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Effect of levels of irrigation and fertility on yield and economics of chickpea (*Cicer arietinum*) and Indian mustard (*Brassica juncea*) under sole and intercropping systems

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ABSTRACT

A field experiment was conducted during winter (*rabi*) season of 2005–06 and 2006–07 in the Agronomy Research Farm of Amar Singh College, Lakhaoti, Uttar Pradesh to study the effect of levels of irrigation and fertility on chickpea (*Cicer arietinum* L.) and mustard (*Brassica juncea* L. czernj & coss.) in sole and intercropping systems. The experiment was conducted in split-plot design with 3 replications. The combination of treatments consisted of 3 cropping systems, namely sole mustard (C_1), sole chickpea (C_2) and chickpea + mustard intercropping (C_3) (4:1 raw ratio) and 4 irrigation levels [no irrigation (I_o), irrigation at pre-flowering (I_1), at pod formation (I_2), at both pre-flowering and pod formation (I_3)] for chickpea allotted to main plots and 3 fertility levels [F_1 (20 : 40 : 10 kg N, P_2O_5 and S/ha), F_2 (40 : 60 : 20 kg N, P_2O_5 and S/ha) and F_3 (recommended dose of fertilisers (RDF)] for both the crops on row length basis to sub-plots. The sole Indian mustard recorded higher seed yield compared to intercropping. The yield reduction in mustard was to the tune of 58.9% and 60.0% in the first and second year, respectively, due to intercropping chickpea. Irrigation, on an average increased the mustard yield by 6.47% (I_1), 12.18%(I_2) and 13.18%(I_3) compared to no irrigation (I_o). Similarly fertilizer treatments F_2 and F_3 on an average increased mustard yield by 10.17% and 18.46%, respectively, over the F_1. The intercropping of chickpea and mustard in 4:1 raw ratio was significantly superior to sole crops of either chickpea or mustard in terms of yield and economics. Between the sole crops, chickpea was better as compared to mustard. Application of recommended dose of fertilizers (20 : 60 : 20 kg, N, P_2O_5 and S/ha) on area basis was superior.

Key words: Chickpea + mustard, Economics, Fertility, Harvest index, Intercropping, Irrigation, Yield

Chickpea (*Cicer arietinum* L.) is a leading pulse crop in India, grown in 6.72 million ha with annual production of 5.47 million tonnes and average productivity of 815 kg/ha (FAI 2006). Likewise, the Indian mustard (*Brassica juncea* L. czern & coss.) stands second in edible oil seed production with an area of 7.32 million ha and production of 7.59 million tonnes at an average productivity of 1 038 kg/ha (FAI 2006). In India chickpea and mustard are commonly grown either in sole or intercropping system. However, not much research effort has been made to augment the productivity of chickpea+ mustard intercropping system. Hence, an experiment was conducted to study the effect of levels of irrigation and fertility on chickpea and mustard in sole and intercropping systems.

MATERIALS AND METHODS

Field experiments were conducted during winter (*rabi*) season of 2005–07 at the Agronomy Research Farm of the Amar Singh College, Lakhaoti, Bulandshahr, Uttar Pradesh situated (28°1′ N, 77°.1′E and 228.6 m above mean level). The soil was sandy loam in texture, well drained, poor in organic carbon (0.33%) and of medium fertility with *p*H 7.4. The available N was 353 kg/ha, available P_2O_5 was 9.52 kg/ha and available K_2O_5 was 158 kg/ha. The experiment was laid out in split-plot design with 3 replications. The main plot consisted combination of 2 factors, i e cropping system - sole mustard (50 cm) [C_1], sole chickpea (25 cm) [C_2] and chickpea + mustard (4:1 ratio) [C_3] and irrigation levels, viz no irrigation (I_0), irrigation to chickpea at pre-flowering stage

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(I_1), at pod formation (I_2) and at pre-flowering and pod formation stages (I_3). Fertilizers were applied as per the treatments 3 fertility levels [NPS dosage (kg/ha)]. Fertilizer levels included [20:40:10 (F_1), 40:60:20 (F_2), Recommended dose of fertilizers (20-60-20 N, P_2O_5 and S (F_3) for both the crops were applied. Since the levels of NPK were same for both the crops, the application of required doses to either of the sole crops of chickpea and mustard and to both the crops intercropped could be easily and uniformly done. The test varieties were 'Avrodhi' chickpea and 'B 70' Indian mustard. The seed and stover yield, harvest index and economics were recorded and statistically analyzed.

RESULTS AND DISCUSSION

The seed yield of mustard was significantly affected by irrigation and fertilizer application. The sole mustard (C_1) recorded higher seed yield compared to intercropping (C_3) (Table 1). The yield reduction in mustard was to the tune of 58.9 and 60.0% in the first and second year, respectively due to intercropping chickpea. The reduction in yield of intercropped mustard attributed to lesser number of plants in 4: 1 row ratio.

Irrigation levels influenced the seed yield of mustard significantly. Irrigation of chickpea at pre-flowering stage at pod-formation stage and 2 irrigations at pre-flowering and pod-formation stages recorded an increase in seed yield of 4.7, 12.2 and 11.3% in first year and 8.24, 12.15 and 15.05% in second year, respectively over the no irrigation. The 2 irrigations at pre-flowering and pod-formation stages of chickpea and irrigation at pod-formation stage of chickpea being at par with each other recorded significantly higher yield over the irrigation at pre-flowering stage of chickpea and no irrigation, which were in turn significantly different from each other. Sharma *et al*. (2005) also reported similar finding of increasing yield with irrigation levels. The recommended dose of fertilizers applied to mustard crop recorded significantly higher seed yield over 40:60:20 kg N, P_2O_5 and S/ha and 20:40:10 kg N, P_2O_5 and S/ha. The quantum of increase in seed yield due to 40 N, 60 P_2O_5 and 20 S kg/ha and recommended dose of fertilizer applied to mustard over 20 N, 40 P_2O_5 and 10 S kg/ha were 10.6 and 16.6% in the first year and 9.73 and 20.31% in the second year, respectively. The availability of nutrient is an important factor for better growth, with the availability of nutrients in optimum amount in recommended dose of fertilizer showed better growth and yield attributes which culminated in higher yield.

The stalk yield was also affected by different treatments. There was a reduction in the stalk yield of mustard when intercropped with chickpea compared with the sole mustard by 60.3 and 60.1% in first and second year, respectively. This is due to lesser number of plants in intercropping as compared to the sole mustard. Although growth parameters were superior in intercropped mustard, it was not sufficient

Table 1 Seed yield, stalk yield and harvest index of mustard as influenced by cropping systems, irrigation and fertility levels

Treatment	2005–06			2006–07		
	Seeds yield (kg/ha)	Stalk yield (kg/ha)	Harvest index (%)	Seeds yield (kg/ha)	Stalk yield (kg/ha)	Harvest index (%)
Cropping system						
Sole mustard	1 487.2	5 571.6	21.07	1 512.7	5 546.1	21.43
Chickpea+mustard(4:1)	6 10.5	2 213	21.62	605.3	2 212.2	21.48
SEm±	0.09	0.09	0.25	0.09	0.09	0.19
CD (*P*=0.05)	0.27	0.27	NS	0.27	0.28	NS
Irrigation level						
No irrigation	979.8	3 961.3	20.11	972.8	3 968.3	20.07
Irrigation at pre-flowering	1 026.1	3915	20.89	1053	3 888.2	21.29
Irrigation at pod formation	1 099.4	3 841.8	22.36	1091	3 850.2	21.99
Irrigations at pre-flowering + pod formation	1 090.1	3 851.1	22.02	1119.2	3 810.0	22.46
SEm±	0.13	0.13	0.35	0.13	0.13	0.26
CD (*P*=0.05)	0.38	NS	1.05	0.38	NS	0.80
Fertility level						
N_{20} $P_2O_{5\text{-}40}$ S_{10}	961.5	3 979.7	19.56	962.6	3 969.6	19.34
N_{40} $P_2O_{5\text{-}60}$ S_{20}	1 063.8	3 877.3	21.62	1056.3	3 884.9	21.49
N_{20} $P_2O_{5\text{-}60}$ S_{20} (RDF)	1 121.2	3 820	22.86	1158.1	3783	23.54
SEm±	0.07	0.06	0.16	0.11	0.11	0.21
CD (*P*=0.05)	0.19	NS	0.47	0.31	NS	0.60

RDF, Recommended dose of fertilizers

to improve stalk yield compared to sole mustard. The fertilizer and irrigation levels did not have any significant influence on the stalk yield of mustard. Since the increased availability of moisture and nutrients invariably lead to increased growth and further transfer of photosynthates to reproductive organs, the vegetative growth remained more or less at par. As a result, no significant differences were observed due to irrigation and fertility levels.

The harvest index was not significantly influenced by the cropping systems. However, irrigation levels brought about significant influence on harvest index in both the years. Two irrigations applied at pre-flowering and pod-formation stages of chickpea being at par with 1 irrigation at pod formation stage recorded significantly higher harvest index over 1 irrigation at pre-flowering stage of chickpea and no irrigation. One irrigation at pre-flowering stage of chickpea also recorded significantly higher harvest index as compared to no irrigation. The recommended dose recorded significantly higher harvest index as compared to 40:60:20 kg N, P_2O_5 and S/ha and 20:40:10 kg N, P_2O_5 and S/ha which were in turn significantly different from each other. Although intercropped mustard recorded higher harvest index, it was not statistically different with the sole mustard, indicating that the favourable conditions in chickpea + mustard (4:1 ratio) were not good enough to record significant increase. The higher moisture and fertility levels are known to increase the vegetative growth and the transfer of photosynthates to reproductive organs, thereby tend to increase the yield.

The seed yield of chickpea was not affected significantly by the cropping systems. Both sole chickpea and intercropped chickpea recorded yield at par with each other (Table 2).

Among the irrigation levels, 2 irrigations at pre-flowering and pod-formation stages of chickpea recorded significantly higher seed yield as compared to all other treatments. One irrigation at pre-flowering stage of chickpea and one irrigation at pod formation stage of chickpea being at par with each other recorded significantly higher yield as compared to no irrigation. One irrigation either at pre-flowering or at pod-filling stage provided good moisture conditions during critical growth stage resulting in higher yield attributes which in turn increased the seed yield. Ahlawat *et al*. (2005) also reported that frequent irrigation were useful in increasing the seed yield of chickpea. The recommended dose of fertilizers on area basis to both the crops being at par with 40:60:20 kg N, P_2O_5 and S/ha - recorded significantly higher seed yield over 20:40:10 kg N, P_2O_5 and S/ha in both the years of study. Similar increase in yield due to fertilizer application was also reported by Chand and Tripathi (2005).

The stover yield of chickpea was significantly higher in sole chickpea in first year of study while both sole chickpea and intercropped chickpea recorded stover yield at par in the second year. It was mainly due to higher plant population in it. It is obvious that with the increased plant population there would be higher stover yield in any crop. The two

Table 2 Seed yield, stover yield and harvest index(%) of chickpea as influenced by cropping systems, irrigation and fertility

Treatment	2005–06			2006–07		
	Seeds yield	Stover yield	Harvest index	Seeds yield	Stover yield	Harvest index
Cropping system						
Sole chickpea	1 063	3 179	24.98	1 203	3 285	26.71
Chickpea+mustard(4:1)	1 043	2 995	25.78	1 195	3 193	27.14
SEm±	14	46	0.11	14.15	45.96	0.17
CD (*P*=0.05)	NS	140	0.33	NS	NS	NS
Irrigation level						
No irrigation	876	2 734	24.29	906	2 640	25.58
Irrigation at pre-flowering	1 030	3 066	25.16	1 231	3 388	26.68
Irrigation at pod formation	1 088	3 181	25.50	1 270	3 386	27.31
Irrigations at pre-flowering + pod formation	1217	3 367	26.57	1 387	3 543	28.15
SEm±	19.96	65	0.16	20.02	65.00	0.24
CD (*P*=0.05)	60.55	198	0.47	60.72	197.17	0.72
Fertility level						
N_{20} $P_2O_{5\text{-}40}$ S_{10}	980	2 963	24.85	1 158	3 241	26.27
N_{40} $P_2O_{5\text{-}60}$ S_{20}	1 073	3 161	25.30	1 204	3 246	26.98
N_{20} $P_2O_{5\text{-}60}$ S_{20} (RDF)	1 106	3 138	25.98	1 234	3 230	27.54
SEm±	12	43	0.10	17.42	51.76	0.12
CD (*P*=0.05)	35	124.46	0.28	50.21	NS	0.34

RDF, Recommended dose of fertilizers

irrigations at pre-flowering and pod-filling stages of chickpea recorded the highest stover yield of chickpea. One irrigation at pre-flowering stage and at pod formation stage of chickpea being at par with each other recorded significantly higher stover yield over no irrigation. This might be ascribed to better and prolonged growth in these treatments as compared to no irrigation. The recommended dose of fertilizers and 40:60:20 kg N, P_2O_5, and S/ha being at par with each other recorded significantly higher stover yield over 20:40:10 kg N:P_2O_5:S/ha in first year, due to better nutrient availability. However such differences among fertility levels were not observed in stover yield during second year.

The intercropped chickpea recorded significantly higher harvest index in the first year while there was no such difference among the cropping systems in the second year. One irrigation at pre-flowering stage of chickpea or at pod-filling stage of chickpea being at par recorded significantly higher harvest index compared with the no irrigation. The fertility levels being significantly different from each other showed superiority in the order of F_3>F_2 >F_1 in respect of the harvest index. Since the two irrigations at pre-flowering and pod-formation stages of chickpea and recommended dose of fertilizers on area basis to both the crops provided the moisture and nutrients in optimum quantity for longer period, these treatments recorded higher harvest index as compared to other treatments.

Economics

The gross returns, net returns and B:C ratio were significantly higher in intercropping of chickpea and mustard in 4:1 row ratio as compared to their sole crops (Table 3). As the investments in intercropping systems did not differ significantly, the higher yield of the system added to increased gross return, net return and B:C ratio. The sole chickpea with higher value for its produce was significantly superior to sole mustard.

Among the irrigation levels, 2 irrigations at pre-flowering and pod-formation stages of chickpea recorded the highest gross returns and net returns as compared to other irrigation treatments. This was due to higher seed yield of both the crops in this treatment. When a particular treatment increases yield of crops it tends to increase the gross and net returns. But the highest B:C ratio was recorded in one irrigation at pod-filling stage of chickpea. All the irrigation levels recorded significantly higher values of these as compared to no irrigation. Since one additional irrigation proportionately increase the cost as compared to output in terms of seed yield and thus B:C ratio tended to be lower in case of 2 irrigations as compared to 1 irrigation. Application of recommended dose of fertilizers on area basis to both the crops recorded significantly higher gross returns, net returns and B: C ratio as compared to 40-60-20 kg N, P_2O_5 and S/ha which was in turn significantly superior to 20-40-10 kg N, P_2O_5 and S/ha.

Table 3 Gross returns, net returns and B:C ratio as influenced by cropping systems, levels of irrigation and fertility

Treatment	2005–06			2006–07		
	Gross returns (Rs /ha)	Net returns (Rs /ha)	B:C ratio	Gross returns (Rs /ha)	Net returns (Rs /ha)	B:C ratio
Cropping system						
Sole mustard	2 2308	10 411	0.88	22 690	10 793	0.91
Sole chickpea	3 6093	20 276	1.27	31 913	16 096	1.01
Chickpea+mustard(4:1)	4 5018	29 985	1.98	40 375	25 342	1.68
SEm±	378	378	0.02	370	370	0.02
CD (*P*=0.05)	1 108	1 108	0.07	1 085	1 085	0.07
Irrigation level						
No irrigation	2 7935	14 685	1.10	27 267	14 018	1.05
Irrigation at pre-flowering	3 4897	20 648	1.41	31 142	16 893	1.17
Irrigation at pod formation	3 6404	22 154	1.52	32 678	18 428	1.27
Irrigations at pre-flowering + pod formation	3 8657	23 408	1.49	35 552	20 302	1.30
SEm ±	436	436	0.03	427	427	0.03
CD (*P*=0.05)	1 279	1 279	0.08	1 252	1 252	0.08
Fertility level						
N_{20} $P_2O_{5\text{-}40}$ S_{10}	32 777	18 766	1.29	29 242	15 230	1.07
N_{40} $P_2O_{5\text{-}60}$ S_{20}	34 732	20 340	1.37	32 027	17 635	1.20
N_{20} $P_2O_{5\text{-}60}$ S_{20} (RDF)	35 911	21 567	1.46	33 709	19 365	1.33
SEm±	350	350	0.02	274	274	0.02
CD (*P*=0.05)	997	997	0.06	779	779	0.05

RDF: Recommended dose of fertilizers

Table 4 Chickpea equivalent yield and land equivalent ration as influenced by cropping systems, irrigation and fertility levels

Treatment	2005–06		2006–07	
	Chickpea equivalent yield	Land equivalent ratio	Chickpea equivalent yield	Land equivalent ratio
Cropping system				
Sole mustard	743	1.0	756	1.00
Sole chickpea	1 203	1.0	1 063	1.00
Chickpea+mustard(4:1)	1 500	1.41	1 345	1.39
SEm±	12.59	0.01	12.33	0.01
CD (*P*=0.05)	36.93	0.02	36.15	0.04
Irrigation level				
No irrigation	931	1.14	908	1.15
Irrigation at pre-flowering	1 163	1.13	1 038	1.14
Irrigation at pod formation	1 213	1.15	1 089	1.13
Irrigations at pre-flowering + pod formation	1 288	1.13	1 185	1.10
SEm±	14.54	0.01	14.23	0.02
CD (*P*=0.05)	42.64	NS	41.74	NS
Fertility level				
N_{20} $P_2O_{5\text{-}40}$ S_{10}	1 092	1.14	974	1.12
N_{40} $P_2O_{5\text{-}60}$ S_{20}	1 157	1.13	1 067	1.13
N_{20} $P_2O_{5\text{-}60}$ S_{20} (RDF)	1 197	1.13	1 123	1.13
SEm±	11.68	0.01	9.12	0.01
CD (*P*=0.05)	33.25	NS	25.96	NS

RDF, Recommended dose of fertilizers

The fertilizer requirement of crops on the basis of their needs in F_3 recorded higher seed yield as compared to other fertility levels, it in turn showed higher gross returns, net returns and B: C ratio. Kumar *et al.* (2005) and Tripathi *et al.* (2005) also reported higher net returns and B:C ratio due to intercropping in chickpea.

The combinations of C_3 and I_3 recorded the highest chickpea equivalent yield among the different combinations in both the years of study. The combinations of C_3 and F_3, I_3 and F_3 recorded significantly higher chickpea equivalent yield during second year (Table 4).

In view of the soil-plant relationship, it is well understood that the growth of crops and its potential of production is governed by nutritional availability and management, besides many other relevant factors. Root interface interactions in soil has been an influential and additional factor for crop growth and thus often an intercropping system has been found as encouraging agronomic technology. The proportion of intercrops obviously depends on the shoot length, crop canopy and rooting system.

Accordingly, a portion of 4:1 ratio of chickpea and mustard intercropping was considered as preferable option by virtue of the characteristics of two crops.

Hence, the system of intercropping of chickpea and mustard in 4:1 row ratio was significantly superior to sole crops of either chickpea or mustard. Between chickpea and mustard, cultivation of chickpea was better as compared to mustard from the economic point of view. If two irrigations are available, their application during pre-flowering and pod-filling stage of chickpea will result in higher yield. Application of recommended dose of fertilizers on area basis to both the crops was found superior as compared to either 20:40:10 kg N, P_2O_5 and S/ha or 40:60:20 kg N,P_2O_5 and S/ ha.

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