Studies on cotton based crop rotations under north Indian irrigated conditions

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ABSTRACT

*Before the early eighties there was mono crop (cotton) cultivation in the cotton growing areas of northern India. Introduction of short duration varieties of cotton made it possible to shift it to multiple cropping. Wheat rotation after cotton is the most dominating crop and much less area is rotated with mustard, chickpea and barley. Considering the objective of crop diversification, an experiment was planned to evaluate performance of cotton-based crop rotations at Punjab Agricultural University, Regional Station, Faridkot during the 2000-01 and 2001-02 seasons. The experiment was laid out in a randomized block design with three replications. The rotations studied were cotton (*Gossypium hirsutum*) in summer followed by wheat (*Triticum aestivum*), chickpea (*Cicer aerietinum*), barley (*Hordeum vulgare*), mustard (*Brassica napus*), field peas (*Pisum sativum*) and fallow during winter. The average rainfall was 233 mm for cotton and 13.5 for other crops. The temperature ranges from 28.9-39.4 ^{0}C for cotton and 8-28.7 ^{0}C for other crops. The soil was sandy loam containing pH 8.1, low organic carbon, and medium in available phosphorous and potassium. The results of two year study showed that during 2000-01 cotton yield has non significant difference while during 2001-02 significantly higher seed cotton yield was obtained form cotton-fallow, cotton-pea and cotton-chickpea than cotton mustard, cotton-barley and cotton-wheat. Total cotton yield indicated that significantly higher yield was achieved in cotton-wheat followed by cotton-chickpea, cotton-barley, cotton-field peas, cotton-mustard and cotton alone. The benefit cost ratio was maximum in cotton-chickpea followed by cotton-wheat, cotton-barley, cotton-fallow, cotton-mustard and cotton-field peas. Therefore it was concluded that cotton-wheat, cotton-chickpea and cotton barley were most suitable crop rotations for irrigated conditions in northern India.*

Introduction

During the last four decades the agricultural scenario in irrigated agro-eco system in northern India has been drastically changed from extensive to intensive agriculture. The selection of suitable crop rotation for higher production with the judicious use of resources has become a matter of concern. With the increase in irrigated area and advances in agricultural science, most of the extensive cropping patterns are giving way to intensive cropping. The cropping intensity of the Punjab has been increased from 126 percent in 1960-61 to 166 percent in 1980-81 and at present it is 187 percent (Dhingra, 2001). In northern India, the cotton growing area is spread over south-western Punjab and Haryana, western Rajasthan and adjoining of Uttar Pardesh. Before the early eighties there only cotton was grown. The introduction of short duration varieties of cotton made it possible to shift towards multiple cropping. In the northern Indian cotton zone, wheat after cotton is the most dominating crop occupying about 80 percent of cotton growing areas and contributes 5 –10 percent in wheat production of India. A much smaller area is rotated with under mustard, chickpea and barley. In cotton-wheat rotations, delays in sowing of wheat after cotton not only reduce wheat yield, but the yield of cotton by up to 40 percent (Smith and Varvil, 1992; Rao, 1989). The productivity of most of the cereal crop rotations has reached a plateau and scope of enhancement is minimal. Therefore sustainable rotations involving oilseed and pulse crop may be alternatives to break this barrier. There is also imbalance amongst the area and production of cereals, pulses and oil seed crops. Beside wheat, the only other crops of this area are chickpea, barley, mustard and field pea. Considering the objective of crop diversification and higher price of oil seed and pulses, an experiment was planned to evaluate performance of cotton-based crop rotations.

Experimental procedure

A field experiment was conducted at Punjab Agricultural University, Regional Station, Faridkot during the 2000-01 and 2001-02 seasons. The experiment was laid out in a randomized block design with three replications. The same experimental site was used for both years. The rotations studied were cotton (*G. hirsutum*) in summer followed by wheat (*Triticum aestivum*), chickpea (*Cicer aerietinum*), barley (*Hordeum vulgare*), mustard (*Brassica napus*) and field pea (*Pisum sativum*) along with fallow during winter. The recommended varieties of Punjab Agricultural University Ludhiana namely, LH1556 (cotton), PBW343 (wheat), GPF2 (chickpea), PL426 (barley), GSL1 (mustard) and PG48 (field pea) were sown. All the recommended production and protection practices were followed. The average rainfall was 233 mm for cotton and 13.5 for other crops. The temperature ranges from 28.9-39.4 °C for cotton and 8-28.7 °C for other crops. The soil was sandy loam containing pH 8.1, organic carbon 0.21%, available phosphorous 14 kg/ha and available potassium 227 kg/ha. Yield of all crops, account of cost of production and returns along with irrigation water applied were recorded and analyzed.

Results and Discussion

Yield

During 2000-01 cotton yield had non significant

difference as it was the start of the trial and all the factors were the same while during 2001-02 significantly higher seed cotton yield was obtained from cotton-fallow (1590 kg/ha), cotton-pea (1580 kg/ha) and cotton-chickpea (1540 kg/ha) than cotton-mustard (1420 kg/ha), cotton-barley (1410 kg/ha) and cotton-wheat (1380 kg/ha). The reason may be the difference in maturity time of winter crops that effect the sowing of cotton. Sowing of cotton was done early in the treatment having fallow, field pea and chickpea as winter crops because field pea and chickpea mature earlier than barley and wheat. Another factor for the higher yield of cotton was the additive effect of legumes (chickpea and field pea). The yield of winter crops is different according to their yield potential. The yield of cereals, i.e. wheat and barley were more than pulses (chickpea and field pea) and oil seed (mustard) during both years. A similar trend was observed in the case of cotton equivalent yield. The highest cotton equivalent yield was obtained for wheat followed by chickpea, barley, pea and mustard during both years. During 2000-01, it was observed that total cotton yield was highest in case of cotton-wheat followed by cotton-chickpea, cotton-barley, cotton-field pea, cotton-mustard and cotton-fallow. Cotton-chickpea and cotton–barley were statistical at par with each other as in case of cotton-field pea and cotton-mustard. During the second year highest total cotton yield was obtained in cotton-wheat and cotton-chickpea followed by cotton-barley, cotton-field pea, cotton-mustard and cotton-fallow.

Economics

The economics of different crop rotations had different trend. During 2000-01 maximum net returns were obtained from cotton-wheat followed by cotton-chickpea, cotton barley, cotton-field pea, cotton-mustard and cotton-fallow, while during 2001-02 cotton-wheat and cotton-chickpea swap their positions and all the other treatments were at the same position. In the case of benefit cost ratio during first year the maximum ratio was observed in cotton-chickpea followed by cotton-wheat, cotton-barley, cotton-fallow, cotton-mustard and cotton-field pea. While during second year due to effect of winter crop on cotton the benefit cost ration was highest in cotton–barley, followed by cotton-chickpea, cotton-wheat, and cotton-field pea, cotton-fallow and cotton-mustard. Mean of two years indicated the benefit cost ratio trend similar to first year except the position of cotton-mustard was replaced by cotton-field pea.

Water use efficiency

For cotton, total water applied during 2000-01, was 475 mm (one pre and five post sowing irrigations) and 400 mm (one pre and four post sowing irrigations) during 2001-02 in all the crop rotations according to weather conditions. For winter crops maximum water was applied to wheat (400 mm) followed by barley (325 mm), chickpea (250 mm), mustard (250 mm) and field pea (175 mm). The same amount of water was applied to each crop during 2001-02. Maximum water use efficiency was obtained in cotton-chickpea followed by cotton-wheat, cotton-barley, cotton-field pea, cotton-fallow and cotton mustard during first year while during the second year maximum water use efficiency was in rotations with pulse crops (cotton-chickpea and cotton-field pea) followed by cotton fallow, rotations with cereal crops (cotton-wheat and cotton-barley) and cotton-mustard. The mean of two years showed a different pattern, maximum water use efficiency was in rotations with pulse crops (cotton-chickpea and cotton-field pea) followed cotton-wheat, cotton fallow, cotton-barley and cotton-mustard. Higher water use efficiency of rotations with pulse crops was due to the lower water requirement and positive effect on second year cotton crop. All though mustard has a lower water requirement but due to low yield potential than cereals it has less water use efficiency.

Conclusion

From the results of the trials it was concluded that under northern Indian irrigated conditions cotton-wheat, cotton-barley and cotton-chickpea would be suitable crop rotations to achieve maximum economic yield. Higher water use efficiency was observed in rotations with pulse crops (chickpea and field pea) followed by rotations with cereal crops (wheat and barley). Therefore, it was concluded that cotton-wheat would be best crop rotation under adequate irrigation facilities and cotton-chickpea for the less irrigation facilities area.

References

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Table 1. *Yield (kg/ha) of different crops in cotton based rotations during two seasons.*

Crop rotation	Year 2000-2001				Year 2001-2002			
	Cotton	Winter crop	Cotton equivalent	Total cotton	Cotton	Winter crop	Cotton equivalent	Total cotton
Cotton - Fallow	1740	--	--	1740	1590	--	--	1590
Cotton - Wheat	1702	5223	1668	3370	1380	5180	1770	3150
Cotton - Chickpea	1732	1878	1327	3059	1540	1930	1501	3041
Cotton - Barley	1785	5183	1221	3006	1410	5320	1330	2740
Cotton – Mustard	1746	956	556	2302	1420	840	583	2003
Cotton – F. Pea	1768	1130	651	2419	1580	1240	827	2407
CD (5%)	NS	--	--	196	105	--	--	128

Table 2. *Economics of different cotton based rotation during two seasons.*

Crop rotation	Year 2000-2001				Year 2001-2002				Mean
	Gross Return (INR)	Net Return (INR)	R: C* ratio	B: C# ratio	Gross Return (INR)	Net Return (INR)	R: C* ratio	B: C# ratio	B: C ratio
Cotton - Fallow	33234	19234	2.37	1.37	28622	12622	1.79	0.79	1.06
Cotton - Wheat	64367	41367	2.80	1.80	56700	31700	2.27	1.27	1.52
Cotton - Chickpea	58427	37927	2.85	1.85	54738	32238	2.43	1.43	1.63
Cotton - Barley	57415	36415	2.73	1.73	49320	26320	2.15	1.44	1.43
Cotton – Mustard	43968	24968	2.31	1.31	36054	15054	1.72	0.72	0.98
Cotton – F. Pea	46203	25703	2.25	1.25	43326	20826	1.92	0.93	1.10

* R: C (return cost ratio) =Gross return/Cost of cultivation

B: C (benefit cost ratio) = Net return/Cost of cultivation

INR: Indian Rupee.

Table 3. *Irrigation water applied and water use efficiency (WUE) of different rotations during two seasons.*

Crop rotation	Year 2000-2001			Year 2001-2002			Mean
	Water applied (mm)		WUE	Water applied (mm)		WUE	WUE
	Cotton	Winter crop	(kg/ha/mm)	Cotton	Winter crop	(kg/ha/mm)	(kg/ha/mm)
Cotton - Fallow	475	-	3.66	400	-	3.98	3.82
Cotton - Wheat	475	400	3.85	400	400	3.94	3.89
Cotton - Chickpea	475	250	4.21	400	250	4.68	4.44
Cotton - Barley	475	325	3.75	400	325	3.78	3.77
Cotton – Mustard	475	250	3.18	400	250	3.08	3.20
Cotton – F. Pea	475	175	3.72	400	175	4.19	3.96

(Water applied: 100mm for pre sowing irrigation and 75 mm for succeeding irrigations)