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Water Requirement of Crops Under Different Sequences and Irrigation Regimes on Sandy Loam Soil in South-West Punjab

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ABSTRACT

A field study was conducted for three years (1994-95 to 1996-97) on a sandy loam (fine loamy, mixed hyperthermic, ustochreptic camborthid) soil at the farm of the Regional Research Station, Bathinda to find out the crop sequences suiting the irrigation water available in the region. The mean annual water requirement for post sowing irrigation under cotton-wheat, cotton-barley, cotton-sunflower and cotton-gram were 42.5, 42.5, 70.0 and 32.5 cm under optimal regime, and 5.0, 5.0, 27.5, 0.0 cm under sub-sub- optimal regime, respectively. Besides high water requirement , the cotton-sunflower sequence gave low economic returns. Wheat in this cotton belt could be replaced by barley under sub-optimal and by gram under sub-sub- optimal irrigation regime .

Introduction

The canal water supply in south-western Punjab is considered inadequate for the prevalent cotton-wheat sequence as the underground water is saline and need to be used with caution. Bharambe et al (1990) reported that at Parbhani economically optimum irrigation needed to be scheduled at 0.75 IW/ CPE to crops with high water requirement(wheat and pea)and at 0.40 IW/CPE to those with low water requirement (chickpea and sunflower). The sequence of sorghum-sunflower and sorghum-chickpea were more remunerative with high water use efficiencies than the other cropping systems such as sorghum-pea, pigeonpea-wheat, rice-wheat and sorghum-wheat. Singh et al (1996) observed that cotton-mustard could be the alternative to the cotton-wheat on loamy sand soil in south-western Punjab. Sharma and Rajput (1990) found that rice-mustard -sarson, rice-mustard-green gram and rice -potato-greengram were more efficient cropping systems in West Bengal. Singh (1996) reported that pearlmillet-toria-sunflower gave good economic returns in Indira Gandhi canal area of Rajasthan. Therefore, an experiment was conducted to evaluate the yields and economic returns of different cropping sequences under different irrigation supplies on sandy loam soil in the cotton belt of Punjab.

Materials and Methods

Field experiments were conducted during 1994-95 to 1996-97 on a sandy loam (fine loamy mixed hyperthermic ustocherptic camborthid) soil at the farm of Regional Research Station, Bathinda to find out the crop sequence with water requirement matching the irrigation water available in the region. The crop sequences tested were : cotton-wheat, cotton-barley, cotton -sunflower and cotton-gram. Predetermined irrigation schedules were imposed. The experiment was laid out in split plot design with crop sequences as main and irrigation regimes as sub treatments. The crops were raised as per general recommendation for the region. The treatments were replicated four times in 8 X 5 m plots. The sowing, harvesting times and the crop varieties are given in table 1. The number of irrigations assigned to different crops under various irrigation levels are given in table 2. Soil moisture was monitored gravimetrically at sowing and at harvest. The economic returns were computed using standard production/ produce costs (Department of Economics and Sociology, PAU, Ludhiana) and subjected to factorial analysis.

Results and Discussion

Crop yields

Cotton : The mean kapas yields under all irrigation regimes during the three years in cotton-barley, cotton-sunflower and cotton-gram were at par , but cotton-sunflower sequence produced 600-800 kg/ ha lesser kapas under different irrigation regimes than under preceding sequences (table 3). During 1996-97 , sub sub optimal irrigation significantly reduced the kapas yield to 1591 kg/ha as compared to 1856 kg/ha under optimal and 1777 kg/ha under sub-optimal irrigation regime in cotton-wheat sequence.

Wheat and barley : During 1994-95, the sub-sub optimal irrigation significantly reduced wheat and barley grain yields to 2850 kg/ha and 2562 kg/ha over optimal (3495 kg/ha and 3415 kg/ha) and sub optimal (3675 and 3175 kg/ha) irrigation regimes which were at par in both the crops.

Table 1. Varieties of crops sown and sowing/harvesting times during the study

Crop sequence	Variety	Sowing			Harvesting		
		1994-95	1995-96	1996-97	1994-95	1995-96	1996-97
Cotton-Wheat	Cotton F846	05-06-94	20-05-95	20-05-96	25-11-94	29-11-95	15-11-96
	Wheat PBW 138	30-11-94	02-12-95	22-11-96	04-05-95	04-05-95	25-04-96
Cotton-Barley	Cotton F846	04-06-94	29-05-95	20-05-96	25-11-94	29-11-95	15-11-96
	Barley PL 172	02-12-94	92-12-95	22-11-96	04-05-95	25-04-96	23-04-97
Cotton-sunflower	Cotton F846	05-06-94	20-05-95	20-05-96	25-11-94	29-11-95	15-11-96
	Sunflower MSBH8	17-01-95	22-01-95	05-02-95	06-06-95	20-05-96	93-06-97
Cotton-Gram	Cotton F846	05-06-94	20-05-95	20-05-96	25-11-94	29-11-95	15-11-96
	Gram	02-12-94	01-12-95	22-11-96	19-04-95	17-04-96	23-04-97

Table 2. Number of irrigation assigned to be given to crops under various irrigation levels

Crop	Optimum	Sub-optimum	Sub-Sub optimum
Cotton	4	2	0
Wheat	4	2	0
Barley	3	2	0
Sunflower	8	6	4
Gram	2	1	0

Sunflower : During 1994-95 and 1995-96, sub-optimal irrigation significantly reduced the grain yield to 807 and 814 kg/ha as compared to 1114 and 973 kg/ha under optimal irrigation, respectively. The sub-sub-optimal irrigation further reduced the yield to 478 kg/ha as compared to 807 kg/ha under sub optimal regime during 1994-95.

Gram : During 1994-95, sub-optimal irrigation regimes reduced the grain yield to 588 kg/ha as compared to optimal regime (709 kg/ha) during

Table 3. Yields of crops in different sequences under different irrigation levels during the three years

Crop (sequence)			Yield (kg/ha)			
			1994-95	1995-96	1996-97	Mean
Cotton-wheat	Cotton	O	2051	1733	1783	1856
		SO	1875	1679	1776	1777
		SSO	1714	1663	1397	1591
		LSD (.05)	ns	ns	243	
	Wheat	O	3495	3358	2566	3340
		SO	2675	3304	2409	3004
		SSO	2850	2350	1637	2130
		LSD (.05)	537	ns	ns	
Cotton-barley	Cotton	O	2077	1672	1683	1800
		SO	2044	1525	1682	1744
		SSO	1906	1504	1390	1600
		LSD (.05)	ns	ns	ns	
	Barley	O	3415	2006	2875	2765
		SO	3175	1881	2489	2515
		SSO	2262	2185	2174	2097
Cotton-sunflower	Cotton	O	1950	431	757	1046
		SO	1901	417	694	1004
		SSO	1857	400	712	990
		LSD (.05)	532	ns	ns	
	Sunflower	O	1114	973	2015	1367
		SO	807	814	1867	1162
		SSO	478	775	1609	954
		LSD (.05)	109	90	ns	

Cotton-gram	Cotton	O	1956	1883	1687	1842
		SO	1923	1879	1602	1801
		SSO	1824	1858	1578	1753
		LSD (.05)	ns	ns	ns	
	Gram	O	709	1165	468	781
		SO	588	1008	441	679
		SSO	493	560	158	404
		LSD (.05)	96	273	163	

Table 4. Mean (1994-95 to 1996-97) irrigation water applied, profile water use, water expense and water expense efficiency under different crop sequences

Crop	Optimal	Sub-optimal	Sub-sub optimal
Irrigation water applied, cm			
Cotton (all rotations)	17.5	15.0	0.0
Wheat	25.0	15.0	5.0
Barley	25.0	15.0	5.0
Sunflower	52.5	40.0	27.5
Gram	15.0	7.5	0.0
Profile water use, cm			
Cotton	15.2	12.9	16.4
Wheat	15.9	12.3	14.2
Cotton	14.6	13.4	16.4
Barley	8.8	10.9	11.3
Cotton	14.1	12.8	17.6
Sunflower	0.3	3.2	8.0
Cotton	15.3	11.9	13.5
Gram	14.5	15.6	13.6
Water expense, cm			
Cotton	81.8	77.6	66.7
Wheat	47.7	34.1	26.0
Cotton	75.5	78.1	66.0
Barley	40.3	32.7	23.1
Cotton	82.5	77.1	67.8
Sunflower	56.6	45.8	65.9
Cotton	83.6	73.8	65.99
Gram	36.3	29.9	20.4
Water expense efficiency			
Cotton	22.7	22.9	23.6
Wheat	70	88.1	81.9
Cotton	23.8	22.3	24.2
Barley	68.6	76.9	90.8
Cotton	22.0	24.4	26.6
Gram	21.5	22.7	19.8

1995-96 and 1996-97; sub-sub optimal irrigation regime reduced gram yield to 560 to 158 kg/ha, respectively as compared to 1008 and 441 kg/ha under sub optimal irrigation regime, respectively.

Water use parameters

Irrigation water applied : The mean irrigation applied (Table 4) to the cotton-wheat, cotton-barley, cotton-sunflower and cotton-gram was 42.5, 42.5, 70.0 and 32.5 cm under optimal, 30.0, 30.0, 55.0 and 22.5 cm under sub optimal and 5.0, 5.0, 27.5 and 0.0 cm under sub-sub- optimal irrigations regimes, respectively. Thus irrigation water required was maximum for cotton-sunflower and minimum for cotton-gram.

Profile water use : The profile water use (table 4) of cotton-wheat ,cotton-barley, cotton- sunflower and cotton-gram was 31.1,23.4,14.4 anmd 29.8 cm under optimum: 25.2,24.3 , 16.0 and 27.5 cm under the sub optimum and 30.6, 27.7, 25.6 and 27.1 cm under the sub-sub- optimum irrigation regimes, respectively. Thus under the optimum and sub optimum irrigation regimes, profile water use was minimum in cotton-sunflower sequence implying thereby its greater dependence on the applied water.. But under the sub-sub-optimum irrigation regime, the profile water use increased considerably in this sequence because of high evapotranspiration demand and reduced irrigation water supply.

Water expense : In general , the water expense increased with the increase in irrigation water supply under all the crops. The water expense of cotton-wheat, cotton-barley, cotton-sunflower and cotton-gram was 129.5, 115.8, 139.1 and 119.9 cm under the optimum ; 111.7, 110.8, 122.9 and 103.7 cm under the sub optimum; and 92.7, 89.1, 133.7 and 86.3 cm under the sub-sub-optimum irrigation regime, respectively. Cotton-sunflower needed maximum water expense under all the

Table 5. Economic returns (Rs/ha) of different crop sequences under different irrigation levels during the three years

Crop sequence	Irrigation	1994-95	1995-96	1996-97	Mean
Cotton-Wheat	O	33408	25245	20251	26302(203)
	SO	31128	24328	19658	25038(224)
	SSO	25870	20060	10505	18815(203)
Cotton-Barley	O	35404	18779	20075	24752(214)
	SO	34235	16514	19082	23277(210)
	SSO	28052	17469	11568	19029(213)
Cotton-Sunflower	O	28180	1456	11304	12676(91)
	SO	24834	3187	9104	17217(140)
	SSO	28901	5081	2346	12110(114)
Cotton-Gram	O	289030	27071	12335	22598(188)
	SO	27080	25762	11025	21289(205)
	SSO	24311	21403	12448	19427(225)
LSD (.05)	Years	2898			
	Crop sequence	5654			
	Irrigation	NS			

Figures in parenthesis indicate returns per cm of water expense

irrigation regimes. The water expense of other sequences diminished in the order cotton-wheat, cotton-barley and cotton-gram.

Water expense efficiency : The water expense efficiency of the crops generally decreased with the increase in water supply from sub-sub-optimal to optimal level. Whereas marginal differences (22 to 26 kg/ha cm) were observed in the water expense efficiency of cotton in cotton- wheat, cotton- barley and cotton- gram, but that of cotton-sunflower was drastically reduced to 12.7 -14.6 kg/ha-cm. Among rabi crops, water expense efficiency of wheat, barley, and sunflower showed noticeable differences with the change in irrigation level. Whereas the water expense efficiency of wheat and barley was maintained higher under sub sub optimal irrigation regime, that under sunflower and gram was virtually reduced. Sunflower is thus the most sensitive to water supply in this region.

Economic returns

The data (Table 5) revealed that cotton-sunflower sequence yielded minimum returns. The mean economic return from cotton-barley and cotton-gram decreased subsequently as compared to that of cotton-wheat. The economic return also diminished with reduction in water supply from optimum to sub sub optimum. These returns per cm of water expense were minimum in cotton-sunflower. These returns were Rs 214 /- under optimal irrigation to cotton-barley, Rs 224/- under sub optimal irrigation to cotton-wheat and Rs 225 /- under sub sub optimal irrigation to cotton-gram.

Considering the water use parameters and the economic returns from different crop sequences it could be concluded that cotton-barley can replace cotton-wheat under optimal and sub optimal irrigation regime and cotton-gram can replace it under sub sub optimal irrigation regime.

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