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Research Paper

Effect of weed management on chickpea (*Cicer arietinum*) + Indian mustard (*Brassica juncea*) intercropping system under irrigated conditions of Jammu region

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ABSTRACT

A field experiment was carried out during the winter (*rabi*) season of 2009–10 and 2010–11 at Chatha, Jammu, to assess the yield along with the monetary benefits in chickpea (*Cicer arietinum* L.) and Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson] intercropping system with different weed-management practices. Significantly higher values of plant height of chickpea (63.36 cm) and Indian mustard (174.72 cm), dry-matter accumulation of chickpea (22.13 g/plant) and Indian mustard (117.22 g/plant) were recorded under sole stands of the each crop followed by chickpea + Indian mustard (replacement series) intercropping system. Both the sole crops gave higher yields than chickpea + Indian mustard, when grown in additive and replacement series in the respective order. The highest chickpea-equivalent yield (1.39 t/ha), land-equivalent ratio (1.65), net returns (₹24,415/ha) and benefit: cost (1.63) ratio were obtained in chickpea + Indian mustard intercropping system in additive followed by replacement series. Weed management practices not only reduced the density and dry weight of weeds but also increased crop production potential of the intercropping system (productivity). Application of pendimethalin @ 1 kg/ha as pre-emergence recorded the maximum weed-control efficiency (85.16%), net returns (₹20,373/ha) and benefit: cost ratio (1.71) followed by the application of fluchloralin @ 1kg/ha.

Key words : Chickpea + Indian Mustard intercropping, Chickpea equivalent yield, Economics, Weed-control efficiency, Weed density

Intercropping system is recognized as a potential weed management practice in widely spaced crops. The weed-suppression efficiency depends largely on the nature of the component crops in an intercropping system. This necessitates that a systematic study on weed dynamics in such crops is essential for strategic weed-management planning. Further, a weed-control method to be accepted by the farmers must be agronomically feasible, economically viable and should be under the farmer's manageable capacity. Among the various methods of weeds control, the traditional methods of weed control like hand-weeding, hoeing, and intercultural operations have many limitations. These are very often back breaking, costly, time-consuming and needs so much of human labour/resource that this work often gets neglected or is given up during the peak periods of labour shortage. Besides, such weed-control measures are often also rendered uncertain due to interference of rains. The use of the herbicides is, thus, the only resort as it offers a good scope for timely and adequate control of weeds. Efficiency of weed control in crops can be further enhanced if herbicidal treatments are coupled with intercropping rather than their sole cropping as intercropping also plays a very significant role in suppression of weeds through their smothering effect. Since chickpea is a poor competitor to weeds because of its slow growth rate and limited leaf-area development at early stages of crop growth and establishment, an intercropping of Indian mustard in chickpea coupled with effective weed-control measures may help the farming community to realize the potential yield of chickpea to its maximum with an additional yield of Indian mustard, which is raised as an intercrop.

Intercropping is a feasible and viable agronomic practice for stepping up the production of pulses and oilseeds from a unit of land during a cropping period. Plant population and spatial arrangement in intercropping have important effects on the balance of competition between

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component crops and their productivity. Cultivation of Indian mustard as an intercrop in chickpea is common in India. Scientific approach of intercropping of these 2 crops increases the productivity per unit area per unit time (Ali, 1998) under a certain situation where two crops are grown in intercropping at a certain proportion. As compared to the sequential cropping and relay cropping the practice of intercropping is known to increase the total productivity, because crops are able to utilize different resources at a time (Willey, 1979). The selection of compatible crops is one of important considerations in deciding an economically viable and feasible intercropping system. Chickpea + Indian mustard is a prominent intercropping system in Indian sub-continent. The majority of the farmers adopt this system under resource constraint conditions. There is a need to develop an approach to control weeds in intercropping system. Hence an experiment was conducted to study the effect of weed management on chickpea + Indian mustard intercropping system under irrigated subtropical conditions of Jammu region.

MATERIALS AND METHODS

A field experiment was carried out during the winter (*rabi*) seasons of 2009–10 and 2010–11 at Research Farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu at Chatha. The soil of the experimental field was sandy loam, slightly alkaline in reaction, medium in organic carbon, available nitrogen, phosphorus and potassium. The experiment comprising 24 treatment combinations comprising of 4 intercropping systems, viz. chickpea (sole), Indian mustard (sole), chickpea + Indian mustard intercropping system as additive series (where chickpea crop was sown at the spacing of 30 cm and 1 row of Indian mustard was sandwitched between 2 rows of chickpea) and chickpea + Indian mustard intercropping as replacement series (where chickpea was sown at the spacing of 30 cm and every alternative row of chickpea was replaced with Indian mustard) were taken as main plot treatments and 6 weed-management practices, viz weedy check, weed free, fluchloralin @ 1 kg/ha (PPI), pendimethalin @ 1 kg/ha (pre-emergence.), isoproturon @ 0.75 kg/ha (post-emergence) at 35 days after sowing (DAS) and quizalofop-ethyl @ 50 ml/ha (post-emergence) at 35 DAS as sub-plot treatments and was laid out in split-plot design with 3 replications. Furrows were opened manually with the help of liners at a specified row to row distance of 30 cm. The chickpea variety 'GNG 469' and Indian mustard variety 'RSPR 01' was sown using a seed rate of 70 kg and 5 kg/ha for chickpea and Indian mustard on 5 November, 2010 and 31 October, 2011. However, the seed rate of chickpea and Indian mustard for replacement series was used @ 35 and 2.5 kg/ha respectively. The recommended nutrients of chickpea were applied uniformly through diammonium phosphate @ 100 kg/ha and the irrigation was given accordingly. Herbicides were sprayed by knapsack sprayer fitted with flat fan T-jet nozzle using a spray volume of 500 litres/ha. Weedy-check plots remained infested with native population of weeds till harvest. Observations on weeds were recorded with the help of quadrate 0.5 m × 0.5 m placed randomly at 2 spots in each plot at harvest. All the growth parameters, viz. plant height, leaf-area index, dry-matter accumulation, were recorded as per standard method at harvest. The weather situations during the period of experimentation revealed that the mean weekly maximum and minimum temperature values ranged from 13.6 to 38.3°C and 2.8 to 22.3°C during the winter season of 2009–10 whereas, the corresponding values during 2010–11 were 11.2 to 38.0°C and 2.9 to 21.4°C respectively. Weed population and weed dry weight was recorded at 30 days interval and at harvest. The weed dry weight was taken with the help of iron frame of 1m^2 from 2 places of each plot and then averaged. The data on weeds were then analyzed by using square root transformation ($\sqrt{X + 0.5}$) to normalize their distribution. The chickpea-equivalent yield, land-equivalent ratio (LER) and area-time equivalent ratio (ATER) were calculated by using the standard formula on the basis of minimum support prices of component crops for the main produce and prevailing market prices for the inputs.

RESULTS AND DISCUSSION

Growth parameters

Significantly highest plant height, leaf area index and dry matter of chickpea and Indian mustard were recorded, when grown as sole crops compared to intercrops (Table 1). This might have happened due to the reduced competition of these plants for light, nutrients and other essentials under sole stands, which probably might have provided favourable physical environment that led to increased height of these crop plants. Thakur *et al*. (2000) also reported that there was significant reduction in plant height of chickpea and Indian mustard when they were grown in an intercropping system as compared to their sole stands. Singh (2005) and Kumar *et al.* (2006) also reported the similar findings for dry-matter plant height and leaf-area index.

The pooled data analysis revealed that weed-management practices favourably influenced the plant height, leaf-area index and dry-matter of chickpea and Indian mustard at harvest over weedy check. Significantly tallest plants and dry-matter were recorded with the application of pendimethalin @ 1 kg/ha as compared to weedy check followed by fluchloralin @ 1kg/ha. Singh and Singh (1998) also reported similar findings. Singh *et al*. (2003)

reported that all the weed-control methods recorded significantly higher plant height, leaf-area index and dry-matter as compared to weedy check in chickpea + Indian mustard intercropping system.

Productivity

Seed yield of chickpea and Indian mustard was the highest in their sole stands (Table 2). Among intercropping systems, chickpea and Indian mustard gave the highest seed yield under chickpea + Indian mustard (additive series), being 19.12 and 22.22% higher than chickpea + Indian mustard (replacement series) respectively. Among weed-management practices, highest grain and stover yields of chickpea and Indian mustard were obtained under weed-free treatment. Two years pooled data indicated that an application of pendimethalin @ 1 kg/ha recorded significantly higher seed and stover yields of chickpea and Indian mustard compared to weedy check. The increase in seed yield of chickpea and Indian mustard in sole stand was 54.22 and 54.55% with the application of pendimethalin @ 1 kg/ha than weedy check. Fluchloralin @ 1 kg/ha and quizalofop-ethyl @ 50 ml/ha were also effective in controlling weeds and registered higher grain and strover yields of chickpea and Indian mustard. Panwar *et al.* (1987) found that yield of chickpea and *raya* was increased by 40.7 and 55% with the application of fluchloralin @ 1 kg/ha and 37.1 and 57.2% by pendimethalin @ 1 kg/ha in chickpea + Indian mustard intercropping system. Similar results were reported by Arya (2004) in chickpea + Indian mustard.

Both the intercropping systems showed superiority to sole cropping in total productivity. The higher equivalent yield showed higher biomass production and efficient use of available growth resources under intercropping than sole cropping. However, among the cropping systems, additive (intercropping system) followed by replacement series treatment recorded the maximum chickpea-equivalent yield. The increase in respect of chickpea equivalent yield for additive series and replacement series over sole chickpea was to the tune of 35.25 and 18.19 % on the basis of pooled data. This increase in chickpea-equivalent yield of intercropping treatments over sole chickpea was mainly owing to beneficial effects of intercropping, which ensured higher total productivity and profitability because of additional yield advantage of intercrop yield, and this happened probably due to differential yield behaviour of the crops under different intercropping combinations coupled with their prevailing market rates accounted for expression of equivalent yields. Tripathi *et al*. (2005) and Ahlawat *et al*. (2005) also recorded similar findings in respect of chickpea-equivalent yield in chickpea + Indian mustard intercropping system. Among the herbicidal treatments, the highest chickpea-equivalent yield was noticed with pendimethalin @ 1 kg/ha, which was followed by fluchloralin @ 1 kg/ha. This might have happened due to superiority in yield attributes of crop components as a result of reduced crop weed competition and increased water and nutrient availability. Arya (2004) reported similar

Table 1. Effect of intercropping and weed-management on growth characters and land equivalent ratio (LER) and area time equivalent ratio (ATER) of chickpea and Indian mustard in intercropping system (pooled data of 2 years)

Treatment	Chickpea			Mustard			LER	ATER
	Plant height (cm)	Leaf-area index	Dry-matter accumulation (g/m^2)	Plant height (cm)	Leaf-area index	Dry-matter accumulation (g/m^2)		
Intercropping system								
Sole chickpea	63.3	1.16	22.1	–	–	–	1.00	1.00
Sole Indian mustard	–	–	–	174.7	1.14	117.2	1.00	1.00
Chickpea + Indian mustard (additive series)	61.2	0.90	16.6	172.1	0.58	112.5	1.65	1.48
Chickpea + Indian mustard (replacement series)	62.1	1.02	19.3	173.8	0.60	114.4	1.30	1.18
SEm±	0.2	0.04	0.5	0.37	0.07	0.41	0.24	0.23
CD (P=0.05)	0.5	0.97	1.21	0.83	0.15	0.94	0.80	0.69
Weed management								
Weedy check	54.0	0.76	13.8	165.0	0.56	85.8	1.67	1.51
Weed free	65.8	1.20	22.5	176.0	1.07	122.7	1.44	1.30
Fluchloralin @ 1 kg/ha (PPI)	63.5	1.02	20.2	173.8	0.80	120.0	1.43	1.29
Pendimethalin @ 1 kg/ha (pre-em)	64.7	1.11	21.2	175.0	0.90	121.2	1.39	1.26
Isoproturon @.75 kg/ha (post-em)	62.3	1.00	19.0	172.5	0.60	118.9	1.45	1.31
Quizalofop-ethyl @ 50 ml/ha (post-em)	62.9	1.01	19.3	172.8	0.70	119.6	1.46	1.31
SEm±	0.43	0.04	0.45	0.46	0.25	0.44	0.30	0.50
CD (P=0.05)	0.86	0.65	0.89	0.89	0.17	0.87	0.10	0.14

Pre-em, Pre-emergence; Post-em, post-emergence

Table 2. Effect of intercropping and weed management on weed-control efficiency, weed density, weeds dry weight, yield, chickpea-equivalent yield economics of intercropping system (pooled data of 2 years)

Treatments	Weed density (No. /m^2)	Weeds dry weight(g/m^2)	Weed control efficiency (%)	Net returns (₹/ha)	Benefit: cost ratio	Chickpea yield (t/ha)		Indian mustard yield (t/ha)		Chickpea equivalent yield (t/ha)
						Grain	Stover	Seed	Stover	
Intercropping system										
Sole chickpea	9.85 (134.72)	8.21 (83.21)	–	11,214	0.79	0.90	2.15	–	–	0.90
Sole Indian mustard	–	–	–	12,524	1.18	–	–	1.16	3.34	0.83
Chickpea + Indian mustard (additive series)	8.19 (100.08)	7.52 (64.31)	–	24,415	1.63	0.68	1.95	0.99	3.19	1.39
Chickpea + Indian mustard (replacement series)	8.97 (117.83)	8.04 (80.25)	–	18,586	1.50	0.55	1.79	0.77	3.00	1.10
SEm±	0.02	0.03	–	–	–	0.24	0.33	0.28	0.35	0.2
CD (P=0.05)	1.10	1.09	–	–	–	0.54	0.79	0.63	0.80	0.44
Weed management										
Weedy check	21.01 (441.94)	15.91 (248.70)	0	8,703	0.43	0.38	1.55	0.50	2.67	0.56
Weed free	1.00 (0.00)	1.00 (0.00)	100	15,488	0.83	0.89	2.16	1.20	3.41	1.31
Fluchloralin @ 1 kg/ha (PPI)	7.39 (55.83)	7.26 (47.01)	82.61	19,020	1.72	0.76	2.03	1.04	3.26	1.13
Pendimethalin @ 1 kg/ha (pre-em)	6.55 (44.50)	6.81 (40.64)	85.16	20,374	1.71	0.83	2.09	1.10	3.33	1.21
Isoproturon @.75 kg/ha (post-em)	9.20 (84.17)	8.24 (61.79)	76.82	16,346	1.55	0.69	1.94	0.95	3.16	1.03
Quizalofop-ethyl @ 50 ml/ha (post-em)	8.87 (78.83)	7.91 (57.39)	79.76	17,016	1.43	0.73	2.01	1.02	3.22	1.09
SEm±	0.03	0.03	0.3	_	_	0.31	0.35	0.36	0.36	0.32
CD (P=0.05)	0.8	1.08	0.9	_	_	0.61	0.71	0.71	0.71	0.64

Pre-em, Pre-emergence; Post-em, post-emergence; PPI, Pre-plant incorporation

results for chickpea equivalent yield.

System productivity

Land-equivalent ratio: Additive series (chickpea + Indian mustard) treatment recorded the highest land-equivalent ratio compared to replacement treatment having LER of more than 1 during both the years than their respective sole stands (Table 3). This yield advantage attributed to the combined effects of better utilization of resources by component crops having different rooting patterns, differential canopy distribution, efficient light interception by their green surfaces and differential nutrient extraction from different soil depths in intercropping system. Tripathi *et al*. (2005) and Ahlawat *et al*. (2005) also recorded similar findings for land equivalent ratio in chickpea+mustard intercropping system.

Area time equivalent ratio (ATER): Intercropping treatment where in chickpea associated with Indian mustard under additive series recorded higher ATER compared to replacement series of the same combination, which might be due to optimum utilization of land resources with respect to time in additive treatments, whereas the less value of ATER for replacement treatment can be attributed to the fact that under this treatment the land was not so efficiently utilized with respect to time. These results are in accordance with the findings of Tripathi *et al.* (2010).

Weed

During crop seasons the experimental field was mainly infested with broad-leaf weeds in the decreasing order of their occurrence including *Medicago sativa* L., *Anagallis arvensis* L., *Trachyspermum* sps., Similarly, grassy weeds included *Cynodon dactylon* Pers. and *Poa annua* L. and the prominent weed amongst sedges was found to be *Cyperus rotundus* L. during both the years. On the basis of pooled data it can be interpreted that among the intercropping systems, the minimum weed density and weeds dry weight of 8.19 g/m^2 and 7.52g/m^2 were recorded under additive treatment followed by replacement treatment (Table 1) which might be due to the lesser space available to the weeds due to intercrops and ultimately lesser availability of resources to the weeds. Among the weed-management treatments, lowest weed density and weed dry weight of 6.55/m^2 and 6.81 g/m^2 were recorded with the application of pendimethalin @ 1 kg/ha followed fluchloralin @ 1 kg/ha. Application of pendimethalin @ 1 kg/ha was highly effective in controlling the weeds, especially *Medicago sativa* and *Anagallis arvensis*. Highest weed-control efficiency at harvest for chickpea to the tune of 85.16% was obtained with pendimethalin @ 1 kg/ha followed by fluchloralin @ 1 kg/ha (82.16%). Arya (2004) reported similar results in favour of pendimethalin. Singh and Singh (1998) reported that pre-plant incorporation of fluchloralin @ 1.5 kg/ha significantly reduced the density and biomass of weeds (*Cyperus rotundus* and *Anagallis arvensis*) by 38.6 and 46% respectively, compared to unweeded control.

Economics

Highest net returns and benefit: cost ratio were recorded with chickpea + Indian mustard (additive series) intercropping system. Pooled analysis revealed that additive series earned maximum net profit of ₹24,415/ha, which was found 15.68, 48.70 and 54.07% higher than the net returns values of replacement series, sole Indian mustard and sole chickpea. Better performance of additive series and replacement series might be associated with additional benefit of component crop of Indian mustard along with the main crop of chickpea. The results are in line with those of Singh *et al.* (2003). Among weed-management treatments, pendimethalin @ 1 kg/ha showed the maximum net profit of ₹20,373/ha, which was found 6.65, 16.48 and 19.77% higher than the net return values of fluchloralin @ 1 kg/ha, quizalofop-ethyl @ 50ml/ha and isoproturon @ 0.75 kg/ha.

In general, it can be concluded that among intercropping treatments, chickpea + Indian mustard in additive treatment proved to be the most promising intercropping system for resource-rich farmers which registered more net returns and benefit: cost ratio under the sub-tropical agro-eco systems of Jammu region. However, for realizing higher net returns and benefit: cost ratio, chickpea + Indian mustard in replacement treatment can be recommended to resource-poor farmers, who are interested in taking both the crops instead of their pure stands, as it proved to be economically better and feasible in generating more monetary benefits by spending less amount for their better livelihood security as well as land-use efficiency. Among the weed management treatments, higher net returns and benefit: cost ratio was obtained with pendimethalin applied as pre-emergence @ 1 kg/ha followed by fluchloralin as pre-plant incorporation @ 1 kg/ha and these herbicides can safely be recommended for efficient weed management practices in chickpea + Indian mustard intercropping system under the sub tropical agro ecosystem of Jammu.

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