Indian Journal of Agricultural Sciences **81** (8): 772–5, August 2011

Evaluation of performance of chickpea (*Cicer arietinum*) and mustard (*Brassica juncea*) intercropping system vis-à-vis their sole crops as influenced by irrigation regimes and fertility gradients *

THOMAS ABRAHAM[1], O V S THENUA[2] and U C SHARMA[3]

Agronomy Amar Singh (PG) College, Lakhaoti, Bulandshahr, Uttar Pradesh

Received: 10 August 2009; Revised accepted: 25 May 2011

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

In India, pulses are grown annually in an area of about 23.86 million ha with a production of 15.12 million tonnes, with the average productivity of meager 633 kg/ha (Ministry of Agriculture 2008). However, India's demand of pulses by 2020 is expected to be as high as 22.3 to 23.8 million tonnes (Ministry of Agriculture 2008). Among the potential pulse crops in the country, chickpea (*Cicer arietinum* L.) is a leading pulse crop which is grown in 7.58 million ha with annual production of 6.91 million tonnes registering an average productivity of 911 kg/ha (Ministry of Agriculture 2008). Similarly, the rapeseed and mustard (*Brassica juncea* L.) stands second in edible oil production in the country with an area of 5.75 million ha and production of 5.80 million tonnes with an average productivity of 1 009 kg/ha (Ministry of Agriculture 2008). Chickpea and mustard are commonly grown either as sole crops or in an intercropping system in the major growing areas in India (Kumar *et al.* 2005). Intercropping is also thought to improve agronomic efficiency and environmental performance (Shili-Touzi *et al.* 2010) apart from enhancing phyto-extraction potential of crops (Hamlin *et al.* 2006). However, not much research efforts have been made to enhance the productivity of the system in these regions (Ahlawat *et al.* 2005, Arya *et al.* 2007).

The field experiments were laid out in split-plot design with three replications during winter (*rabi*) season of 2005–06 and 2006–07 at the Agronomy Research Farm, Amar Singh College, Lakhaoti, Bulandshahr, situated at $28^{0}1'$ N,$77^{0}1'$E and 228.6 m asl. The soil was sandy loam in texture, well drained and of medium fertility with slightly alkaline in reaction (*p*H 7.4). It was poor in organic carbon (0.33%), medium in phosphorous (24 kg/ha) and high in potash content (205 kg/ha). The main plot consisted of combination of two factors, viz cropping system - sole mustard sown at a row distance of 50 cm (C_1), sole chickpea sown at a row distance of 25 cm (C_2) and chickpea + mustard (4:1 ratio of rows) (C_3) and four irrigation levels were proposed keeping chickpea in the view, viz no irrigation (I_0), irrigation at pre-flowering stage (I_1), irrigation at pod formation (I_2) and irrigation at pre-flowering and pod formation of chickpea (I_3). The sub-plots consisted of three levels of fertilization, viz 20 N: 40 P_2O_5: 10 S kg/ha (F_1), 40 N: 60 P_2O_5: 20 S kg/ha (F_2) and the recommended dose of fertilizers, viz 20 N: 60 P_2O_5: 20 S kg/ha (F_3). The test varieties were 'Avrodhi' of chickpea and 'B70' of mustard. All the operations were carried out as per treatments proposed and the plant protection measures were attempted as and when required.

Prior to harvesting, for determining the dry weight of the plant and uptake of N, P and S, plants standing in 1 m length in the middle of the middle row in each treatment plot of sole crops of chickpea and mustard and similarly, plants in one of the middle two rows of chickpea and similar length segment having only one row of mustard were earmarked. These earmarked sites of plant rows were kept moistened overnight by water application prior to digging the plants from 30 cm depth with roots intact. After digging out the plants the soils stuck to the roots were removed by forced tap water. The plants were then counted and seeds were separated and saved for adding to the plot yield obtained from various treatment plots for computing the yield on hectare basis. Further, the sampled plant parts were cut into pieces for easy handling and placed in the oven at 65°C for 48 hr before their dry weights were recorded. The dry weight per plant as well as on hectare basis were computed from the counted number of sampled plants/m multiplied by the total length of crop rows in a hectare for calculating N,P and S uptake. For calculating the nutrient uptake, the dried plant samples including root and shoot of chickpea and mustard were ground to pass through 40 mesh sieve in a "macro wiley

*Short note

Part of Ph D thesis of the first author submitted to CCS University, Uttar Pradesh in 2008

[1]Research Scholar, [2]Head, Departmental of Agronomy, [3]Research Associate, NAIP KAB II, Pusa, New Delhi 110 012

mill" and N, P and S were determined separately. Incorporating the values for straw and seed yield in kg/ha, the total uptake was calculated by the following formula:

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Straw yield} \times \text{nutreint content (\%)}}{100} + \frac{\text{Seed yield} \times \text{nutrient content (\%)}}{100}$$

Land equivalent ratio (LER), which is the relative size of land under a sole crop system was computed using the following formula:

$$\text{LER} = \frac{\text{Y ab}}{\text{Y aa}} + \frac{\text{Y ba}}{\text{Y bb}}$$

Where, Yab = Yield of 'a' grown in mixture (a and b), Yba = Yield of 'b` grown in mixture (a and b), Yaa = Yield of 'a' in pure stand and Ybb = Yield of 'b' in pure stand.

Further, chickpea equivalent yield was calculated by converting the seed yield of mustard into chickpea equivalent yield, based on the prevailing selling prices of the commodities by the following formula:

$$\text{Chickpea equivalent yield} = \frac{\text{Seed yield of mustard (kg/ha)}}{\text{Price of sole crop of mustard (₹/kg)}}$$

The data obtained on growth, yield and nutrient uptake were statistically analysed for computing the critical difference (CD) at 5% level of significance as per the technique commonly used for split-plot design.

The findings on the impact of cropping systems, irrigation regimes and fertility gradients on the biomass production; N, P and S uptake; and seed yield of chickpea and mustard are presented in Tables 1, 2. From the perusal of the data it is clear that the agronomic practices investigated herein had variable effects on various traits in space and time. For example, in the first year, intercropped chickpea (C_3) recorded significantly higher dry matter accumulation, whereas in the second year, there was no effect of cropping systems on biomass production. This suggests that weather conditions also play important role in drymatter accumulation. The drymatter accumulation was higher in intercropped chickpea (C_3) as compared to sole chickpea (C_1). This may be due to slightly wider space and lesser competition that prevailed in the intercropped crop as compared to sole chickpea. Likewise, two irrigations in first year and only one irrigation in second year recorded higher drymatter accumulation showing enhanced growth as compared to the crop receiving no irrigation. As far as the effect of nutrients were concerned the fertility status provided by recommended dose of 20 N: 60 P_2O_5: 20 S kg/ha resulted in significantly higher dry matter accumulation as compared to fertility levels either lower or higher than the recommended dose. The recommended dose of fertilizers to both the crops (F_3) led to higher drymatter accumulation as compared to other fertility levels. Obviously, it is attributable to increased availability of nutrients (Table 1) as per its requirement unlike in other two treatments, which were not suitable to the chickpea. However, the dry matter accumulation in mustard was not significantly affected by the cropping systems. Further, intercropped mustard (C_3) too did not acquire any additional benefit by available space.

As far as the crop-nutrient relationship is concerned, the sole mustard extracted (C_1) significantly higher amount of N, P and S as compared to intercropped mustard (C_3) in both years of experimentation. Although N and S contents in seeds and stalk were at par in both the cropping systems. The total uptake of N was significantly higher in sole mustard (C_1) as compared to intercropped mustard (C_3). Further, although

Table 1 Dry matter production (DMP) at harvest and total N, P and S uptake by mustard and chickpea (kg/ha) as influenced by cropping systems, irrigation regimes and fertility gradients

Treatment	Mustard				Chickpea			
	DMP (g/plant)	N	P	S	DMP (g/plant)	N	P	S
Cropping systems								
Sole mustard/sole chickpea	63.52	76.21	12.32	22.47	12.84	46.97	15.04	7.25
Chickpea+mustard (1:4)	63.63	30.91	4.99	9.12	13.38	46.25	14.67	7.02
CD (*P*=0.05)	NS	1.84	0.22	0.44	0.55	NS	NS	NS
Irrigation levels								
No irrigation	60.58	49.19	8.21	15.12	11.96	36.57	12.00	5.72
Irrigation at flowering stage	63.92	53.50	8.77	15.87	13.28	46.92	15.34	7.23
Irrigation at pod formation stage	64.99	55.45	8.73	15.88	13.23	49.17	15.51	7.60
Irrigation at flowering+pod formation stage	64.81	56.10	8.90	16.31	13.96	53.77	16.58	7.99
CD (*P*=0.05)	2.42	2.60	0.31	0.63	0.60	2.83	0.97	0.40
Fertility levels								
N20 P_2O_5-40 S10	59.05	47.78	8.11	14.97	12.70	43.31	13.85	6.44
N40 P_2O_5-60 S20	63.27	53.89	8.68	15.90	13.20	47.24	15.01	7.19
N20 P_2O_5-60 S20 (RDF)	68.40	59.01	9.17	16.51	13.43	49.29	15.71	7.77
CD (*P*=0.05)	1.41	1.67	0.18	0.29	0.39	1.90	0.65	0.31

Table 2 Effect of cropping systems, irrigation regimes and fertility gradients on the yield of mustard and chickpea

Treatment	Mustard seed yield (kg/ha)		Chickpea seed yield (kg/ha)	
	2005–06	2006–07	2005–06	2006–07
Cropping systems				
Sole mustard	1 487.2	1 512.7	1 063.8	1 203.1
Chickpea + mustard (4:1)	610.5	605.3	1 043.2	1 195.2
CD (*P*=0.05)	27	27	NS	NS
Irrigation levels				
No irrigation	979.8	972.8	876.9	906.8
Irrigation at flowering	1 026.1	1 053	1 030.6	1 231.8
Irrigation at pod formation	1 099.4	1 091	1 088.4	1 270.5
Irrigation at flowering+ irrigation at pod formation	1 090.1	1 119.2	1 217.9	1 387.8
CD (*P*=0.05)	38	38	60.5	60.7
Fertility levels				
N20 P_2O_5-40 S10	961.5	962.6	980.8	1158.1
N40 P_2O_5-60 S20	1 063.8	1 056.3	1 073.2	1 204.7
N20 P_2O_5-60 S20 (RDF)	1 121.2	1 158.1	1 106.4	1 234.9
CD (*P*=0.05)	19	31.2	35.7	50.2

Table 3 Chickpea equivalent yield and land equivalent ratio as influenced by cropping systems, irrigation and fertility gradients

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
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
CD (*P*=0.05)	42.64	NS	41.74	NS
Fertility level				
N20 P_2O_5-40 S10	1 092	1.14	974	1.12
N40 P_2O_5-60 S20	1 157	1.13	1 067	1.13
N20 P_2O_5-60 S20 (RDF)	1 197	1.13	1 123	1.13
CD (*P*=0.05)	33.25	NS	25.96	NS

RDF, Recommended dose of fertilizers

there was no higher content of P in seed, it was sufficient to enhance the total P uptake of intercropped mustard (C_3) as compared to sole mustard (C_1) due to higher dry matter production and higher yield (Table 1). Likewise, irrigation levels too had significant impact on the total uptake of N, P and S with the seasons once again exerting variable effects such that the effects of one irrigation at pod-filling stage of chickpea (I_2) and two irrigations at pre-flowering and pod-filling stages of chickpea (I_3) were at par with each other, though recorded higher total N uptake as compared to no irrigation (I_0).

The seed yield of mustard was significantly affected by all the treatments employed. Between sole mustard (C_1) and intercropped mustard (C_3), the sole mustard (C_1) recorded significantly higher seed yield as compared to intercropped mustard (C_3). The decrease in the intercropped mustard yield was to the tune of about 59% as compared to its sole crop. The irrigation levels also recorded significant impact on the seed yield of mustard. In general, irrigation at pod-filling stage proved more beneficial than at other growth stage enhancing the yield by about 12%. The application of recommended dose of fertilizers to both the crops (F_3) recorded significantly higher seed yield over other two fertilizer doses. The quantum of increase in seed yield due to F_2 and F_3 over F_1 varied between 10% and 20% on the average (Table 2). Similar findings on nutrient response in intercropping system were also reported by Arya *et al.* (2007) and Ghosh *et al.* (2009).

Ahlawat *et al.* (2005) reported that frequent irrigations were useful in increasing the seed yield of chickpea and it could be due to higher nutrient uptake due to two irrigations. The seed yield was not significantly affected by the cropping systems. Results revealed that the lesser number of plants in intercropped chickpea (C_3) was compensated by the better growth and yield attributes. On the other hand, the combinations of C_3 and I_3 recorded the highest chickpea equivalent yield amongst the different combinations in both the years of experiment. The combinations of C_3 and F_3, I_3 and F_3 were found to have significantly higher chickpea equivalent yield during second year (Table 3). Therefore, in view of the soil-plant relationship, it is clear that the growth of crops and its potential of production are governed by nutritional availability and management, besides many other relevant factors (Migliaccio *et al.* 2008, Bhattarai *et al.* 2008). Root-interface interactions in soil are crucial factors for crop growth and thus, often an intercropping system has been found an encouraging agronomic practice. The proportion of intercrops apparently depends on the crop canopy, shoot length and rooting system. Hence, a proportion of 4:1 ratio of chickpea and mustard intercropping is suggested to be a preferable option by virtue of the characteristics of two crops as the gross returns, net returns and cost : benefit (C:B) ratio were significantly higher in intercropped chickpea and mustard in comparison to their sole crops.

SUMMARY

The system of intercropping of chickpea and mustard in 4:1 row ratio is significantly superior to sole crops of either chickpea or mustard. Among chickpea and mustard, cultivation of chickpea was better in comparison to mustard from the economic point of view. From the practical point of view, the findings revealed that when the two irrigations are expected to be available, their application during pre-flowering and pod-filling stage of chickpea would result in higher yield. Further, the recommended dose of fertilisers (20 N: 60 P_2O_5: 20 S kg/ha) application to both the crops was found superior in comparison to either 20 N:40 P_2O_5:10 S kg/ha or 40 N:60 P_2O_5:20 S kg/ha. The biomass production and the nutrient uptake by chickpea and mustard crops were found well tuned with the irrigation regimes and fertility gradients.

REFERENCES

Ahlawat, I P S, Gangaiah, B and Singh, O. 2005. Irrigation requirement in gram (*Cicer arietinum*) +Indian mustard (*Brassica juncea*) intercropping system. *Indian Journal of Agricultural Sciences* **75** (1) : 23–6.

Ministry of Agriculture. 2008. *Agricultural Statistics at a Glance*. Ministry of Agriculture, New Delhi.

Arya R L, Varshney and J G, Lalit K. 2007. Effect of integrated nutrient application in chickpea+mustard intercropping system in semi arid tropics of North India. *Communications in Soil Science and Plant Analysis* **38** (2) : 229–0.

Bhattarai S P, Midmore D J and Pendergast L. 2008. Yield, water-use efficiencies and root distribution of soybean, chickpea and pumpkin under different subsurface drip irrigation depths and oxygation treatments in vertisols. *Irrigation Science* **26** (5) : 439–50.

Ghosh P K, Tripathi A K, Bandyopadhyay K K and Manna M C. 2009. Assessment of nutrient competition and nutrient requirement in soybean/sorghum intercropping system. *European Journal of Agronomy* **31** (1) : 43–50.

Hamlin R L and Barker A V. 2006. Phytoextraction potential of Indian mustard at various levels of zinc exposure. *Journal of Plant Nutrition* **29** (7) : 1257–72.

Kumar S, Verma K P, Ram S and Kushwaha S P. 2005. Evaluation of chickpea (*Cicer arietinum*) and yellow sarson (*Brassica compestris*) inter cropping patterns under rainfed condition in central plain zone of U.P. *Plant Archives* **5** (1): 145–8.

Migliaccio K W, Schaffer B, Li Y C, Evans E, Crane J H and Muñoz-Carpena R. 2008. Assessing benefits of irrigation and nutrient management practices on a southeast Florida royal palm (*Roystonea elata*) field nursery. *Irrigation Science* **27** (1) : 57–66.

Shili-Touzi I, Tourdonnet S, deLaunay M and Dore T. 2010. Does intercropping winter wheat (*Triticum aestivum*) with red fescue (*Festuca rubra*) as a cover crop improve agronomic and environmental performance? A modeling approach. *Field Crops Research* **116** (3) : 218–29.