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Effect of Irrigation and Fertilizer Management on Yield and Economics of Simultaneous Planting of Winter Sugarcane Plus Wheat

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Abstract

The field experiment was conducted during winter seasons of 2003-04 and 2004-05 to study the effect of irrigation and fertilizer management on yield and economics of simultaneous planting of winter sugarcane + wheat. The experiment was carried out in split plot design, keeping four irrigation options in main-plot, viz. irrigation scheduled at 0.8 (I_1), 1.0 (I_2), 1.2 (I_3) IW/CPE ratio and critical stages i.e. crown root initiation, tillering, late jointing, flowering, milk and dough stages of wheat (I_4), and four nutrient levels, viz. 100% (F_1), 125% (F_2), 150% (F_3) and 175% (F_4) of nutrient levels with four replications (100% recommended dose of nutrient means 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha). Maximum cane germination (35.3%) was noticed under treatment having irrigation at physiological stages of wheat, which was 3.9 to 5.5% higher over the 0.8 and 1.0 IW/CPE ratio irrigation regimes. Shoot height (379.3 cm), dry matter accumulation (199.4 g/shoot), number of millable cane (94.41 thousand/ha), cane yield (83.85 t/ha) and green top yield (12.93 t/ha) were also maximum under plot irrigated at important physiological stages of wheat crop. Application of 175% of recommended NPK fertilizer cane and wheat yields were 8.4 to 12.7% and 16.4 to 31.9% higher as compared to 125 and 100% recommended NPK, respectively. Application of 175% recommended dose of nutrients resulted significantly higher nitrogen uptake (223.9 kg/ha), phosphorus uptake (27.7 kg/ha) and potassium uptake (288.9 kg/ha) than that of 100, 125 and 150% recommended NPK. The maximum gain of gross return (Rs 126,992.0/ha), net return (Rs 75,882.5/ha) and B : C ratio (1.49) was obtained with irrigation at physiological stages of wheat followed by irrigation at 1.2 IW/CPE ratio over the irrigation at 0.8 and 1.0 IW/CPE ratio whereas, least net returns (Rs 48,687.4/ha) and B : C ratio (1.34) was under 0.8 IW/CPE ratio. Crop fertilized with 175% recommended dose of nutrient gave highest gross return (Rs 130,938/ha), net return (Rs 79,067.4/ha) and B : C ratio (1.53) over 100% and 125% recommended dose of nutrients. This indicates that application of 175% recommended NPK (210 kg N, 105 kg P_2O_5 and 70 kg K_2O/ha) and irrigation at critical stages of wheat is sufficient to provide nutrients for higher yield and economics of simultaneous planting of sugarcane and wheat in tarai region of Uttarakhand.

Key words : Irrigation, Fertilizer levels, Sugarcane, Wheat, Yield.

In India, sugarcane (*Saccharum officinarum* L.) is a major cash crop which supporting sugar industry next to textile industry. It plays pivotal role in contributing 2.0% share towards national gross domestic product. India is the maximum sugarcane producer in the world with annual cane production of 236.2 million tones from 4.0 million hectare acreage. The cane yield throughout the country is almost stagnant or even decline in some patches over the past few year surveys that were mainly due to imbalance and injudicious use of fertilizers application and untimely panting of sugarcane due to delay harvesting of wheat. The present scenario reveals that the burgeoning population of the country will require 25 million tonnes sugar by 2020 AD (1). To overcome such goals, country will require producing 415 million tonnes sugarcane by stipulated time, which only be possible through conjoint use of modern agronomic manipulations. In general autumn, spring and summer planting of sugarcane is done in northern India. However, summer planting (April/May) is pre-dominant in northern part of the country due to following sugarcane-ratoon-wheat crop system. Area under autumn (October) planted cane is low that yields are 15—20% more than spring season but its cropping intensity is much lower than spring ones. A drastic reduction in cane productivity (30 to 50%) was found in delay/summer planted sugarcane. Different scattered studies reveal the possibility of improving cane yield in sugarcane-ratoon-wheat crop system by simulta-

neous planting of sugarcane + wheat crops during winter season (2-3). The main constraints for grown sugarcane crop are canes sprouting suppression as results of prolong low temperature and limited available soil moisture in winter and high temperature and low soil moisture in summer season. In this regard, an adjustment of irrigation options coinciding with period of sugarcane germination may favor more cane sprouting. But wheat and sugarcane crops grown simultaneously may respond differently to nutrients application than grown in system. Keeping these in view, present study was taken to assess the yield and economics of simultaneous planting of sugarcane plus wheat as influenced by irrigation and nutrient levels in tarai region of Uttarakhand.

Methods

The field experiments were conducted 2 cosecutive year of 2003-04 and 2004-05 on two crop seasons at the Crop Research Center at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand. The crop Research Center is located at 29^0N latitude, 79.3 E longitude and at altitude of 243.8 meters above the mean sea level. Pantnagar is located in the tarai region in foothills of Shivalik range of Himalayas. The experiment was laid out in split plot design, keeping four irrigation options in main -plots irrigation scheduled at 0.8 (I_1), 1.0 (I_2), 1.2 (I_3) IW/CPE ratio and critical stages i.e. crown root initiation, tillering, late jointing, flowering, milk and dough stages of wheat (I_4), and four nutrient levels, viz. 100% (F_1), 125% (F_2), 150% (F_3) and 175% (F_4) of nutrient levels for sugarcane in sub-plot with four replications (100% nutrient levels means 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha). A composite soil sample from 0—30 cm depth for physical constants and 0—15 cm depth for mechanical and chemical analysis was taken before planting of experimental crop (4). The soil of the experimental site was silty clay loam, rich in organic carbon (1.05%), medium in available phosphorus (14.09 kg/ha) and potassium (266.03 kg/ha) with neutral in reaction (pH 7.1). The moisture content of top layer (0—30 cm) soil at field capacity and permanent wilting point were 23.38 and 8.01%, respectively. A uniform irrigation was given at crown root initiation of wheat crop for all the treatments. Thereafter irrigation was applied as per treatments till harvesting of wheat crop and thereafter it was given based on need of the sugarcane crop. One third of nitrogen and full dose of phosphorus and potassium were applied as basal in furrows and one third nitrogen was top dressed in January after irrigation at after crown root initiation of wheat crop and remaining one third nitrogen was top dressed in June (after harvesting of wheat crop). In wheat, number of tillers/m row length was counted at maximum flowering (70 days after sowing). Shoot height, dry matter production g/m^2, spike length, 1,000 grain weight was measured at maturity. At harvest, samples were drawn from bulk of produce and harvest index was measured. In sugarcane, germination percent of sugarcane was recorded at 60 days after sowing. Highest number of shoots count thousand/ha at 180 days after planting, dry matter production g/plant at 240 DAP and thereafter decreased with advancement of the growth stage. Yield and yield attributes of sugarcane was recorded from each plot. Randomly selected five canes from each plot determined juice quality attributes at physiological maturity. Juice sucrose (%) was determined by Horne's dry lead Acetate Method as described by Spencer and Meade (5). Schmitz's table was used to calculate juice sucrose. The purity coefficient and available sugar percent in juice were calculated by using following formulae :

Available sugar per cent = [S -{0.4 (B - S)} 0.73]

Where, S is the sucrose percent in juice, B is the corrected brix of juice and 0.4 and 0.73 are constants and CCS yield (t/ha) = available sugar in cane % × cane yield (t/ha)/100.

The nutrients uptake was worked out by multiplying cane, green tops and trash yield of sugarcane and grain and straw yield of wheat along with their respective nutrients content values were calculated. The cost of cultivation was worked out by considering the current price of the inputs/commodity used under different treatment options. The gross return and net return were worked out by multiplying cane and green tops yield of sugarcane and grain and straw yield of wheat along with their prices. For this, market price of cane (Rs 102/q), green tops (Rs 37.5/q), wheat grains (635/q) and straw (Rs 190/q) was kept. Accordingly benefit : cost ratio was calculated. The

Table 1. Effect of irrigation and fertilizer levels on growth and yield of winter sugarcane grown under simultaneous planting of wheat (mean two year).

Treatments	Germination (%)	No of shoot counts (000/ha) Jun	Jul	Aug	Dry matter production (g/shoot)	No millable canes (000/ha)	Cane yield (q/ha)	Green top yield (q/ha)	CCS yield (t/ha)
Irrigation Schedule									
I_1	29.82	152.3	128.4	103.5	179.6	85.11	743.0	99.8	9.60
I_2	31.43	153.5	128.5	104.6	184.6	88.34	772.0	116.7	9.67
I_3	34.37	156.3	129.4	109.3	192.8	93.90	826.4	127.1	9.74
I_4	35.30	159.1	132.8	110.5	199.4	94.41	838.5	129.3	9.90
CD (P =0.05)	4.83	11.85	12.57	12.39	12.5	7.94	61.0	16.8	0.91
Fertilizer Levels									
F_1	32.07	145.7	122.0	97.7	181.9	88.8	774.3	108.7	9.08
F_2	33.34	150.0	127.2	103.4	189.3	90.8	805.3	121.5	9.97
F_3	34.33	160.5	132.4	1110.0	194.0	94.2	842.0	129.9	9.94
F_4	35.17	164.3	137.6	113.8	201.2	98.8	872.2	136.8	10.21
CD (P=0.05)	NS	11.91	9.27	8.09	11.5	6.2	48.0	13.1	0.80

significance of treatment were assessed using by F test (6).

Results and Discussion

Growth, Yield and Yield Attributes of Sugarcane

Irrigation scheduled at critical stages of wheat had significantly maximum cane germination (35.3%), followed by irrigation scheduled at 1.2 IW/CPE ratio and was 3.9 to 5.5% higher over other irrigation options (Table 1). It is pertinent to mention here that application of irrigation at critical stages (CRI, tillering, jointing, boot, flowering, milk and dough stages) of wheat increased micro-environment temperature through latent heat and made it favorable for sprouting of cane germination. On the other hand, wide interval in irrigation application under 0.8 and 1.0 IW/CPE ratio did not save crop from severe low temperature during December and January (4.4 to 8.3 C) and poor germination was noticed (29.82 to 31.43%).

Table 2. Effect of irrigation and fertilizer management on yield and yield attributes of wheat grown under simultaneous planting of winter sugarcane (mean two year).

Treatments	Plant height (cm)	Dry matter accumulation (g/m^2)	Spike length (cm)	1000-Grain weight (g)	Grain yield (q/ha)	Straw yield (q/ha)
Irrigation Schedule						
I_1	85.9	527.8	8.9	37.3	27.6	53.5
I_2	90.3	551.5	9.7	39.4	31.7	57.7
I_3	93.1	581.8	10.5	41.5	35.2	60.3
I_4	95.8	598.5	10.9	43.2	36.1	64.3
CD (P = 0.05)	5.1	46.4	1.06	3.6	2.8	7.5
Fertilizer Levels						
F_1	85.6	524.3	8.7	36.8	27.4	53.1
F_2	90.4	550.1	9.8	39.9	31.8	57.7
F_3	93.2	583.4	10.5	41.7	35.3	60.4
F_4	95.9	601.8	11.7	43.3	36.2	65.2
CD (P = 0.05)	4.75	40.8	2.5	2.0	3.9	2.3

Table 3. Effect of irrigation and fertilizer levels on economics and nutrient uptake of winter sugarcane and wheat grown under simultaneous planting (mean two year).

Treatments	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Gross returns (Rs/ha)	B : C ratio	Nutrient uptake wheat (kg/ha) N	P	K	Nutrient uptake sugarcane (kg/ha) N	P	K
Irrigation Schedule										
I_1	48687.4	116367	66622.6	1.34	79.5	18.4	76.2	186.4	20.3	241.8
I_2	49201.8	120453	70093.2	1.39	90.8	20.8	92.8	190.7	21.1	247.6
I_3	49712.1	124538	73515.9	1.44	98.8	23.5	94.6	195.9	22.8	255.9
I_4	49712.5	126992	75882.5	1.49	106.9	25.6	102.4	198.2	24.5	262.8
CD (P = 0.05)	-	-	-	-	8.2	NS	NS	14.8	NS	NS
Fertilizer Levels										
F_1	49253.4	112053	62799.6	1.28	75.1	17.3	76.3	157.8	19.2	211.1
F_2	50109.7	119197	69087.3	1.38	89.1	20.4	83.5	186.3	22.5	243.0
F_3	50793.7	124544	73750.3	1.46	104.6	23.9	92.2	207.2	24.5	266.3
F_4	51860.6	130938	79067.4	1.53	114.8	26.6	102.8	223.9	27.8	288.9
CD (P = 0.05)	-	-	-	-	5.82	1.62	5.81	13.7	1.6	14.7

The advantages of early crop establishment were also accrued in terms of growth and yield attributes, viz. number of tillers counts (115 to 124.4 thousand/ha) at 180 DAP, dry matter production (199.5 g/plant), number of millable cane (94.41 thousand/ha), cane yield (838.5 q/ha), green top yield (129.3 q/ha) and CCS yield (9.9.0 t/ha) under irrigation at critical stages of wheat. The increased juice extraction may be argued in terms of higher translocation of water and photosynthetes and its subsequent conversion in economic parts under optimal water and nutrient availability. These results also confirmed the findings of Verma and Yadav (7) and Mehboob et al. (8).

Nutrient levels had significantly influenced on growth, yield and yield attributes of sugarcane (Table 1). Crop fertilized with 175% of recommended NPK noted significantly maximum number of tillers counts (115 to 124.4 thousand/ha) at 180 DAP, dry matter production (201.2 g/plant) number of millable cane (94.4 thousand/ha), cane yield (872.2 q/ha), green top yield (136.8 q/ha) and CCS yield (9.94 t/ha) at harvest which was statistically at par to that of 150% of recommended NPK rates. Yield gave under 175% of recommended NPK fertilized plots were 12.7 and 8.4% higher over 100 and 125% recommended NPK rates, respectively. Since both sugarcane and wheat crops shares for their nutrient demands an enhanced dose of recommended NPK might have provided optimal nutrition to supply the crop, which in turns resulted as synchrony in plants shoot counts, its height, cane length, dry matter accumulation and more leaf area (photosynthetic area) and all these physiological growth improvement resulted in maximum number of millable canes, cane length, and average cane weight and ultimately produced more cane yield. These results are also agreement with the findings of Singh et al. (9) and Mehboob et al. (8).

Growth, Yield and Yield Attributes of Wheat

Irrigation options had significant impact on growth, yield and yield attributes of wheat (Table 2). Irrigation scheduled at critical stages of wheat resulted significantly higher plant height (95.9 cm) dry matter production (598.5 g/m^2), spike length (10.8 cm) and 1,000-grain weight (43.3 g), being at par with irrigation scheduled at 1.2 IW/CPE ratio. Yield studies in wheat viz. grain ; straw yield and 1,000-grain weight were also higher (12.2 to 23.6%, 10.3 to 16.8% and 8.8 to 13.7%) when crop was irrigated at important critical stages over irrigation applied at 1.0 and 0.8 IW/CPE ratio. Results are also conformity with the findings of Sing and Bhan (10) and Verma et al. (11).

Fertilizer levels had also significant impact on different growth, yield and yield attributes of wheat (Table 2). Application of 175% of recommended NPK produced significantly maximum plant height (95.9 cm) dry matter production (601.8 g/m^2), spike length (11.7

cm) and 1000-grain weight (43.3 g), which was statistically at par with 150% of recommended NPK application. Application of 175% of recommended NPK gave 13.8 and 31.9% more grain yield than 125 and 100% recommended NPK (31.8 and 27.4 q/ha, respectively). Higher rate of nutrient requirement in present case may be visualized in terms of more nutrients demand though simultaneously grown both crops in winter season and therefore, total NPK demand was increased up to 150%. Since sugarcane and wheat both are high nutrients responsive crop, lower NPK application rates would have adverse impact on productivity of both the crop. These results are in close conformity with the findings of Bandyopadhyay (12) and Rehman et al. (13).

The interaction between irrigation and nutrient levels with respect to nitrogen, phosphorus and potassium uptake of sugarcane was not significant.

Nutrient Uptake

Differences in nitrogen uptake in sugarcane crop due to irrigation levels was significant, however, phosphorus and potassium uptake due to irrigation levels was not significant (Table 3). Irrigation at critical stages of wheat removed maximum nitrogen of 208.9 kg/ha, being at par with that of 1.2 IW/CPE ratio but significantly higher than 0.8 and 1.0 IW/CPE ratio. Differences in nitrogen, phosphorus and potassium uptake in sugarcane crop due to fertilizer levels was significant. Application of 175% of recommended NPK resulted significantly higher total nitrogen uptake (223.9 kg/ha), phosphorus uptake (27.7 kg/ha) and potassium uptake (288.9 kg/ha) over 100, 125 and 150% of recommended NPK. These results are also confirmed by the findings of Singh and Jafri (14).

Nitrogen uptake in wheat crop due to irrigation levels was significant, however, phosphorus and potassium uptake due to irrigation options was not significant. Crop receiving irrigation at critical stages of wheat removed maximum nitrogen of 100.9 kg/ha, being at par with that of 1.2 IW/CPE ratio but significantly higher than that of 0.8 and 1.0 IW/CPE ratio. Nitrogen, phosphorus and potassium uptake in wheat significantly affected due to nutrient levels. Crop fertilized with 175% of recommended NPK removed maximum nitrogen (115 kg/ha), phosphorus (26.6 kg/ha) and potassium (102.8 kg/ha), being significantly higher than that of 100, 125 and 150. These results are also confimed by the findings of Rehman et al. (13).

Effect on Economics

The maximum cost of cultivation (Rs 49,712.5/ha) was involved when crop were irrigated at physiological stages of wheat followed by irrigation at 1.2 IW/CPE ratio over 0.8 and 1.0 IW/CPE ratio whereas, with the application of 175% recommended dose of nutrients invested (Rs 51,860.6/ha) over 125 and 100% recommended NPK. Economic comparison worked out (Table 3) in terms of net returns and B : C ratio indicates that the maximum gain gross return (Rs 126,992.0/ha), net return (Rs 75,882.5/ha) and B : C ratio (1.49) with irrigation at physiological stages of wheat followed by irrigation at 1.2 IW/CPE ratio over the irrigation at 0.8 and 1.0 IW/CPE ratio whereas, least net returns (Rs 48,687.4/ha) and B : C ratio (1.34) was under 0.8 IW/CPE ratio. Crop fertilized with 175% recommended dose of nutrient gave highest gross returns (Rs 130938/ha), net return (Rs 79,067.4/ha) and B : C ratio (1.53) over 100 and 125% recommended dose of nutrients. Irrigating field during initial critical growth stages and 175% recommended nutrients doses played a vital role for enhancing cane productivity as well as wheat yield grown simultaneously, which also ultimately reflected in term of its economic viability. Similar results were also reported by Shukla (3) and Verma and Yadav (7).

Thus it reveals that sugarcane + wheat crop grown simultaneously receiving irrigation at critical stages of wheat significantly higher grain yield and cane yield in winter season. Crop fertilized with 175% of recommended NPK (210 kg N, 105 kg P_2O_5 and 70 kg K_2O/ha) produced significantly higher yield of cane and wheat over 100 and 125% recommended nutrients dose. This, indicates that with the application of 175% recommended NPK (210 kg N, 105 kg P_2O_5 and 70 kg K_2O/ha) with irrigation at critical stages of wheat is sufficient to provide nutrients and optimum soil moisture for higher productivity and profitability of simultaneous planting of sugarcane + wheat crops in tarai region of Uttarakhand.

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