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Response of late-sown wheat (*Triticum aestivum*) to row spacing-cum-population densities and levels of nitrogen and irrigation in north-western Rajasthan

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ABSTRACT

A field investigation was conducted during the winter (*rabi*) season of 1998–99 and 1999–2000, to find out the optimum row spacing-cum-population density, nitrogen and irrigation level requirement for late-sown wheat (*Triticum aestivum* L. emend. Fiori & Paol.). Narrow row spacing of 15 cm using 205 kg seed/ha resulted in significant higher grain yield (29.9 and 27.9 q/ha) compared with normally used spacing of 22 cm with 140 kg seed/ha. Significant increase in yield was recorded up to 150 kg N/ha and it did not differ significantly with that obtained with 180 kg N/ha. Irrigations at IW : CPE 0.8 with each irrigation of 6.0 cm, recorded significantly higher grain yield (29.5 and 27.6 q/ha) than that of irrigation at IW : CPE 0.6, but it was at par with that of irrigation at IW : CPE 1.0. Similarly, 150 or 180 kg N/ha recorded higher water use-efficiency (8.5 and 7.7 kg/ha-mm). Increase in irrigation levels decreased water-use efficiency. The highest water-use efficiency of 76.4 and 66.9 kg grain/ha-cm during 1998–99 and 1999–2000, respectively, was recorded with narrow spacing. Narrow row spacing recorded higher net return (Rs 11,729 and 10156)/ha and benefit : cost ratio (2.2 and 2.0). Nitrogen levels of 150 kg/ha gave the highest net return (Rs 12, 203 and 10,678) and benefit : cost ratio followed by 180 kg and 120 kg N/ha. The highest net return and benefit : cost ratio were obtained with 6 cm irrigations applied at IW : CPE ratio 1.0 and IW : CPE ratio 0.8 in 1998–99 and 1999–2000, respectively, schedule for a wheat after a 10 cm pre-sowing irrigation. Interaction effect of spacing and nitrogen, nitrogen and irrigation and spacing and irrigation had significant effect on grain yield in both the years.

Key words : Late-sown wheat, Spacing, Nitrogen, Irrigation, Water use, Economics

In considerable area sowing of wheat gets delayed due to late harvesting of upland cotton in cotton–wheat cropping system which occupies more than 70% of the canal irrigation area of north–western Zone of Rajasthan (Nehra and Bhunia, 2002). Yield of late-sown wheat is lower than normal sown wheat, but profitability and stable performance of this cropping system still makes sowing of late-sown wheat a common and popular practice among the farming community of the region. An increase in plant and fertilizer can be effective in boosting the productivity of wheat under late-sown conditions (Hegde and Bhatia, 1993). Low plant population with normal 22 cm spacing in late-sown condition results in lower yield than generally obtained with closer spacing using higher seed rate. Late-sown wheat is exposed to high temperature coupled with high evaporation demand of the atmosphere during the reproductive phase, along with reduced growing season. Consequently, thereafter results in reduced growth and productivity. Productivity of late-sown wheat can be boosted under favourable soil-moisture regime, which can be created by proper scheduling of irrigation (McDonald *et al.*, 1984), as it not only takes care of the deleterious effect of high temperature but also increases water-use efficiency (through improved yields). Hence this investigation was undertaken to find out the optimum spacing, nitrogen and irrigation schedule for late-sown wheat, grown after cotton in the north-western Zone of Rajasthan on deep sandy-loam alluvials of medium water retentivety and below average fertility status.

MATERIALS AND METHODS

The field experiment was conducted at the Agricultural Research Station, Sriganganagar, during winter (*rabi*) seasons of 1998–99 and 1999–2000. The treatments included 2 spacings-cum-population density, viz S_1, 22 cm (140 kg seed/ha); and S_2, 15 cm (205 kg seed/ha) assigned to the main plots; 4 nitrogen levels (90, 120, 150 and 180 N/ha) in the subplots; and 3 irrigation schedules of irrigating wheat with 6 cm water at I_1 (IW : CPE 0.6); I_2 (IW : CPE 0.8) and I_3 (IW : CPE 1.0) assigned to the subplots. The design was a double split plot having 3 replications. The soil was sandy loam with organic carbon 0.18%, available phosphorus 33 kg/ha and potash 330 kg/ha, pH 8.1 and electrical conductivity (1:2) 0.2 mmhos/cm. The N and

P_2O_5 were applied through urea and diammonimum phosphate respectively. One-third of N (as per treatments) and full dose of P_2O_5 were applied at sowing and the remaining N was applied in 2 splits at first and second irrigation. Wheat variety ' Raj 3077' was sown on 15 January in both the years. A pre-sowing irrigation of 100 mm was applied by surface method of irrigation, thereafter post-sowing irrigations of 60 mm each were applied as per treatment.

RESULTS AND DISCUSSION

Yield attributes

Row spacing had significant effect on yield attributes, viz. plant height, grains/ear and test weight (Table 1). Higher plant height was recorded in narrow row spacing-cum-population densities (15 cm and 205 kg seed/ha) than at the normal spacing having low population density (22 cm and 140 kg seed/ha). This could be possible due to greater competition for light at higher plant density (22 cm row spacing). Grains/ear and test weight were significantly higher with normal spacing with low population density than those at narrow spacing with high population density. This might be due to more competition due to higher population density for growth resources in high population density situation (15 cm and 205 kg seed/ha) than under lesser population obtained with 22 cm row spacing and 140 kg seed/ha). Singh *et al.* (1999) also obtained lower values of yield attributes except the height with 205 kg seed/ha at 15 cm spacing, i.e. high population density under late-sown conditions of Delhi.

Each increment in N level resulted in significant increase in plant height and grains/ear up to 150 kg/ha and test weight up to 120 kg/ha (Table 1) with no significant increase in plant height, grains/ear and test weight with further increase in N dose.

Plant height, grains/ear and test weight varied significantly and the highest values of all these attributes were recorded with IW:CPE ratio 1.0 which was at par with IW:CPE ratio 0.8 (Table 1). Such increase in yield attributes was due to more water supply at higher IW: CPE ratio providing congenial growth environment which improved the cell turgidity, opening of stomata and finally the partitioning of photosynthates efficiently to the sink. Singh and Bhan (1998) and Panda *et al.* (1988) also reported such results. Non-significant differences were however, observed for effective ear-bearing tillers and ear length with different low spacing, N and irrigation levels.

Yield and harvest index

Population density had significant impact on grain yield in both the years and straw yield in 1999–2000 (Table 2). Favourable effect of narrow spacing-cum-high seed rate (15 cm and 205 kg seed/ha) was well marked on grain and straw yields and it resulted in higher yield than those obtained with low population density treatments, i.e. normal spacing (22 cm and 140 kg seed/ha). Higher harvest index (37.8%) was also obtained with higher population density than those obtained with low population density (36.9%). Nitrogen level of 180 kg/ha gave the maximum grain and straw yields and proved significantly superior to lower N levels of 90 and 120 kg/ha but was at par with 150 kg/ha. The increase in grain and straw yields was possibly owing to better growth and development of yield-attributing characters at higher N levels. The results confirm the findings of Patel and Upadhyay (1993) and Singh and Brar (1994).

Increase in N levels increased harvest index steadily with maximum values of 38.3% with N /ha in 1998–99 and 38.5% with 150 kg N/ha in 1999–2000 and further increase in dose to 180 kg/ha in 1999–2000 decreased the harvest index. Irrigation level of IW:CPE ratio 0.8 resulted in significantly higher yields than IW:CPE ratio 0.6. Any further increase in irrigation level had no significant effect on grain as well as straw yields. Irrigation levels had inconsistent effect on harvest index with maximum values at IW : CPE ratio 0.6 in 1998–99 and IW : CPE ratio 0.8 in 1999–2000.

Water use and water-use efficiency

Mean seasonal water use was 36.2 and 37.1 cm in 1998–1999 and 1999–2000, respectively, for the population densities and 4 N levels (Table 2). In 1998–99, the water use was 30.2, 36.1 and 42.2 mm water and with the soil moisture regimes of IW : CPE ratio 0.6, 0.8 and 1.0, respectively, and in 1999–2000 it was 33.1, 39.1 and 39.1 cm water. Water-use efficiency was higher at higher population density than low population density.

Each increment in N level from 90 kg to 150 kg/ha increased water-use efficiency (WUE), while it decreased with increase in irrigation levels, and highest WUE was recorded with irrigation treatment IW : CPE ratio 0.6.

Economics

Higher population density (15 cm and 205 kg seed/ha) gave higher net returns of Rs 11,719 and Rs 10,156 with benefit : cost ratio of 2.2 and 2.0 than that of low population treatment (Table 2). Among the N levels, there was steady increase in net returns with increase in N level from 90 kg/ha to 150 kg/ha. There was however, a marginal reduction in net returns (Rs 258 and 212) at highest level of 180 kg N over 150 kg N and benefit : cost ratio also followed the similar trend with highest values of 2.3 and 2.0 at N level of 150 kg/ha. Irrigation levels had inconsistent effect on net return and benefit : cost ratio, the highest net return (Rs 12, 279) and benefit : cost ratio (2.3) was ob-

Table 1. Effect of row spacing and levels of nitrogen and irrigation on yield attributes of late-sown wheat (pooled data of 2 years)

Treatment	Effective tillers/m length	Plant height (cm)	Ear length	Grains/ ear (cm)	1,000-seed weight (g)
Row spacing					
S_1, 22 cm (140 kg seed/ha)	79.6	85.3	8.4	30.8	27.2
S_2, 15 cm (205 kg seed/ha)	79.4	88.9	8.2	30.6	26.8
CD (P=0.05)	NS	2.1	NS	0.2	0.4
Nitrogen					
N_1, 90 kg/ha	78.7	83.6	7.9	30.0	25.8
N_2, 120 kg/ha	79.5	87.8	8.5	30.8	27.0
N_3, 150 kg/ha	79.7	89.4	8.3	31.0	27.3
N_4, 180 kg/ha	79.8	89.4	8.3	31.1	27.8
CD (P=0.05)	NS	1.5	NS	0.8	0.8
Irrigation					
I_1, IW : CPE 0.6	79.0	85.0	8.3	29.9	24.6
I_2, IW : CPE 0.8	79.2	88.1	8.3	31.0	28.0
I_3, IW : CPE 1.0	79.4	88.2	8.3	31.3	28.4
CD (P=0.05)	NS	1.2	NS	1.0	2.7

Table 2. Yield, harvest index, water use, water-use efficiency and economics of late-sown wheat under different row spacing and levels of N and irrigaion

Treatement	Grain yield (q/ha)		Straw yield (q/ha)		Harvest index (%)		Water use (cm)		Water-use efficiency (kg/ha-cm)		Net return (Rs)		Benefit : cost ratio	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
Row spacing														
S_1, 22 cm (140 kg seed/ha)	27.6	24.8	46.8	42.4	37.2	36.9	36.2	37.1	76.4	66.9	10,746	8.527	2.2	1.9
S_2, 15 cm (205 kg seed/ha	29.9	27.9	52.1	45.8	36.5	37.8	36.2	37.1	82.7	75.2	11,729	10,156	2.2	2.0
CD (P=0.05)	1.8	0.8	NS	2.1										
Nitrogen														
N_1, 90 kg/ha	24.9	22.7	49.8	40.8	33.3	35.8	36.2	37.1	68.7	61.3	9,468	7,294	2.0	1.7
N_2, 120 kg/ha	28.9	25.4	48.5	43.8	37.4	36.7	36.2	37.1	80.0	68.6	11,344	8,902	2.2	1.9
N_3, 150 kg/ha	30.7	28.6	49.9	45.7	38.1	38.5	36.2	37.1	84.8	77.1	12,203	10,678	2.3	2.0
N_4, 180 kg/ha	30.7	28.6	49.5	46.1	38.3	38.2	36.2	37.1	84.8	77.1	11,945	10,466	2.2	2.0
CD (P=0.05)	0.9	0.9	NS	1.4										
Irrigation														
I_1, IW : CPE 0.6	26.8	24.0	44.1	43.4	37.9	35.6	30.2	33.1	89.0	72.5	9,735	8,116	2.0	1.8
I_2, IW : CPE 0.8	29.5	27.6	50.1	44.1	37.1	38.5	36.2	39.1	81.6	70.7	11,705	10,008	2.2	2.0
I_3, IW : CPE 1.0	30.0	27.4	54.1	44.7	35.7	38.0	42.2	39.1	71.2	70.1	12,279	9,932	2.3	2.0
CD (P=0.05)	0.8	0.8	4.3	1.0										

Including rainfall (2.17 cm in 1999, 5.05 cm in 2000) and pre-sowing irrigation (10.0 cm in each year)
Y_1, 1998–99; Y_2, 1999–2000

tained at IW : CPE 1.0 in 1998–99, whereas in 1999–2000, the highest net return of Rs 10,008 and benefit : cost ratio of 2.0 were obtained with IW : CPE ratio 0.8.

Interaction effect

Interaction effect of row spacing-cum-seed rate, i.e. population density × nitrogen, had significant effect on grain yield (Table 3). Closer spacing with higher seed rate (15 cm and 205 kg seed/ha) resulted in significantly higher grain yield than lower population density, i.e. normal spacing with normal seed rate (22 cm and 140 kg seed/ha) under all N levels (90, 120, 150 and 180 kg/ha). Each increment in N levels from 90 to 150 kg/ha increased grain yield significantly under both spacings and further increase of N levels to 180 kg/ha had no significant effect on grain yield.

Table 3. Interactive effect of plant population density and nitrogen, nitrogen and irrigation and plant population and irrigation on grain yield (q/ha) of late-sown wheat

Treatment	Plant population density × nitrogen interaction							
	1998–99				1999–2000			
	N_1 (90 kg)	N_2 (120 kg)	N_3 (150 kg)	N_4 (180 kg)	N_1 (90 kg)	N_2 (120 kg)	N_3 (150 kg)	N_4 (180 kg)
S_1, 22 cm (140 kg seed/ha)	24.0	28.4	28.9	29.3	22.7	23.8	26.5	26.2
S_2, 15 cm (205 kg seed/ha)	25.8	29.5	32.4	32.1	22.8	27.0	30.7	30.9
CD (P=0.05)	1.3				1.2			

	Nitrogen × irrigation levels					
	1998–99			1999–2000		
	I_1 (IW : CPE 0.6)	I_2 (IW : CPE 0.8)	I_3 (IW : CPE 1.0)	I_1 (IW : CPE 0.6)	I_2 (IW : CPE 0.8)	I_3 (IW : CPE 1.0)
N_1, 90 kg/ha	23.5	25.1	25.9	20.1	23.6	24.5
N_2, 120 kg/ha	27.5	28.7	30.6	22.9	26.7	26.6
N_3, 150 kg/ha	28.7	32.1	31.2	26.2	30.4	29.2
N_4, 180 kg/ha	27.7	32.1	32.3	26.6	29.8	29.2
CD (P=0.05)	1.2			1.6		

	Plant population × irrigation interaction					
	1998–99			1999–2000		
	I_1	I_2	I_3	I_1	I_3	I_3
S_1, 22 cm (140 kg seed/ha)	25.6	28.5	28.9	22.5	25.8	26.1
S_2, 15 cm (205 kg seed/ha)	28.1	30.5	31.2	25.5	29.4	28.7
CD (P=0.05)	1.7			1.1		

Interaction effect of nitrogen × irrigation on the grain yield was also significant (Table 3). In most of the cases irrigation level of IW : CPE 0.8 and 1.0 gave significantly higher grain yield over 0.6 at all the N levels. Similarly, significantly higher grain yields were obtained in the most cases up to 150 kg N /ha under all the irrigation levels.

Row spacing-cum-seed rate × irrigation interaction effect on grain yield too was significant (Table 3). Narrow row spacing-cum-higher seed rate (15 cm and 205 kg seed/ha) had well marked effect on grain yield than normal spacing-cum-lower seed rate (22 cm and 140 kg/ha) under all soil-moisture regimes (IW:CPE 0.6, 0.8, and 1.0). Significant higher grain yields were thus obtained with IW : CPE 0.8 over IW : CPE 0.6 and further increase in irrigation level to IW : CPE 1.0 had no significant effect.

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