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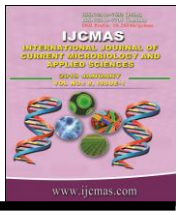

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Performance of Chickpea-Mustard Intercropping on Yield and Economics of Chickpea and Mustard Crop under Different Fertility Management and Various Row Combinations

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A B S T R A C T

A field experiment was carried out at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.) during Rabi season of 2015-16 and 2016-17 to study the effect of fertility management on chickpea-mustard intercropping under various row combinations. Twenty four treatment combinations and consisted of three levels of fertility management (75% RDF, 100% RDF and 125% RDF for both crops) and eight row combinations of chickpea + mustard (2:1, 4:1, 6:1, 2:2, 4:2, 6:2, sole crop of mustard and sole crop of chickpea).The experiment was conducted in Factorial RBD with three replications. The yield components of chickpea & mustard were maximum under 4:1 (4 row chickpea+ 1 row mustard) row combination in both the consecutive years and among the fertility management 125% RDF being at par with 100% RDF during both the consecutive years. The maximum chickpea equivalent yield (CEY) was recorded under the treatment combinations of 4:1 (4 row chickpea + 1 row mustard) with 125% RDF which was significantly superior to overall the treatment during both the years and maximum land equivalent ratio (LER) was obtained at 125% RDF in a combination of 4:1 (4 row chickpea + 1 row mustard) in both the years. Number of seeds plant^{-1} and harvest index in chickpea crop were not influenced significantly due to fertility management and row combinations during both the consecutive years. The highest net return (Rs. 87103 ha^{-1}) and benefit cost ratio (4.68) were obtained with fertility management 125% RDF for both crops in a combination of 4:1 (4 row chickpea + 1 row mustard) could be most economical.

Introduction

Chickpea, the third most important pulse crop, plays a vital role in global agricultural economy. In the central and northern region of India, the most commonly grown winter pulse and oilseed crops are chickpea and mustard. When a legume is grown in association with other crop (intercropping), commonly oilseeds and cereals, the nitrogen nutrition of the associated crop improved by direct nitrogen transfer from legume to oilseed or cereal (Giller and Wilson, 1991). Legume intercrops are also potential sources of plant nutrient that

compliment/ supplement inorganic fertilizers. In addition, legumes are included in cropping system because they reduce soil erosion (Giller and Cadisch, 1995) and suppress weeds (Exner and Cruse, 1993).

Intercropping utilizes the inter space of widely space crop like mustard and chickpea. Chickpea cultivation with mustard crop augments the production and profitability. Chickpea being legume augment the nitrogen nutrition through nitrogen fixation and consequently improve the soil fertility. Further the production and profitability of mustard-chickpea intercropping may be increased through the use of optimum dose of fertilizers. Cereal with legume intercropping is common but the work done so far on oilseed and legume intercropping with a suitable nutrient management and proper crop ratio in merge. Hence, the present study is to be ethiopian mustard/chickpea intercropping system recorded higher mustard equivalent yield over sole mustard and sole chickpea. In intercropping, the values of relative crowding coefficient, AY L, aggressivity, and competitive ratio indicated that the Ethiopian mustard was more competitive than chickpea. In association with mustard + chickpea as inter crop with optimum dose of fertilizers improved the yield of both crops. Tanwar *et* al. (2011) replied that mustard + chickpea intercropping with ratio of (1:6) and fertilizer with 100% RFN + full P and K recorded highest yield and net profit. Hence, an experiment was planned to study the production potential of chickpea + mustard intercropping at various row combination at varying fertility levels.

Materials and Methods

The field experiment was conducted at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj) Faizabad (U.P.), during *Rabi* season of 2015-16 and 2016-17. The soil of experimental field was low in available nitrogen (203.00 and 208.00 kg/ha) and organic carbon (0.38% and 0.42%), medium in available phosphorus (12.25 and 13.20 kg/ha) and high in potassium (265.00 and 267 kg/ha) in Ist and IInd year, respectively. The reaction of the soil was slightly alkaline (7.8). The experiment was laid out in Factorial RBD with three fertility management (75% RDF, 100% RDF and 125% RDF for both crops) and eight row combinations (2:1, 4:1, 6:1, 2:2, 4:2, 6:2, sole crop of mustard and sole crop of chickpea) with three replication. There were twenty four treatment combinations comprised of 3 fertility management and 8 row combinations. The sowing was done on 25 October in 2015 and 27 October in 2016 with the seed rate of 100 kg/ha for chickpea crop and 6 kg/ha for mustard crop and spacing between rows was 30 cm apart. An uniform dose of 100 kg P_2O_5 ha^{-1} in chickpea and 114 kg N + 125 kg P_2O_5 + 67 kg K_2O ha^{-1} in mustard was applied to all treatments. Full dose of phosphorus as per treatments and potassium along with half of the nitrogen were applied as basal while remaining half dose of nitrogen was top-dressed at first irrigation. Tube-well was the source of irrigation. Irrigations were applied at all critical stages. In order to check the weeds growth one manual weeding was done at 35 days after sowing. The crop was harvested at proper stage of maturity as determined by visual observations on 17 February in 2015 and 19 February in 2016.

Results and Discussion

Chickpea

Yield contributing characters

Number of pods $plant^{-1}$

A perusal of data in table 1 revealed that the maximum number of pods $plant^{-1}$ recorded in fertilizer 125% RDF and significantly superior

over rest of the fertility management during both the years.

Combination of sole chickpea produced significantly higher number of pods plant^{-1} which was at par with 2:1, 4:1, 6:1, 4:2 and 6:2 and found significant with 2:2 chickpea+mustard row combination during both the consecutive years. Interaction effect between fertility management and row combination was not significant.

Higher value of these indices was recorded at 125 % RDF which increased slightly with an increase in levels of fertilizer. This findings are in line of those Abraham *et al*. (2010), Gokhale *et al*. (2008), Karwasra and Kumar (2007), Tripathi *et al.* (2005b), Hossain *et al.* (2003), and Bhohra and Srivastava (2002).

Number of pods plant^{-1} varied significantly among the row combinations of chickpea-mustard intercropping pattern. Among the row ratios in intercropping systems, maximum values of these indices were recorded under sole chickpea which was at par with all row combinations and found significant with 2:2 row combination in both the years. This might be due to lesser inter-crop competition, higher photosynthetic active radiation and latent heat available to the crops leading to higher production of photosynthates which together favourably influenced the yield attributing parameters. This finding is in conformity with the results of Kumar and Singh (2006), Kumar *et al.* (2006), Tripathi *et al.* (2005b) and Ahlawat *et al.* (2005a).

Number of seeds plant^{-1}

The data revealed that the number of seeds plant^{-1} was not influenced significantly by fertility management and row combination. Number of seeds plant^{-1} did not vary significantly at different fertility levels in both the years. This findings are in line of those Abraham *et al*. (2010), Gokhale *et al*. (2008), Karwasra and Kumar (2007), Tripathi *et al.* (2005b), Hossain *et al.* (2003), and Bhohra and Srivastava (2002).

100-seed weight (g)

The data revealed that the maximum 100-seed weight (g) was recorded with fertilizer 125% RDF which was at par with 100% RDF and found significant with 75% RDF during both the years. However, as regards row combinations, sole chickpea recorded higher test weight being at par with 2:1, 4:1, 6:1, 4:2 and 6:2 and significantly superior over 2:2 chickpea-mustard intercropping in both the years. Interaction effect between fertility management and row combination was not significant.

Test weight of chickpea influenced significantly at different fertility levels in both the years. Higher value of these indices was recorded at 125 % RDF which increased slightly with an increase in levels of fertilizer. This findings are in line of those Abraham *et al*. (2010), Gokhale *et al*. (2008), Karwasra and Kumar (2007), Tripathi *et al.* (2005b), Hossain *et al.* (2003), and Bhohra and Srivastava (2002).

Test weight (g) varied significantly among the row combinations of chickpea-mustard intercropping pattern. Among the row ratios in intercropping systems, maximum values of these indices were recorded under sole chickpea which was at par with all row combinations and found significant with 2:2 row combination in both the years. This might be due to lesser inter-crop competition, higher photosynthetic active radiation and latent heat available to the crops leading to higher production of photosynthates which together favourably influenced the yield attributing parameters. This finding is in conformity with the results of Kumar and Singh (2006), Kumar

et al. (2006), Tripathi *et al.* (2005b) and Ahlawat *et al.* (2005a).

Yield characters

Biological yield (q ha^{-1})

The biological Yield (q ha^{-1}) influenced significantly by fertility management and row combination. The maximum biological yield was found with 125% RDF and significantly superior over rest of the fertility management during both the consecutive years. This might be due to increasing levels of fertilizers to intercrops increases photosynthetic rates and translocation of photosynthate to different plant parts and influenced the yield of intercrops. Abraham *et al*. (2011), Tripathi *et al*. (2005b), Bohra and Srivastava (2002), Singh and Verma (1997) and Singh *et al*. (1998) reported the similar results.

Combination of sole chickpea produced significantly higher biological yield at all the stages of growth which was significantly more than rest combinations of row in both the years. Interaction effect between fertility management and row combination was not significant. Sole chickpea recorded maximum biological yield which was found significantly superior to overall the row combinations in both the years. The result of this investigation also get supported from those obtained by Kumar and Nandan (2007), Kumar and Singh (2006), Kumar *et al*. (2006), Tripathi *et al*. (2005b), Ahlawat *et al.* (2005a) and Thakur *et al.* (2000).

Seed yield (q ha^{-1})

The highest seed yield of 16.72 q ha^{-1} in first year and 16.99 q ha^{-1} in second year was obtained with 125% RDF and significantly superior to other fertility management. However, the lowest seed yield was recorded with 75% RDF. This might be due to increasing levels of fertilizers to intercrops increases photosynthetic rates and translocation of photosynthate to different plant parts and influenced the yield of intercrops. Abraham *et al*. (2011), Tripathi *et al*. (2005b), Bohra and Srivastava (2002), Singh and Verma (1997) and Singh *et al*. (1998) reported the similar results (Table 2).

Row combination had significant effect on the seed yield. The maximum seed yield was obtained of 18.92 q ha^{-1} in first year and 19.12 q ha^{-1} with sole chickpea which was significantly superior to over all the treatment. However, the lowest seed yield was recorded with 2:2 (2 row chickpea + 2 row mustard) row combination. The interaction between fertility management and row combination did not influence seed yield significantly.

In the present experiment seed yield of chickpea were highest in their respective sole crop as compare to their intercropping, it was obvious due to more number of plant population in sole than intercropping. The result of this investigation also get supported from those obtained by Kumar and Nandan (2007), Kumar and Singh (2006), Kumar *et al*. (2006), Tripathi *et al*. (2005b), Ahlawat *et al.* (2005a) and Thakur *et al.* (2000).

Straw yield (q ha^{-1})

The highest straw yield of 20.75 q ha^{-1} in first year and 21.07 q ha^{-1} was obtained with 125% RDF and significantly superior to other fertilizers. However, the lowest straw yield was recorded with 75% RDF fertility management in both the years.

This might be due to increasing levels of fertilizers to intercrops increases photosynthetic rates and translocation of photosynthate to different plant parts and influenced the yield of intercrops. Abraham *et al*. (2011), Tripathi *et al*. (2005b), Bohra and

Srivastava (2002), Singh and Verma (1997) and Singh *et al*. (1998) reported the similar results.

Row combination had significant effect on the straw yield. The maximum straw yield was obtained of 23.47 q ha^{-1} in first year and 23.63 q ha^{-1} with sole chickpea which was significantly superior to overall the treatments. However, the lowest straw yield was recorded with 2:2 (2 row chickpea + 2 row mustard) during both the years. The interaction effect between fertility management and row combinations was found not significant.

In the present experiment straw yield of chickpea were highest in their respective sole crop as compare to their intercropping, it was obvious due to more number of plant population in sole than intercropping. The result of this investigation also get supported from those obtained by Kumar and Nandan (2007), Kumar and Singh (2006), Kumar *et al*. (2006), Tripathi *et al*. (2005b), Ahlawat *et al.* (2005a) and Thakur *et al.* (2000).

Harvest index (%)

Harvest index was influenced non-significantly with fertility management and row combinations during both the years. This might be due to increasing levels of fertilizers to intercrops increases photosynthetic rates and translocation of photosynthate to different plant parts and influenced the yield of intercrops. Abraham *et al*. (2011), Tripathi *et al*. (2005b), Bohra and Srivastava (2002), Singh and Verma (1997) and Singh *et al*. (1998) reported the similar results.

In the present experiment harvest index was not influenced significantly with various row combinations.

The result of this investigation also get supported from those obtained by Kumar and Nandan (2007), Kumar and Singh (2006), Kumar *et al*. (2006), Tripathi *et al*. (2005b), Ahlawat *et al.* (2005a) and Thakur *et al.* (2000).

Mustard

Yield contributing characters

Number of siliquae $plant^{-1}$

A perusal of data in table 3 revealed that the maximum number of siliquae $plant^{-1}$ recorded in fertilizer 125% RDF which was at par with fertilizer 100% RDF and found significant with fertilizer 75% RDF during both the years.

Combination of 6:1 chickpea+mustard produced significantly higher number of siliquae $plant^{-1}$ which was at par with 2:1, 4:1, 2:2, 4:2 and 6:2 row combination and found significant with sole mustard row combination during both the consecutive years. Interaction effect between fertility management and row combination was not significant.

The maximum number of siliquae $plant^{-1}$ of mustard was recorded at 125% RDF, which was significantly superior to 75% RDF and at par with 100% RDF in both the years. This findings are in line of those Abraham *et al*. (2010), Gokhale *et al*. (2008), Karwasra and Kumar (2007), Tripathi *et al.* (2005b), Hossain *et al.* (2003), and Bhohra and Srivastava (2002).

In the present investigation, maximum value of these indices were recorded under 6:1 row combination which was found at par with all row combination and found significant with sole mustard in both the years.

Similar results were obtained by Kumar and Singh (2006), Tripathi *et al.*, (2005b) and Ahlawat *et al.* (2005a) also.

Length of siliquae (cm)

The maximum length of siliquae was noted with the application of 125% RDF which was at par with 100% RDF and found significant with 75% RDF during both the years.

As regards row combinations of chickpea+mustard intercropping, length of siliquae (cm) increased significantly upto 6:1 row combination being at par with 2:1, 4:1, 2:2, 4:2 and 6:2 row combination and found significant with sole mustard row combination in both the consecutive years. Interaction effect was not significant.

In the present investigation, maximum value of these indices were recorded under 6:1 row combination which was found at par with all row combination and found significant with sole mustard in both the years. Similar results were obtained by Kumar and Singh (2006), Tripathi *et al.*, (2005b) and Ahlawat *et al.* (2005a) also.

Number of seeds siliquae^{-1}

The number of seeds siliquae^{-1} influenced by fertility management and row combinations. The maximum number of seeds siliquae^{-1} was found with recommended dose of fertilizer 125% RDF for both crops which was at par with 100% RDF and found significant with 75% RDF during both the consecutive years.

Combination of 6:1 chickpea+mustard intercropping produced significantly higher number of seeds siliquae^{-1} which was at par with 2:1, 4:1, 2:2, 4:2 and 6:2 row combination and found significant with sole mustard row combination in both the consecutive years.

Interaction effect between fertility management and row combination was not significant.

The maximum number of seeds siliquae^{-1} of mustard was recorded at 125% RDF, which was significantly superior to 75% RDF and at par with 100% RDF in both the years. This findings are in line of those Abraham *et al*. (2010), Gokhale *et al*. (2008), Karwasra and Kumar (2007), Tripathi *et al.* (2005b), Hossain *et al.* (2003), and Bhohra and Srivastava (2002).

In the present investigation, maximum value of these indices were recorded under 6:1 row combination which was found at par with all row combination and found significant with sole mustard in both the years. Similar results were obtained by Kumar and Singh (2006), Tripathi et al. (2005b) and Ahlawat *et al.* (2005a) also.

Test weight (g)

The data revealed that the maximum test weight (g) was recorded with fertilizer 125% RDF which was at par with 100% RDF and found significant with 75% RDF during both the years. However, as regards chickpea+mustard row combinations, 6:1 recorded higher test weight being at par with 2:1, 4:1, 2:2, 4:2 and 6:2 row combination and significantly superior over sole mustard in both the years. Interaction effect between fertility management and row combination was not significant.

Test weight of mustard crop influenced significantly among the different fertility levels in both the years. This findings are in line of those Abraham *et al*. (2010), Gokhale *et al*. (2008), Karwasra and Kumar (2007), Tripathi *et al.* (2005b), Hossain *et al.* (2003), and Bhohra and Srivastava (2002).

In the present investigation, maximum value of these indices were recorded under 6:1 row combination which was found at par with all row combination and found significant with

sole mustard in both the years. Similar results were obtained by Kumar and Singh (2006), Tripathi et al. (2005b) and Ahlawat *et al.* (2005a) also.

Yield characters

Seed yield (q ha^{-1})

The highest seed yield of 7.60 q ha^{-1} in first year and 7.67 q ha^{-1} in second year was obtained with 125% RDF and significantly superior to other fertility management. However, the lowest seed yield was recorded with 75% RDF (Table 4).

Row combination had significant effect on the seed yield. The maximum seed yield was obtained of 14.29 q ha^{-1} in first year and 14.44 q ha^{-1} in second year with sole mustard which was significantly superior to over all the treatment. However, the lowest seed yield was recorded with 6:1 (6 row chickpea + 1 row mustard) row combination. The interaction between fertility management and row combination did not influence seed yield significantly.

In mustard maximum seed yield were recorded at 125 % RDF and significantly scored over 75% RDF in both the years. This might be due to increasing levels of fertilizers to intercrops increases photosynthetic rates and translocation of photosynthate to different plant parts and influenced the yield of intercrops. Abraham *et al*. (2011), Tripathi *et al*. (2005b), Bohra and Srivastava (2002), Singh and Verma (1997) and Singh *et al*. (1998) reported the similar results.

In the present experiment grain yield of mustard were highest in their respective sole crop as compare to their intercropping, it was obvious due to more number of plant population in sole than intercropping. The result of this investigation also get supported from those obtained by Kumar and Nandan (2007), Kumar and Singh (2006), Kumar *et al*. (2006), Tripathi *et al*. (2005b), Ahlawat *et al*. (2005a) and Thakur *et al*. (2000).

Stover yield (q ha^{-1})

The highest stover yield of 23.79 q ha^{-1} in first year and 31.73 q ha^{-1} was obtained with 125% RDF and significantly superior to other fertilizers. However, the lowest stover yield was recorded with 75% RDF fertility management in both the years.

Row combination had significant effect on the stover yield. The maximum stover yield was obtained of 44.36 q ha^{-1} in first year and 59.16 q ha^{-1} with sole mustard which was significantly superior to overall the treatments. However, the lowest straw yield was recorded with 6:1 (6 row chickpea + 1 row mustard) during both the years. The interaction effect between fertility management and row combinations was found not significant.

In mustard maximum stover yield were recorded at 125 % RDF and significantly scored over 75% RDF in both the years in both the years. This might be due to increasing levels of fertilizers to intercrops increases photosynthetic rates and translocation of photosynthate to different plant parts and influenced the yield of intercrops. Abraham *et al*. (2011), Tripathi *et al*. (2005b), Bohra and Srivastava (2002), Singh and Verma (1997) and Singh *et al*. (1998) reported the similar results.

In the present experiment straw yield of mustard were highest in their respective sole crop as compare to their intercropping, it was obvious due to more number of plant population in sole than intercropping. The result of this investigation also get supported from those obtained by Kumar and Nandan (2007), Kumar and Singh (2006), Kumar *et al*. (2006), Tripathi *et al*. (2005b), Ahlawat *et al*. (2005a) and Thakur *et al*. (2000) (Table 5).

Chickpae

Table.1 Yield contributing characters of chickpea as influenced by different fertility management and various row combinations

Treatments	No. of Pods/ Plant	No. of Seeds/ Pod	100 Seed Weight (g)
Fertilizer management-			
F1- 75% RDF	58.8	1.04	17.66
F2- 100% RDF	63.3	1.07	18.15
F3- 125% RDF	65.8	1.14	18.37
S.Em.±	0.65	0.05	0.15
C.D.(5%)	1.86	NS	0.43
Row combinations-			
C1- 2:1	61.6	1.07	17.86
C2- 4:1	62.8	1.09	18.04
C3-6:1	63.7	1.10	18.30
C4- 2:2	61.1	1.06	17.75
C5- 4:2	62.1	1.07	17.86
C6- 6:2	62.9	1.09	18.16
C7-Sole Chickpea	64.2	1.11	18.45
S.Em.±	0.99	0.07	0.23
C.D.(5%)	2.84	NS	0.66

Table.2 Seed yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index as influenced by different fertility management and various row combinations

Treatments	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest Index (%)
Fertilizer management-				
F1- 75% RDF	15.15	18.78	28.08	44.595
F2- 100% RDF	16.86	20.91	33.92	44.655
F3- 125% RDF	0.24	0.58	37.765	44.62
S.Em.±	0.68	0.58	0.775	0.37
C.D.(5%)	0.68	1.65	2.215	NS
Row combinations-				
C1- 2:1	13.15	16.32	29.47	44.6
C2- 4:1	16.50	20.49	36.99	44.605
C3-6:1	16.70	20.70	37.395	44.65
C4- 2:2	10.49	13.04	23.525	44.595
C5- 4:2	13.41	16.66	30.07	44.585
C6- 6:2	14.77	17.99	32.765	44.62
C7-Sole Chickpea	19.02	23.55	42.57	44.675
S.Em.±	0.37	0.88	1.185	0.565
C.D.(5%)	1.04	2.52	3.385	NS

Mustard

Table.3 Yield contributing characters of mustard as influenced by different fertility management and various row combinations

Treatments	Number of siliquae plant^{-1}	Length of siliquae (cm)	Number of seeds siliquae^{-1}	1000-grain weight (g)
Fertility management				
F1- 75% RDF	225.3	5.8	10.5	4.1
F2- 100% RDF	244.8	6.1	11.0	4.2
F3- 125% RDF	253.7	6.3	11.2	4.3
S.Em.±	3.45	0.09	0.14	0.06
C.D.(5%)	9.85	0.26	0.39	0.16
Row combinations				
C1- 2:1	244.5	6.1	11.0	4.2
C2- 4:1	246.3	6.2	11.1	4.3
C3-6:1	250.0	6.3	11.3	4.3
C4- 2:2	236.3	5.9	10.7	4.1
C5- 4:2	239.4	6.0	10.8	4.1
C6- 6:2	242.1	6.1	10.9	4.2
C7-Sole Mustard	230.0	5.8	10.5	4.0
S.Em.±	5.27	0.14	0.21	0.09
C.D.(5%)	15.06	0.40	0.59	0.24

Table.4 Seed yield, stover yield and harvest index as influenced by different fertility management and various row combinations

Treatments	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest Index (%)
Fertility management			
F1- 75% RDF	5.0	18.5	23.78
F2- 100% RDF	6.7	24.4	24.105
F3- 125% RDF	7.6	27.8	24.06
S.Em.±	0.08	0.20	0.09
C.D.(5%)	0.23	0.56	0.26
Row combinations			
C1- 2:1	5.8	21.5	23.855
C2- 4:1	3.8	13.9	24.06
C3-6:1	2.7	10.1	23.68
C4- 2:2	8.7	31.6	24.175
C5- 4:2	5.5	20.5	23.755
C6- 6:2	4.3	15.7	23.97
C7-Sole Mustard	14.4	51.8	24.355
S.Em.±	0.13	0.30	0.14
C.D.(5%)	0.35	0.86	0.39

Table.5 Chickpea yield equivalent (CYE) and land equivalent ratio (LER) as influenced by different fertility management and various row combinations

Treatments	Seed Yield (q ha^{-1})		*CYE (q/ha)	#LER
	Chickpea	Mustard		
T1- 75% RDF- 2:1	11.21	4.46	14.34	1.08
T2- 75% RDF- 4:1	13.44	2.92	15.51	1.08
T3 75% RDF-6:1	14.22	2.02	15.64	1.05
T4- 75% RDF- 2:2	8.77	6.93	13.62	1.25
T5- 75% RDF- 4:2	11.62	4.24	14.64	1.09
T6- 75% RDF- 6:2	12.46	3.18	14.80	1.04
T7- 75% RDF-MUSTARD	0.00	11.28	8.57	1.00
T8- 75% RDF- CHICKPEA	16.43	0.00	16.43	1.00
T9- 100% RDF- 2:1	13.48	6.04	17.66	1.11
T10- 100% RDF- 4:1	16.20	3.95	18.98	1.15
T11-100% RDF-6:1	17.13	2.94	19.19	1.13
T12- 100% RDF- 2:2	10.82	9.11	17.10	1.17
T13- 100% RDF- 4:2	13.77	5.75	17.77	1.12
T14- 100% RDF- 6:2	15.29	4.39	18.42	1.12
T15- 100% RDF-MUSTARD	0.00	14.77	10.99	0.92
T16- 100% RDF- CHICKPEA	19.32	0.00	19.32	1.08
T17- 125% RDF- 2:1	14.77	6.96	19.49	1.13
T18- 125% RDF- 4:1	19.87	4.45	22.96	1.25
T19-125% RDF-6:1	18.76	3.17	20.96	1.12
T20- 125% RDF- 2:2	11.87	10.09	18.78	1.16
T21- 125% RDF- 4:2	14.86	6.52	19.33	1.11
T22- 125% RDF- 6:2	16.57	5.21	20.13	1.13
T23- 125% RDF-MUSTARD	0.00	17.04	12.40	0.96
T24- 125% RDF- CHICKPEA	21.32	0.00	21.32	1.07
S.Em±	0.38	0.37	0.59	-
C.D.(5%)	1.12	1.05	1.69	-
C.V.(%)	6.88	6.13	6.08	-

Table.6 Economics of various treatment combinations

Treatments	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C
T1- 75% RDF- 2:1	16382	65618	49236	3.01
T2- 75% RDF- 4:1	17102	71234	54132	3.17
T3 75% RDF-6:1	17359	72065	54706	3.15
T4- 75% RDF- 2:2	15559	61972	46413	2.98
T5- 75% RDF- 4:2	16382	66846	50464	3.08
T6- 75% RDF- 6:2	16844	67479	50635	3.01
T7- 75% RDF-MUSTARD	12988	34722	21734	1.67
T8- 75% RDF- CHICKPEA	18130	76070	57940	3.20
T9- 100% RDF- 2:1	17218	81011	63793	3.71
T10- 100% RDF- 4:1	17849	87194	69345	3.89
T11-100% RDF-6:1	18074	88367	70293	3.89
T12- 100% RDF- 2:2	16497	78120	61623	3.74
T13- 100% RDF- 4:2	17218	81430	64212	3.73
T14- 100% RDF- 6:2	17623	84330	66707	3.79
T15- 100% RDF-MUSTARD	14244	45448	31204	2.19
T16- 100% RDF-CHICKPEA	18750	89472	70722	3.77
T17- 125% RDF- 2:1	18054	89802	71748	3.97
T18- 125% RDF- 4:1	18596	105699	87103	4.68
T19-125% RDF-6:1	18790	96641	77851	4.14
T20- 125% RDF- 2:2	17435	85982	68547	3.93
T21- 125% RDF- 4:2	18054	88897	70843	3.92
T22- 125% RDF- 6:2	18402	92769	74367	4.04
T23- 125% RDF-MUSTARD	15500	52426	36926	2.38
T24- 125% RDF-CHICKPEA	19370	98708	79338	4.10

Harvest index

The harvest index influenced significantly by fertility management and row combination. The maximum harvest index was found with 100% RDF which was at par with 125% RDF and found significant with 75% RDF in first year and maximum harvest index was found with 100% RDF which was at par with 75% RDF and 125% RDF in second year.

Combination of sole mustard produced significantly higher harvest index which was at par with 4:1 and 2:2 and found significantly superior to rest of the chickpea+mustard row combinations in first year and maximum harvest index was recorded with sole mustard which was at par with 2:2 and 6:2 and significantly superior to rest of the chikpea+mustard row combinations in second year. Interaction effect between fertility management and row combination was not significant.

Harvest index of mustard influenced significantly at different levels of fertilizer in both the years. This might be due to increasing levels of fertilizers to intercrops increases photosynthetic rates and translocation of photosynthate to different plant parts and influenced the yield of intercrops. Abraham *et al*. (2011), Tripathi *et al*. (2005b), Bohra and Srivastava (2002), Singh and Verma (1997) and Singh *et al*. (1998) reported the similar results. The result of this investigation also get supported from those obtained by Kumar and Nandan (2007), Kumar and Singh (2006), Kumar *et al*. (2006), Tripathi *et al*. (2005b), Ahlawat *et al.* (2005a) and Thakur *et al.* (2000).

Chickpea yield equivalent (CYE) and land equivalent yield (LER)

In the present investigation, the maximum CYE and LER were recorded at 125% RDF in a combination of 4:1 chickpea+mustard during both the years of experimentation; differences were found to be significant among the fertility levels in both the years. These findings are in the line of those of Abraham et al. (2011), Srivastava et al. (2007), Tripathi *et al.* (2005a), Varshney and Arya (2004) and Shrivastava *et al.* (1996).

In the present investigation, the maximum CYE and LER was recorded in 4:1 row ratio of chickpea + mustard which was found significantly superior to overall the row combinations. The higher CYE and LER ratio in this row ratio of 4:1 was as result of increase in seed yield of component crop in intercropping systems with little effect on the yield of main crop. This finding is in close conformity with the result of and Kumar and Nandan (2007), Kumar and Singh (2006), Kumar *et al*. (2006), Tripathi *et al*. (2005a), Ali and Mishra (2002) and Pali *et al*. (1997).

Economics

In the present investigation gross return, net return and benefit: cost ratio show significant variation among the fertilizer levels in both the years of investigation. Maximum gross return, net return and benefit: cost ratio was recorded under 125% RDF in both the years. These indices increased with increase in levels of fertilizers up to 125 % RDF, increase in fertilizer levels slightly increased the value of these indices in both the years. This might be due to higher cost involvement in the application of fertilizers at higher fertility level without commensurate increase in the crop yield of the systems. This may have followed the trend of the law of diminishing returns. These results are in close conformity with those of Abraham *et al.* (2011), Srivastava *et al.* (2007), Tripathi *et al*. (2005a), Dubey *et al*. (2001), Tripathi *et al*. (1998) and Shrivastava *et al.* (1996) (Table 6).

Crop production technology not only be technically feasible but it must be economically viable, ecologically sound and sustainable for greater benefit and adoption to the farmers. In the present investigation, maximum gross return, net return and B:C ratio were recorded in 4:1 row ratio of chickpea + mustard in both the years. These results are in accordance with those of Abraham *et al.* (2010), Kumar and Singh (2006), Kumar *et al*. (2006) and Pali *et al*. (2000).

Thus by raising intercrops not only gives additional yield of intercrop but higher net return can also be generated. In the present investigation mustard has been found to be promising and compatible crop for intercropping with chickpea in 4:1 row ratios, which can increase income considerably without any additional land.

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