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Research Paper

Yield analysis of chickpea (*Cicer arietinum*) + Indian mustard (*Brassica juncea*) intercropping system through computation of intercropping indices

RANJEET KOUR[1], B.C. SHARMA[2], ANIL KUMAR[3] AND NEETU SHARMA[4]

Sher-E-Kashmir University of Agriculture and Technology, Jammu, Jammu and Kashmir 180 009

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ABSTRACT

A field experiment was carried out during the winter *(rabi)* season of 2009–2010 and 2010–2011 at Chatha, Jammu to assess the yields of chickpea (*Cicer arietinum* L.) and Indian mustard [*Brassica juncea* (L.) czernj. & cosson] by computing intercropping indices along with weed-management practices. Significantly higher yields of chickpea (903 kg/ha) and Indian mustard (1,156 kg/ha) were obtained in their respective sole crops. The highest land-equivalent ratio, aggressivity, land-use efficiency, production efficiency and relative crowding coefficient (RCC) were obtained in additive series and replacement series, whereas highest relative yield total (1.30) was recorded in replacement series. Among the weed-management treatments, pendimethalin @ 1 kg/ha recorded higher value of land-use efficiency (44.52) and production efficiency (7.35), followed by fluchloralin @ 1 kg/ha. Application of pendimethalin @ 1 kg/ha as pre-emergence recorded the maximum net returns (₹20,373/ha) and benefit: cost ratio (1.71), followed by the application of fluchloralin @ 1 kg/ha.

Key words : Aggressivity, Land-equivalent ratio, Land-use efficiency, Production efficiency, Relative yield total, Relative crowding coefficient

In the tropical countries growing of intercrops is a common practice; intercropping is a practice of growing of 2 or more crops in a definite pattern simultaneously on the same area which can provide substantial yield advantages compared to sole cropping. Intercropping can be a suitable and viable agronomic practice for stepping up the production and yield stability from a unit of land during a cropping period. It increases the intensity, productivity and profitability under optimum utilization of soil, water, nutrients and sunlight in time and space. Scientific approach of intercropping increases the productivity/unit area/unit time under a situation where 2 crops are grown in a certain row proportions (Ali, 1998). It has gained interest because of potential advantages it offers in yield through improved utilization of resources by the crops and particularly when a legume is grown in association with another crop in an intercropping system, commonly a cereal or oilseed as the nitrogen nutrition of the associated crop may be improved by direct nitrogen transfer from the legume (Giller and Wilson, 1991).

Initial slow growth of the crops and adequate soil moisture provide conducive conditions for profuse growth of weeds relatively in wide-spaced crops. This necessitates that a systematic study on weed dynamics in such crops is essential for strategic weed-management planning. The traditional methods of weed control 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. 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. 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 Subcontinent. The majority of the farmers adopt this system under resource-constraint conditions.

Being a rich source of protein energy coupled with the

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[1]**Corresponding author Email:** ranjeet1661@yahoo.com
[1]Ph.D. Scholar; [2,3]Professor, [4]Assistant Professor, Sher-E-Kashmir University of Agriculture and Technology, Jammu-Chatha, Jammu and Kashmir 180 009

unique ability to improve soil health and minimal reliance on external inputs, pulses under crop diversification have assumed the role of panacea for sustainable farming system thereby, arresting deleterious effects on natural resources due to continuous cultivation of high water and input-intensive cereal crops. Since chickpea is a poor competitor for weeds because of its slow growth rate and limited leaf-area development at early stages of crop growth and establishment. Amongst the various pulse crops, chickpea is the most important winter pulse crop of India which is grown both under assured irrigation as well as on residual soil moisture of *kharif* rains during winter (*rabi*) season. Therefore, 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. Since no, there is scarcity of information on the efficacy of herbicides for controlling weeds in chickpea + Indian mustard intercropping, the present experiment was conducted to study the dynamics of intercrop situations through computation of various indices and to work out the relative economics of the treatments.

MATERIALS AND METHODS

The field experiment was carried out at the Research Farm, Main Campus, Chatha of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu during *rabi* season of 2009–10 and 2010–11. The soil was sandy loam, slightly alkaline (*p*H 7.2), medium in organic carbon (0.531%) and available nitrogen (252.5 kg/ha), phosphorus (13.7 kg/ha) and potassium (162.9 kg/ha). The experiment was laid out in a split-plot design with 3 replications. Twenty-four treatment combinations comprising 4 intercropping systems, viz. chickpea (sole), Indian mustard (sole), chickpea + Indian mustard (additive series) and chickpea + Indian mustard (replacement series) were taken as main plot treatments and 6 weed-management practices, viz. Weedy-check, weed-free, fluchloralin @ 1 kg/ha as pre-plant incorporation (PPI), pendimethalin @ 1 kg/ha as pre-emergence (PE), isoproturon @ 0.75 kg/ha as post-emergence (POE) and quizalofop-ethyl @ 50 ml/ha (POE) as sub-plot treatments. The recommended nutrients of chickpea : 18 kg/ha of nitrogen and 46 kg/ha of phosphorus were applied with equal distribution to both the crops through 100 kg diammonium phosphate as basal application at the time of sowing in lines below the seed. Furrows were opened manually with the help of liners at a specified row-to-row distance of 30 cm. A seed rate of 70 kg and 5 kg/ha for chickpea and Indian mustard was used in their sole plots and additive series, respectively, whereas the seed rate of both the crops for replacement series was used as 50% less than seed rate used in the sole and additive series. The seeds of chickpea and Indian mustard were sown in furrows by *kera* method in sole stand, whereas an additional row was opened between 2 rows of chickpea for sowing of Indian mustard in additive series and in replacement series sowing of chickpea and Indian mustard were done in alternate rows. Both chickpea and Indian mustard crops were sown on the same day, i.e. on 5 November during winter 2009–10 and 31 October during winter 2010–11. The mean monthly maximum and minimum temperature values ranged from 13.6 to 38.3°C and 2.8 to 22.3°C, respectively, 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. The intercropping indices, viz. Land-equivalent ratio (LER), relative yield total (RYT), aggressivity (A), relative crowding coefficient (K), land-use efficiency (LUE) and production efficiency (PI) were calculated as per standard method.

Production efficiency was calculated as:

$$\text{Production efficiency (kg/ha/day)} = \frac{\text{Total production of sequence}}{\text{Total duration of crops in the sequence}}$$

RESULTS AND DISCUSSION

Productivity

Seed yield of chickpea and Indian mustard was the highest in their sole stands (Table 1). Among intercropping systems, chickpea and Indian mustard gave the highest seed yield under chickpea + Indian mustard (additive series), which was 19.1 and 22.2% higher than chickpea + Indian mustard under replacement series crops respectively. Among weed-management practices, the highest grain and stover yields of chickpea and Indian mustard were obtained under weed-free treatment. Application of pendimethalin @ 1 kg/ha recorded significantly higher seed yields of chickpea and Indian mustard compared to weedy-check. The increase in seed yield of chickpea and Indian mustard in sole stand was 54.2 and 54.5% with the application of pendimethalin than weedy-check. Fluchloralin @ 1 kg/ha and quizalofop-ethyl @ 50 ml/ha were also effective in controlling weeds and registered higher grain yields of chickpea and Indian mustard than rest of the herbicides used. Panwar *et al.* (1987) found that yield of chickpea and *raya* was increased by 40.7 and 55% with the application of fluchloralin and 37.1 and 57.2% by pendimethalin in chickpea + Indian mustard intercropping system. Arya (2004) in chickpea + Indian mustard also reported similar results

Land-equivalent ratio

Land-equivalent ratio (LER) is relative land area under sole crops required to produce the same yield as were obtained under their intercropping and the land-equivalent ratio of more than unity expresses that the biological efficiency of such systems is higher. The LER of different intercropping treatments revealed that the intercropping of chickpea + Indian mustard in additive series was found biologically more efficient than replacement series and which is quite obvious from their LER values of 1.65 and 1.30 respectively (Table 1).

Relative yield total

Relative yield total (RYT) of 1.30 was obtained under replacement series of chickpea + Indian mustard intercropping system which indicated a yield advantage of 30% over sole chickpea. Undie *et al*. (2012) also reported similar findings for RYT in intercropping of maize + soyabean.

Relative crowding coefficient

The relative crowding coefficient (RCC) of chickpea and Indian mustard was higher in additive series than replacement series. However, Indian mustard crop with higher RCC was the dominant crop both in additive and replacement series, but the impact of its crowding was by and large inconspicuous on the productivity of accompanying chickpea crop. This might be due to differential resource utilization at different periods owing to temporal differences in their growth, development and reproduction phases. Ahlawat *et al*. (2005) and Tripathi *et al*. (2005) reported similar results for relative crowding coefficient in chickpea based intercropping systems.

Aggressivity

The competitive ability of the component crops in an intercropping system is determined by its aggressivity value (Table 1). The zero value of aggressivity indicates that component crops are equally competitive. For any other situation, both crops will have the same numerical value but the sign of the dominant species will be positive and that of dominated negative. The greater the numerical value, the bigger the differences between actual and expected yields, viz. the component crops did not compete equally. Among the intercropping treatments, positive value of 0.17 and 0.11 were recorded in Indian mustard crop and negative value of –0.17 and –0.11 in chickpea crop in additive and replacement treatments respectively. This trend showed that Indian mustard was the dominant crop and chickpea was dominated crop. This probably happened owing to early suppressive ability of the fast-growing high foliage Indian mustard crop along with its better ability to intercept light and also utilize soil resources which enabled it to become more efficient in resource utilization as compared to chickpea crop.

Table 1. Effect of chickpea + Indian mustard intercropping system on land equivalent ratio (LER), relative yield total (RYT), aggressivity, relative crowding coefficient (K), land-use efficiency (LUE) and production efficiency (PE) and economics

Treatment	Yield (kg/ha)		LER	RYT	RCC	LUE	PE	Aggressivity		Net returns (₹/ha)	Benefit : Cost ratio
	Chickpea	Mustard						Chickpea	Mustard		
Intercropping											
Sole chickpea	903	–		1	–	43.84	5.48	–	–	11,213	0.79
Sole Indian mustard	–	1156		1	–	35.62	5.03	–	–	12,524	1.18
Chickpea + Indian mustard (additive series)	682	986	1.65	–	18.02	44.11	8.43	-0.17	0.17	24,415	1.63
Chickpea + Indian mustard (replacement series)	552	768	1.30	1.3	3.17	43.98	6.68	-0.11	0.11	18,586	1.50
SEm±	024	028	–	–	–	–	–	–	–	–	–
CD (P=0.05)	097	107	–	–	–	–	–	–	–	–	–
Weed-management	000	000									
Weedy-check	380	501	–	–	–	43.06	3.36	–	–	8,703	0.43
Weed-free	890	1200	–	–	–	44.89	7.96	–	–	15,488	0.83
Fluchloralin @ 1 kg/ha (PPI)	764	1043	–	–	–	44.16	6.88	–	–	19,019	1.72
Pendimethalin @ 1 kg/ha (PE)	825	1104	–	–	–	44.52	7.35	–	–	20,373	1.71
Isoproturon @ 0.75 kg/ha (POE)	687	953	–	–	–	43.43	6.24	–	–	16,346	1.55
Quizalofop-ethyl @ 50 ml/ha (POE)	731	1018	–	–	–	43.79	6.6	–	–	17,015	1.43
SEm±	031	036	–	–	–	–	–	–	–	–	–
CD (P=0.05)	090	102	–	–	–	–	–	–	–	–	–

Srivastava and Bohra (2006) reported similar findings for aggressivity in wheat and Indian mustard.

Land-use efficiency

Under intercropping systems, the highest value of land-use efficiency in additive treatment was achieved followed by replacement treatment, which were in turn higher than their respective sole crop stands (Table 1). This could be attributed to the increased light interception, reduced water evaporation that improved conservation of the soil moisture in intercropping treatments compared to sole cropping. These results confirms the findings of Ghanbari *et al.* (2010), who also reported that intercropping systems have been found to enhance land-utilization efficiency. Among the weed-management treatments, highest land-use efficiency was recorded in weed-free treatment over rest of the treatments. Among the herbicidal treatments, pendimethalin recorded higher land-use efficiency values followed by fluchloralin, whereas it was lower in isoproturon @ 0.75 kg/ha. This could have happened due to the fact that effective control of weeds by weed-management treatments might have provided a competition-free environment that led to increased land-use efficiency as compared to weedy-check treatments.

Production efficiency

Production efficiency calculated on chickpea-equivalent yield basis indicated that highest value of production efficiency was recorded in additive treatment, followed by replacement treatment among intercropping systems as compared to sole chickpea during both the years (Table 1). This can be ascribed to better utilization of resources by the component crops in an intercropping combination accompanied with discouraged weed population and weed dry-matter due to smothering effect of the crops which might have provided an advantage in the production of component crops in totality as compared to sole chickpea. These results are in agreement with the findings of Tripathi *et al*. (2010). Among weed-management practices, the highest production efficiency was recorded with weed-free treatment, while the lowest value was recorded in weedy-check treatment during both the years. Among the herbicidal treatments, pendimethalin recorded higher value of production efficiency, followed by fluchloralin and quizalofop-ethyl, while relatively lower value of production efficiency was recorded with isoproturon followed by quizalofop-ethyl during both the seasons respectively.

Economics

As regards variations realized in gross returns under different intercropping and weed- management treatments, the possible reasons were differences in grain yields of chickpea and Indian mustard crops attained in different treatments along with their respective sale rates. The highest net returns obtained under additive treatment, followed by replacement treatment over sole chickpea and mustard treatments might be owing to the highest chickpea-equivalent yields acquired in these treatments. Among the weed-management practices, the highest and lowest net returns under different herbicidal treatments were because of dissimilarities in the costs as well as quantity of herbicides used in herbicide-applied treatments and in weed-free treatment it was mainly owing to extra labourers engaged in manual removal of weeds. Likewise, net returns variations in benefit: cost ratio realized under different intercropping and weed-management treatments, was mainly owing to the differences in costs of seeds in intercropping and dissimilarities in the costs as well as quantity of herbicides used in herbicide applied treatments and in weed-free treatment it was mainly due to extra labourers engaged in manual removal of weeds. Tripathi *et al.* (2005) reported similar results in respect of net returns and benefit: cost ratio in chickpea + Indian mustard intercropping system. Arya (2004) reported the similar findings with the application of pendimethalin for net returns and benefit: cost ratio in weed-management treatments. Our results findings of Singh *et al.* (2003) confirms the similar findings with regard for economics of weed-management treatments.

It can be concluded that chickpea + Indian mustard intercropping system in additive series proved to be the most promising system which obtained more net returns and benefit: cost ratio. However, for realizing higher net returns and benefit: cost ratio chickpea + Indian mustard in replacement treatment may be recommended to 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.

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