maximum (24.04, 24.27 and 24.15) recorded under sole stand of chickpea. However minimum (22.85, 22.90 and 24.15) seed index was recorded in Chickpea + mustard (1:1) row ratio of intercropping system during all experimental year respectively. This might be due to more vigorus and luxuriant vegetative growth which is turn favoured a better partining of assimilates from source to sink. Similar results also reported by Bhargavi et al. [10].

In case of grain yield significantly higher (2062.08, 2161.33 and 2153.21 kg/ha) recorded under sole cropping of chickpea which was significantly superior over the rest of the treatments and none of treatments were found to be at par during all experimental year among all intercropping system.

3.3.2 Liquid manures

Analysed data Table 3 of chickpea showed that yield attributes and yield of chickpea were influenced significantly by application different liquid manures. Significantly higher (25.69, 25.78 and 25.74) seed index of chickpea was recorded through foliar application of panchagavya @ 3% which was at par with foliar application of vermiwash @ 10 % during all experimental year respectively.

Grain yield of chickpea were also influenced significantly through foliar application of liquid manures Table 3. Significantly higher (2034.73, 2054.73 and 2044.73 kg/ha) were recorded under foliar application of panchagavya @ 3% which was at par with foliar application of vermiwash @ 10% at all experimental year. The positive impact of availability of individual plant nutrients and different growth hormones from organic manures and balance supplement of major nutrient through organic manure might have induced cell division, expansion of cell wall, meristematic activity, photosynthetic efficiency that help to healthy seed. Chongre et al. [8] also recorded similar results.

3.4 Yield Attributes and Yield of Mustard (Component Crop)

3.4.1 Intercropping system

Among the different intercropping system yield attributes of mustard not influenced significantly Table 4. Maximum (5.19, 5.28 and 5.24) test weight was recorded under sole stand of mustard. However minimum (4.61, 4.69 and 4.65) test weight were recorded under chickpea + mustard 1:1 row ratio of intercropping system.

Different intercropping system showed significant influence on grain yield of mustard. Significantly maximum (2062.08, 2066.67 and 2064.38 kg ha^{-1}) grain yield was recorded under sole crop of mustard which was significantly superior over the rest of the treatments and none of the treatments found at par among different intercropping treatments during all experimental year.

3.4.2 Liquid manures

There was significant effect on yield attributes and yield of mustard through foliar application of different liquid manures Table 4. The treatment foliar application of panchagavya 3% produced significantly higher (5.83, 5.90 and 5.87) test weight of mustard which were at par with foliar application of vermiwash 10% during first, second as well as pooled data.

Table 1. Growth attributes of Chickpea as influenced by row ratio and liquid manures

Treatments	Chickpea								
	Plant height (cm) at harvest			Number of nodules/plant at harvest			Dry weight g/plant at harvest		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
Intercropping system									
Sole chickpea	71.31	71.35	71.33	9.44	8.84	9.44	26.36	26.76	26.56
Sole mustard	-	-	-	-	-	-	-	-	-
Chickpea + mustard (1:1)	71.84	71.20	71.52	9.80	9.39	9.80	26.89	27.25	27.07
Chickpea + mustard (2:1)	72.00	72.57	72.28	10.39	9.87	10.39	27.25	27.61	27.43
Chickpea + mustard (3:1)	72.65	73.14	72.90	11.74	10.91	11.74	27.66	28.05	27.86
F test	NS	NS	NS	NS	NS	NS	NS	NS	NS
SE(m)±	0.95	1.99	1.02	0.72	0.64	0.72	0.63	0.46	0.52
CD (p=0.05)	-	-	-	-	-	-	-	-	-
Liquid manures									
Control (No spray)	63.42	62.58	63.00	6.83	6.65	6.83	23.93	24.31	24.12
Panchagavya 3%	81.55	81.96	81.75	13.91	13.29	13.91	30.60	30.80	30.70
Cow urine 10%	64.55	64.67	64.61	8.41	8.11	8.41	25.13	25.46	25.30
Vermiwash 10%	78.28	79.05	78.67	12.22	10.97	12.22	28.51	29.10	28.81
F test	S*	S	S	S	S	S	S	S	S
SE(m)±	1.85	1.88	1.13	1.14	0.87	1.14	0.74	0.62	0.66
CD (p=0.05)	5.39	5.49	3.30	3.32	2.55	3.32	2.17	1.82	1.93

**Significance at 5 %*

Table 2. Growth attributes of Mustard as influenced by row ratio and liquid manures

Treatments	Mustard					
	Plant height (cm) at harvest			Dry weight g/plant at harvest		
	2018	2019	Pooled	2018	2019	Pooled
Intercropping system						
Sole chickpea	-	-	-	-	-	-
Sole mustard	168.03	168.75	168.39	32.58	33.15	32.86
Chickpea + mustard (1:1)	169.32	170.2	169.76	33.40	33.62	33.51
Chickpea + mustard (2:1)	169.94	171.16	170.55	33.76	34.07	33.91
Chickpea + mustard (3:1)	172.33	173.05	172.69	34.30	35.02	34.66
F test	NS	S	NS	NS	NS	NS
SE(m)±	1.18	0.83	0.87	1.53	1.28	1.04
CD (p=0.05)	-	2.86	-	-	-	-
Liquid manures						
Control (No spray)	157.86	159.59	158.72	29.47	30.15	29.81
Panchagavya 3%	179.56	180.02	179.78	37.72	37.96	37.84
Cow urine 10%	166.08	166.82	166.44	31.97	32.31	32.14
Vermiwash 10%	176.13	176.73	176.43	34.87	35.44	35.15
F test	S	S	S	S	S	S
SE(m)±	1.042	1.65	1.39	1.34	1.44	1.04
CD (p=0.05)	4.14	4.83	4.06	3.91	4.21	3.04

**Significance at 5 %*

Table 3. Yield attributes and yield of Chickpea as influenced by row ratio and liquid manures

Treatments	Chickpea					
	Seed index (g)			Grain yield kg/ha		
	2018	2019	Pooled	2018	2019	Pooled
Intercropping system						
Sole chickpea	24.04	24.27	24.15	2145.08	2161.33	2153.21
Sole mustard	-	-	-	-	-	-
Chickpea + mustard (1:1)	22.85	22.90	22.88	1107.30	1131.55	1119.43
Chickpea + mustard (2:1)	23.26	23.56	23.41	1451.08	1476.91	1463.99
Chickpea + mustard (3:1)	23.50	23.69	23.60	1927.44	1943.28	1935.36
F test	NS	NS	NS	S	S	S
SE(m)±	0.72	0.63	0.44	60.83	48.14	45.36
CD (p=0.05)	-	-	-	210.76	166.81	157.16
Liquid manures						
Control (No spray)	20.89	21.11	21.00	1197.81	1218.06	1207.93
Panchagavya 3%	25.69	25.78	25.74	2034.73	2054.73	2044.73
Cow urine 10%	22.82	22.99	22.90	1487.12	1509.62	1498.37
Vermiwash 10%	24.25	24.53	24.39	1911.25	1930.67	1920.96
F test	S*	S	S	S	S	S
SE(m)±	0.84	0.70	0.53	68.26	69.01	44.28
CD (p=0.05)	2.46	2.04	1.54	199.25	201.45	129.25

**Significance at 5 %*
NS- Non significant

Table 4. Yield attributes and yield of Mustard as influenced by row ratio and liquid manures

Treatments	Mustard					
	Test weight (g)			Grain yield (kg/ha)		
	2018	2019	Pooled	2018	2019	Pooled
Intercropping system						
Sole chickpea	-	-	-	-	-	-
Sole mustard	5.19	5.28	5.24	2062.08	2066.67	2064.38
Chickpea + mustard (1:1)	4.61	4.69	4.65	1265.38	1276.96	1271.17
Chickpea + mustard (2:1)	4.91	4.96	4.93	961.53	973.27	967.40
Chickpea + mustard (3:1)	5.01	5.16	5.09	821.75	833.75	827.75
F test	NS	NS	NS	S	S	S
SE(m)±	0.16	0.24	0.18	5.30	11.83	7.93
CD (p=0.05)	-	-	-	18.35	41.00	27.49
Liquid manures						
Control (No spray)	3.72	3.84	3.78	1192.92	1196.26	1194.59
Panchagavya 3%	5.83	5.90	5.87	1343.65	1354.74	1349.19
Cow urine 10%	4.78	4.84	4.81	1238.42	1249.51	1243.97
Vermiwash 10%	5.40	5.51	5.46	1335.74	1350.15	1342.94
F test	S	S	S	S	S	S
SE(m)±	0.16	0.18	0.15	7.43	15.18	8.60
CD (p=0.05)	0.48	0.53	0.43	21.67	44.31	25.10

**Significance at 5 %*

Foliar application of panchagavya 3% also produced significantly higher (1343.65, 1354.74 and 1349.19 kg ha^{-1}) grain yield of mustard which was at par with foliar application of vermiwash 10% during all experimental year. Higher yield attributes and yield due to the presence of higher amount of organic matter and micro nutrient as fe and zn and smaller amount of IAA and GA present in panchagavya which might have enhance the growth and yield. Same line as reported by Kumar et al. [11].

3.4.3 Interaction effects of intercropping system and liquid manures

Interactive effects of intercropping system and liquid manures on yield attributes were non significant in both crop and also non significant difference were noticed in chickpea crop. And in case of mustard grain yield interactive effects were found significant.

4. CONCLUSION

Thus it concluded that considering the result of the experiment, it may be advocated that chickpea + mustard 3:1 row ratio intercropping system recorded higher growth attributes, however sole stand of both crop recorded higher yield and yield attributes among different intercropping treatments. Among liquid manures panchagavya 3% at branching and flowering stage recorded maximum growth, yield attributes and yield of both crops.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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