Evaluation of Irrigation Scheduling on Performance of Summer Legumes Grown in Association with Sugarcane

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Abstract*: The study was carried out in 2017 in order to find an optimum irrigation schedule for performing intercropping in case of sugarcane, with silty clay-loam soil type. The highest yield rate was noted in mung bean (Phaseolus radiatus L.), urad bean (P. mungo L.) and cowpea [Vigna unguiculata (L.) Walp.] that is 4.1, 3.85 and 73.0 q/ha, respectively, with irrigation at 1.2 IW:CPE ratio as compared to 3.25, 2.75 and 6.10 q/ha when irrigation was done at the flowering and pod-filling stage. However, the cane yield was found to be reduced in case of intercropping due to less number of millable canes and weight of the cane. The rate of reduction in case of growing sugarcane with cowpea, urad beans and mung beans was 14.2%, 11.5% and 9.2%, respectively, With irrigation at 1.2 IW:CPE ratio, which led to an increased cane yield of 97.0 tonnes/ha. This value was 3.7%, 8.1% and 13.3% higher than 1.0 and 0.8 IW:CPE ratio along with irrigation at critical growth stages. Highest cane yield and economic return was obtained in case of intercropping with cowpea (107 tonnes/ha; Rs. 101,650/ha)), which was 6.8%, 10%, and 8.7% more as compared to growing only sugarcane (Rs 95,190/ha), sugarcane with urad bean (Rs 92,435), and with mung bean, respectively. The benefit:cost ratio was 0.89, 0.90 and 0.73, respectively. Highest cane yield was observed with irrigation at 1.2 IW:CPE ratio (109.5 tonnes/ha) with benefit:cost ratio of 0.85 as against 92.4 tonnes/ha and 0.77 with irrigation at critical growth stages of intercrops.

Index Terms*: CEY, Intercropping, IW: CPE ratio, Monetary return, Sugarcane.

I. INTRODUCTION

Sugarcane is a major cash crop of North India, particularly in Uttar Pradesh and foot-hills *(tarai)* belt of Uttaranchal. A wider row spacing, delayed germination and slow growth during initial phase not only lead to poor utilization of resources but also offer opportunity to weeds to establish first and outgrow crop plants. Intercropping of compatible crops in inter-row space can be a good tool to achieve proper utilization of resources and time leading to higher output per unit area and time besides suppression of weed flora. Summer legumes can fit very well as an intercrop in spring-planted sugarcane having largest area in North India. High temperature, low humidity, desiccating winds and the resultant high ET demands are however major limiting factors in harnessing the potential of intercropping systems. The problem can be overcome with optimum use of water through proper irrigation scheduling. Thus, the study was carried out to assess the irrigational impact of scheduling during summer months on the intercrops and productivity of the system as a whole.

II. MATERIALS AND METHODS

The experimentation took place in 2017 at Experimental Farm, with clay-loam soil type with bulk density of 1.66 g/cc, moisture content of 23.4% at field capacity and 8.6% at permanent wilting point (PWP). The soil was found to be reach in organic carbon, potassium and phosphorus with neutral reactions. Treatments comprising combination of cropping system, i.e. only sugarcane, intercropping with cowpea, urdbean and mungbean, and irrigation schedules at IW: CPE ratio of 1.2, 1.0, and 0.8 and at critical growth stages of intercroppings with three replicates in randomized block design. Sugarcane crop was planted on 5 March, during both the years and was raised with recommended package of practices. Two rows each of the cowpea ('Pusa Komal'), urdbean ('PU 19') and mungbean ('UPM 98') were grown in inter-row space of the sugarcane as per treatment. Cowpea was raised for green pod and others for grains. Sugarcane crop was fertilized with 120:60:40 kg of N, P_2O_5 and K_2O respectively. Half of the N and full P and K were applied basal. Intercrop was supplied with 16 kg N and 48 kg P_2O_5/ha. Half of N to sugarcane was applied at harvest of intercrops. A common irrigation to depth of 6 cm was applied 20 days after planting, irrespective of the treatments and later on crops were irrigated as per schedule during intercrop period and further as per need of sugarcane crop. Water-use efficiency (WUE) was calculated based on green pods and grain yield (kg) of intercrops, whereas in cane equivalent yield was used to compute computed WUE of the intercropping systems. Irrigation water was measured with Parshall flume.

III. RESULTS AND DISCUSSION

A. Intercrops

Yield of intercrop (q/ha) varied significantly due to irrigation scheduling (Table 1). Irritation at 1.2 IW:CPE ratio resulted in highest yield of cowpea (73 q/ha green pods), urad bean (3.85 q/ha) and mung bean (4.1 q/ha), respectively 18.7, 40.0 and 26.0% higher than irrigation at flowering and pod-filling stages. The

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increase in the yield and higher growth rate was attributed to irrigational conditions, with high evapotranspiration demand during cropping. Tewari and Chaplot and Kher *et al.* also reported higher yield of summer legumes with frequent irrigation [1,2].

Table 1. Effect of irrigation schedules on yield and water-use efficiency (WUE) in intercrops

Treatment	Water requirement (mm)	Cowpea		Urdbean		Mungbean	
		Yield (q/ha)	WUE (kg/ha-mm)	Yield (q/ha)	WUE (kg/ha-mm)	Yield (q/ha)	WUE (kg/ha-mm)
Irrigation schedule (IW:CPE ratio)							
1.2	600	73.0	12.2	3.85	0.64	4.10	0.68
1.0	480	67.1	14.0	3.45	0.72	3.75	0.78
0.8	420	64.5	15.4	3.00	0.71	3.30	0.79
Critical growth stages	240	61.5	25.6	2.75	1.15	3.25	1.35
CD (P=0.05)		6.0		0.6		0.7	

Water-use efficiency (kg/ha-mm) tended to decline with increasing frequency of irrigation, being 25.6, 1.15 and 1.35% in cowpea, urdbean and mungbean, respectively, with 2 irrigations at flowering and pod-filling stages; and 12.2, 0.64 and 0.68% with 7 irrigations. Among the crops, cowpea was the most efficient user of water (16.8 kg/ha-mm), followed by mungbean (0.9 kg/ ha-mm) and urdbean (0.8 kg/ha-mm), attributed to their differential carbon assimilating power.

A. Intercrops on sugarcane

Cane yield and yield attributes, *viz.* cane weight and number of millable canes, were significantly influenced by intercrops (Table 2). All the intercrops led to reduction in cane yield and its attributes in comparison to sole sugarcane. The mean reduction was 16.6, 13.1 and 10.2% with cowpea, urdbean and mungbean, respectively, attributed to lower order of yield attributes. Respective reduction in number of unliable canes was 16.2, 14.6 and 12.8%. Bhutada and Parashar also noted decline in cane yield with intercrops [3]. Less number of millable canes with intercrops was attributed to poor tillering and further poor conversion of tillers into canes, as indicated by shoot count at harvest of intercrops and maximum tillering stage. The effect, however got narrowed down after harvest of intercrops but could not get nullified. Among the intercrops, lowest shoot population was recorded with mungbean. The findings are in conformity with those of Sethi *et al*. [4].

Table 2. Effect of cropping systems and irrigation schedules on growth, yield and attributes in sugarcane

Treatment	Shoot population ('000/ha)		Shoot height (cm)		NMC ('000/ha)	Cane weight (g)	Cane yield (t/ha)	Sucrose (%)	CCS (t/ha)
	HI	MT	HI	MT					
Cropping system									
Sugarcane sole	142	161	181	230	104.6	1,138	100.2	16.6	10.3
Sugarcane + cowpea	134	153	188	231	90.0	1,107	86.0	16.4	9.3
Sugarcane + urdbean	127	154	172	133	91.3	1,103	88.7	16.1	9.5
Sugarcane + mungbean	122	155	174	232	92.7	1,121	91.0	16.3	9.7
CD (P=0.05)	14	6.0	12	NS	10.2	25	8.0	NS	0.8
Irrigation (IW: CPE ratio)									
1.2	135	160	180	230	102.7	1,146	97.0	16.7	10.4
1.0	125	155	176	230	97.7	1,122	93.5	16.6	10.0
0.8	130	154	179	232	91.5	1,111	89.7	16.1	9.4
Critical growth stages	135	154	181	234	86.8	1,090	85.6	15.9	9.0
CD (P=0.05)	NS	6.0	NS	NS	10.2	25	8.0	0.3	0.8

Juice sucrose remained statistically unaffected by inter-crops; however, lower values were observed with intercrops attributed to release of nitrogen in soil during later phase of sugarcane. Parashar and Prasad also noted adverse effect of increased availability of nitrogen during later part of crops on juice sucrose [5]. Commercial cane sugar

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yield exhibited the trend similar to that of cane yield, being highest of 10.3 tonnes/ha in sole stand and lowest of 9.3 tonnes/ha with cowpea intercrop. Water-use efficiency was higher in intercropping system owing to increased output in the better exploitation of soil moisture by well-distributed roots in the rhizosphere. Moreover, intercrops provided a good cover on soil surface and might have suppressed evaporation.

A. Irrigation scheduling on sugarcane

Irrigation schedule had significant effect on cane yield (Table 2). Highest cane yield (97.0 tonnes/ha) was obtained with irrigation applied at 1.2 IW:CPE ratio, being 8.1 and 14.1% higher than that with IW : CPE ratio of 0.8 and irrigation at flowering and pod-filling stages. The reduction in cane yield was in conformity to reduction in number of millable canes and cane weight, as also noted by Gulati *et al.* under less-frequent irrigations [6]. Delayed irrigation might have lowered cell turgour pressure and consequently poor proliferation of tillers. Moreover, better nutrient uptake with frequent irrigation might have also contributed indirectly towards better growth and yield. Thanki *et al.* also reported similar results [7]. Commercial cane sugar yield was in accordance to cane yield, the major sugar yield determinant in sugarcane. Water-use efficiency (kg/ha-mm) followed the law of marginal diminishing return, being highest of 101.5 kg/ha mm with 2 irrigations (flowering and pod-filling stages) and lowest with most frequent irrigation at 1.2 IW : CPE.

B. Cane-equivalent yield and net returns

Intercrop had significant effect on production efficiency of intercropping system and thereby monetary returns (Table 3). Highest cane-equivalent yield of 107 tonnes/ha was obtained with sugarcane + cowpea intercropping systems, being 6.7, 9.9 and 8.7% higher than that of sole sugarcane, and intercropping with urdbean and mungbean. Superiority of cowpea was attributed to higher green pod yield that fetched good price in the market. Sugarcane + cowpea intercropping systems returned Rs 47,741/ha over cost of cultivation with benefit: cost ratio of 0.89 as against Rs 45,097 and benefit: cost ratio of 0.90 from sole sugarcane. Malavia *et al.* also reported higher returns from intercropping systems than sole sugarcane [8].

Cane-equivalent yield and returns of sugarcane-based intercropping system varied significantly due to irrigation schedules (Table 3). Frequent irrigations resulted in significantly higher cane-equivalent yield (109.5 tonnes/ha) over nation at 0.8 IW: CPE ratio and only at flowering and pod-filling stages. Highest net return of Rs 47,885 with benefit: cost ratio of 0.85 were obtained under IW:CPE ratio of 1.2. The increase in net return was attributed to higher intercrop yields, resulting in highest cane-equivalent yield under frequent irrigation. The results are in conformity with those of Gulati *et al.* [6].

Table 3. Effect of cropping systems and irrigation schedules on cane-equivalent yield, water- use efficiency and monetary returns in sugarcane-based intercropping systems

Treatment	Cane equivalent yield (tonnes/ha)	Water requirement (ha-mm)	WUE (kg/ha-mm)	Net return (Rs/ha)	Net return (Rs/ha/day)	Benefit:cost Ratio
Cropping system						
Sugarcane sole	100.2	1,060	94.6	45,097	123.6	0.90
Sugarcane + cowpea	107.0	1,060	100.9	47,741	130.8	0.89
Sugarcane + urdbean	97.3	1,060	91.8	38,886	106.5	0.73
Sugarcane + mungbean	98.4	1,060	92.9	39,803	108.0	0.74
CD (P=0.05)	6.2		4.8	2,000	5.0	0.06
Irrigation (IW: CPE ratio)						
1.2	109.5	1,210	90.5	47,885	131.2	0.85
1.0	105.5	1,090	96.8	45,665	125.0	0.84
0.8	95.5	1,030	92.7	39,765	108.9	0.78
Critical growth stages	92.4	910	101.5	38,212	104.7	0.77
CD (P=0.05)	6.2		4.8	2,000	5.0	0.06

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