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Effect of Mustard on Yield Attributes, Nutrient Uptake and Quality of Chickpea under Different Nutrient Management Levels and Intercropping Treatments in Chickpea + Mustard Intercropping System

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A B S T R A C T

A field experiment was undertaken during *rabi* season, 2017-18 on **"**Population Compatibility and Nutrient Management Strategies in Chickpea (*Cicer arietinum* L.) + Mustard (*Brassica juncea* L.) Intercropping System" at "Sardar Vallabhbhai Patel University of Agriculture and Technology", Meerut (U.P). Twenty treatments comprising combination of 04 intercropping treatments *viz.*, Chickpea + mustard in 3:1 and 4:1 row ratio and both in additive and replacement series and 05 nutrient management practices *viz.*, recommended dose (RD) to chickpea and mustard both (N_1), N_1 + biofertilizers (N_2), N_2 +FYM (N_3), N_1 but mustard with 150% RD (N_4) and N_4 with biofertilizers (N_5) along with sole stand of component crops tested in RBD with 3 replications. Recommended doses were 100 kg DAP +20kg S ha^{-1} for chickpea and 120 kg N +40 kg P_2O_5+20 kg S for mustard. Chickpea seeds were inoculated with *Rhizobium* and mustard with *Azotobacter* along with soil application PSB. The results revealed that the performance of chickpea was better in sole crop than in intercropping systems. The yield attributes *viz.*, number of pods $plant^{-1}$ (49.2) & number of seeds pod^{-1} (3.2), grain yield (21.0 qha^{-1}), protein content (21.3%), nitrogen (117.0), phosphorous (16.8) & potassium uptake (80.7) were maximum in sole crop of chickpea. Also, nutrient management options exhibited significant effect on performance of both crops giving best results in chickpea with the addition of FYM + RDF to chickpea& mustard along with chickpea inoculation with *Rhizobium* & mustard inoculation with *Azotobacter* + soil application of *Phosphorous solubilising bacteria*.

Introduction

Chickpea and mustard are important pulse and oilseed crops in Indo-Gangetic plains particularly, western part of Uttar Pradesh. The crops differ in their growing habits and can be grown synergistically with each other in intercropping systems. Cultivation of these energy rich crops in rainfed area is one of the major constraints in achieving their yield potential. However, population compatibility and crop nutrition needs that differ with the genotype and environment, needs to be ascertained to harness the advantages. Willey (1979a) clearly and evidently proposed that intercropping gives higher yields in a given season and greater stability of yields in different seasons compared with sole

cropping. Moreover, Mead and Willey (1980) stated in detail that in intercropping systems, yields are more stable. The selection of an appropriate intercropping system for each case is quite complex as the success of intercropping systems depend much on the interactions between the component species, available management practices and the environmental conditions.

Intercropping provides year-round ground cover, or at least for a longer period than monocultures, in order to protect the soil from desiccation and erosion. By growing more than one crop at a time in the same field, farmers maximize water use efficiency, maintain soil fertility, and minimize soil erosion, which are the serious drawbacks of mono-cropping. Also, soil nutrient status plays a key role in boosting crop yields in an intercropping system. Due to continuous and abundant use of chemical fertilizers by farmers of our country, the fertility status of the soil has deteriorated to a level that even the application of fertilizers at higher rates is not able to sustain the productivity of soil. Therefore, use of organic nutrient sources along with chemical fertilizers is recommended in order to sustain the productivity and promote the health of the soil under intensive modern agriculture. During decomposition, organic manures also release some growth promoting substances, which bring about favourable changes in soil ecosystem. These organic manures being slow in release of nutrients, assume greater significance in a cropping sequence than individual crops and their usefulness needs to be investigated. Soil contains numerous microorganisms, some of them are beneficial like nitrogen fixers, phosphate solubilizers, plant growth promoting rhizobacteria etc. Inoculation of legumes with exotic strains of *rhizobia* is a common agricultural practice intended to promote nitrogen fixation and increase crop yield. Nitrogen fertilizers with *Rhizobium* inoculation have direct impact on various growth and yield attributes in chickpea.

Materials and Methods

A research experiment in the field was carried out at Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), during *rabi* season, 2017-18. The experimental field was well drained, sandy loam in texture and slightly alkaline in reaction. Soil was low in organic carbon & available nitrogen, while medium in available phosphorus & potassium with electrical conductivity and bulk density of 1.63 dS/m and 1.36 Mg/m^3, respectively. Twenty treatments comprising of 04 intercropping systems *viz.,* Chickpea + mustard in 3:1 and 4:1 row ratio and both in additive and replacement series along with 05 nutrient management options *viz.,* recommended dose (RD) to chickpea and mustard both (N_1), N_1 + biofertilizers (N_2), N_2 +FYM (N_3), N_1 but mustard with 150% RD (N_4) and N_4 with biofertilizers (N_5) along with sole stand of component crops tested in randomized block design with 3 replications. Chickpea seeds were inoculated with *Rhizobium* and mustard with *Azotobacter* while PSB was soil applied. Chickpea variety BGM 547 and mustard variety Kranti were sown on 25th of October 2017 and harvested on 14th of March and 30th of April 2018, respectively. Seeds were sown manually in line at a depth of 8 cm for chickpea and 4 cm for mustard. The row to row and plant to plant spacing for chickpea was 30 cm and 15 cm while in case of mustard the spacing varied according to different intercropping situations. Crop were kept weed free by regular hand weeding.

Results and Discussion

Yield attributes and yield

Number of pods plant^{-1}

Intercropping exhibited significant effect on

number of pods plant^{-1} in chickpea while nutrient management options did not exhibit any significant influence on pod count plant^{-1}. The number of pods produced per plant was significantly higher in sole chickpea crop. This might be due to lesser competition for available resources *i.e* light, space, nutrient and water in sole cropping in comparison to intercropping treatments. Incorporation of FYM resulted in better availability of macro and micro nutrients at pod formation stage which led to enhanced value of yield attributes. These results are in close findings with Singh *et al.,* (2002) and Varsheny and Arya (2004). Among intercropping systems, maximum value of pods plant^{-1} was counted when chickpea was grown with mustard in 4:1 replacement series which was at par with respective 3:1 and superior over when chickpea was grown with mustard in 3:1 and 4:1 additive series. This might be possibly due to lesser inter-crop competition for available resources in replacement series while in additive series, additional rows of mustard were adjusted between chickpea rows which led to greater competition between component crops and resulted in reduction of yield attributes and overall performance of chickpea plants (Table 2).

These findings are in close conformity with the results of Kumar and Singh (1987) and Prasad *et al.,* (2003). Also, among different nutrient management strategies, maximum number of pods plant^{-1} was recorded with nutrient management option of RDF in chickpea treated with *Rhizobium* + RDF in mustard treated with *Azotobacter* + FYM + PSB.

Number of seeds pod^{-1}

Significant effect of intercropping treatments was observed on number of seeds pod^{-1} in chickpea; however, nutrient management options did not exhibit any significant influence number of seeds pod^{-1}. Highest number of seeds pod^{-1} was counted under sole crop of chickpea. Among intercropping treatments, more seeds pod^{-1} was observed in chickpea + mustard 4:1 replacement series which was at par with respective 3:1 and superior over chickpea + mustard 3:1 and 4:1 additive series. With regard to nutrient management options, maximum number of seeds pod^{-1} was recorded with the application of recommended dose of fertilizer in chickpea inoculated with *Rhizobium* and mustard treated with *Azotobacter* +FYM +PSB while lowest number of seeds pod^{-1} were found when the component crops received recommended dose of fertilizers.

Grain yield (q ha^{-1})

Intercropping treatments and nutrient management options significantly affected the grain yield in chickpea. Sole chickpea crop produced maximum grain yield over all intercropping treatments. Highest grain yield among intercropping row ratios was found in chickpea +mustard 4:1 additive series which was at par with respective 3:1 additive series and superior over chickpea +mustard 3:1 and 4:1 replacement series. Moreover, when compared to different nutrient management options, maximum grain yield was observed in sole chickpea followed by nutrient management option of RDF in chickpea inoculated with *Rhizobium* + RDF in mustard inoculated with *Azotobacter* +FYM +PSB as soil applied, which was at par with nutrient dose of 100% RDF in chickpea treated with *Rhizobium* + 150% RDF in mustard with *Azotobacter* + PSB. Similar results were given by Prasad *et al.,* (2003), they reported from Kanpur that 80% population of chickpea in intercropping with mustard varieties, produced grain yield of 70% to 79.3% which stand the losses of 0.7 to 9.9 % in chickpea yield due to mustard varieties. Also, Singh (2003) reported yield reduction of chickpea from 2.18 to 12.95 % due to intercropping of different varieties of mustard.

Nutrient uptake (kg ha^{-1})

Nutrient uptake (nitrogen, phosphorous and potassium) in chickpea differed significantly among various intercropping systems and nutrient management options. Total nitrogen, phosphorous and potassium uptake was higher in sole cropping of chickpea as against both additive and replacement series of intercropping. Among intercropping treatments, maximum nutrient uptake in grain and straw of chickpea was recorded in 4:1 additive series against all row ratios. This could be possibly due to closely spaced rows of chickpea and mustard, which posed lesser weed competition and more nutrients availability to plants. Also, due to high plant population, higher completion between roots of component crops for available nutrients led to enhanced uptake of nutrients. The results are in close corroboration with the findings of Tripathi *et al.*, (2005) and Singh *et al.*, (1997). Total nutrient content and uptake in chickpea differed significantly among different nutrient management options. Chickpea plants fed with RDF & treated with *rhizobium* + RDF in mustard treated with *azotobacter* + FYM + PSB resulted in significantly higher nutrient uptake. It could be possibly due to integrated application of FYM + recommended doses of fertilizers along with treatment of component crops with bio fertilizers which enhanced the availability of nutrients in soil to be absorbed by plants resulting in higher uptake of nitrogen, phosphorous and potassium in chickpea. These results are in close findings with Nepali and Jain (1998)**,** Puri *et al.*, (1999)**,** Kawatra and Mishra (1999)**,** Rana *et al.*, (2005), Sah *et al.*, (2006) and Abraham *et al.*, (2011) (Table 1).

Table.1 Effect of intercropping treatments and nutrient management options on nutrient uptake in chickpea

Treatments		Nitrogen uptake (kg ha^{-1})			Phosphorus uptake (kg ha^{-1})			Potassium uptake (kg ha^{-1})		
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Sole chickpea		71.7	45.2	117	8.4	8.4	16.8	27.3	53.3	80.7
Cropping system										
Chickpea + mustard (3:1 A)		61.8	38.0	99.8	6.8	6.9	13.7	22.6	44.1	66.7
Chickpea + mustard (4:1 A)		70.7	39.0	109.7	7.4	7.0	14.4	24.5	44.3	68.9
Chickpea + mustard (3:1 R)		45.8	25.3	71.1	4.6	4.1	8.7	14.5	28.4	43
Chickpea + mustard (4:1 R)		49.0	28.1	77.2	5.1	4.6	9.8	16.3	31.3	47.6
S.Em.±		1.47	0.83	2.30	0.16	0.15	0.31	0.51	0.94	1.45
CD (P=0.05)		4.22	2.38	6.60	0.45	0.44	0.89	1.46	2.70	4.16
Nutrient Management Options										
Chickpea	Mustard									
RDF	RDF	54	29.8	83.8	5.4	5.1	10.6	17.8	33.2	51.0
RDF + Rhizo.	RDF + Azoto.	57.2	32.2	89.4	6.1	5.7	11.8	19.8	37.0	56.8
PSB										
RDF + Rhizo.	RDF + Azoto.	61.9	36.3	96.2	6.5	6.3	12.6	21.3	41.7	60.5
PSB +FYM										
RDF	150% RDF	52.4	30.4	82.8	5.6	5.2	10.8	18.3	34.2	52.6
RDF + Rhizo.	150% RDF + Azoto.	58.7	34.3	95	6.2	6.0	12.6	20.2	39.2	62.0
PSB										
S.Em.±		1.65	0.93	2.57	0.18	0.17	0.35	0.57	1.05	1.62
CD (P=0.05)		4.72	2.66	7.38	0.51	0.49	0.99	1.63	3.02	4.65

Table.2 Effect of intercropping treatments and nutrient management options on yield attributes & yield and protein content of chickpea

Treatments		Yield attributes		Grain yield (qha^{-1})	Protein content (%)
		Number of pod plant^{-1}	Number of seed pod^{-1}		
Sole chickpea		49.2	3.2	21.0	21.3
Cropping system					
Chickpea + mustard (3:1 A)		36.6	2.2	19.0	20.2
Chickpea + mustard (4:1 A)		37.4	2.2	19.8	22.2
Chickpea + mustard (3:1 R)		46.0	2.2	15.7	18.2
Chickpea + mustard (4:1 R)		46.9	2.5	16.1	18.5
S.Em.±		0.66	0.04	0.28	0.21
CD (P=0.05)		1.90	0.11	0.81	0.61
Nutrient Management Options					
Chickpea	Mustard				
RDF	RDF	40.9	2.2	17.1	19.6
RDF + Rhizo.	RDF + Azoto.	41.8	2.3	17.8	19.8
PSB					
RDF + Rhizo.	RDF + Azoto.	42.5	2.4	18.4	20.7
PSB +FYM					
RDF	150% RDF	41.1	2.2	17.3	18.7
RDF + Rhizo.	150% RDF + Azoto.	42.2	2.3	18.0	20.1
PSB					
S.Em.±		0.74	0.04	0.31	0.24
CD (P=0.05)		NS	0.12	0.90	0.68

Nitrogen uptake in grain and straw

Nitrogen uptake in grain and straw of chickpea varied significantly under different intercropping treatments and nutrient management options. Uptake of nitrogen was higher in sole crop of chickpea when compared to various intercropping treatments. However, among different intercropping systems, chickpea +mustard 4:1 additive series recorded highest nitrogen uptake in grain and straw while lowest uptake was recorded in chickpea +mustard 3:1 replacement series. Compared to different nutrient management options, sole chickpea recorded maximum nitrogen uptake in grain and straw. Among various nutrient management options, highest uptake of nitrogen in grain (61.95 kg ha^{-1}), straw (36.35 kg ha^{-1}) and total (96.57 kg ha^{-1}) was observed with application of RDF in chickpea treated with *Rhizobium* + RDF in mustard treated with *Azotobacter* + FYM +PSB while lowest was recorded when component crops were given recommended dose of fertilizers.

Phosphorous uptake in grain and straw

Intercropping systems and nutrient management options significantly influenced the phosphorous uptake in grain and straw of chickpea. In comparison to intercropping treatments, sole chickpea recoded highest phosphorous uptake followed by Chickpea + mustard 4:1 additive series which was at par with respective 3:1 additive. Lowest phosphorous uptake was recorded under chickpea + mustard 3:1 replacement series. Among different nutrient management options,

highest uptake of nitrogen in grain (6.58 kg ha^{-1}), straw (6.36 kg ha^{-1}) and total (12.68 kg ha^{-1}) was noted with application of 100% RDF in chickpea inoculated with *Rhizobium* + 100 % RDF in mustard with *Azotobacter* + FYM +PSB which was at par with 100% RDF in chickpea inoculated with *Rhizobium* + 150 % RDF in mustard with *Azotobacter* +PSB while significantly superior over rest of the nutrient management treatments.

Potassium content in grain and straw

Potassium uptake in grain and straw of chickpea were significantly affected by intercropping systems and nutrient management options. Chickpea grown with mustard in intercropping treatments recorded low potassium uptake in grain and straw in comparison to sole cropping. Among different intercropping systems, chickpea + mustard 4:1 additive series recorded highest potassium uptake in grain (22.65 kg ha^{-1}) and straw (44.11 kg ha^{-1}) against all row ratios. With regard to nutrient management options, highest potassium uptake was recorded with incorporation of FYM +RDF in chickpea treated with *Rhizobium*+ RDF in mustard treated with *Azotobacter* + FYM +PSB, which was at par with 100% RDF in chickpea inoculated with *Rhizobium* + 150% RDF in mustard with *Azotobacter* +PSB and significantly superior over rest of the nutrient management options.

Quality

Protein content (%)

Different row ratios among intercropping systems had pronounced effect on the protein content of chickpea. Sole chickpea recorded highest protein content in comparison to intercropping treatments. Among various intercropping situations, highest protein content was recorded with chickpea + mustard 3:1 additive series. This could be possibly to closer spacing of chickpea with mustard in additive series which offers less weed infestation and high competition between component crops which might have caused higher nitrogen content in chickpea leading to higher protein yield. Also, there could be utilization of nitrogen fixed by azotobacter in mustard by chickpea resulting in higher protein yield.

Singh and Rathi (2003), Kumar and Singh (2006) reported similar results. With regard to nutrient management options, sole chickpea recoded maximum protein content. Significantly, higher protein content in chickpea was observed in treatment provided with RDF in chickpea inoculated with *Rhizobium* + RDF in mustard inoculated with *Azotobacter* + FYM + PSB, which was at par with nutrient dose of 100% RDF in chickpea inoculated with *Rhizobium* + 150% RDF in mustard with *Azotobacter* +PSB while lowest protein content was recorded when the component crops were fertilized with recommended dose of fertilizers.

This might be due to higher availability of nutrients to chickpea attributed to addition of FYM and bio fertilizer inoculation which readily increased available nitrogen and phosphorous content in soil to be absorbed by plants resulting in higher protein content and yield. Similar results were given by Patel and Shelke (1998) and Singh *et al.*, (1998).

Based on above results it can be concluded that yield attributes & yield, nitrogen, phosphorus & potassium uptake and protein content was maximum in sole cropping of chickpea. Among different intercropping treatments, nutrient uptake was higher in chickpea + mustard 4:1 replacement series. Similar findings in chickpea + mustard intercropping have also been reported by Tripathi *et al.*, (2005) and Kumar and Singh (2006).

Nutrient management options also exhibited significant effect on the performance of component crops being best in chickpea with application of FYM + RDF to component crops along with chickpea treatment with *Rhizobium* & mustard treatment with *Azotobacter* + soil application of *Phosphorous solubilising bacteria*. Consequently, more research is

required to discover potential diversified intercropping systems which would offer less competition among component crops and higher profitability of the intercropping system.

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