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Research Paper

Response of late-sown wheat (*Triticum aestivum*) to limited irrigation, seed rate and depth of sowing

L.K. IDNANI[1]

ICAR-Indian Agricultural Research Institute, New Delhi 110 012

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2014–15 and 2015–16 at New Delhi, to study the effect of limited irrigation, seed rate and depth of sowing on growth, yield, water-use parameters and economics of late-sown wheat (*Triticum aestivum* L.). The experiment comprised 3 factors, viz. 3 irrigation levels [(I_1, irrigation at crown-root initation (CRI) stage; I_2, irrigation at CRI stage + 0.2 irrigation water: cumulative pan evaporation (IW : CPE) ratio; and I_3, irrigation at CRI stage + 0.4 IW : CPE ratio), 3 seed rates (S_1, 75; S_2, 100 and S_2, 125 kg/ha) and 2 depths of sowings (D_1, 5 cm and D_2, 10 cm). The field experiment comprising 18 treatment combinations, replicated thrice, was laid out in strip-plot design. Interactions between irrigation levels and seed rates, and irrigation levels and depths of sowing for grain yield were significant during 2014–15. Irrigation levels, seed rates and depths of sowing also significantly affected plant height, yield attributes, grain yield, straw yield and harvest index. Irrigation at CRI stage + 0.4 IW : CPE ratio resulted in significantly the highest plant height (86.3 cm), effective tillers/m^2 (407.82), spike length (14.40 cm), spikelets/spike (17.43), grains/spike (44.20), grain weight/spike (2.05 g), 1,000-grain weight (48.95 g), grain yield (4.22 and 3.75 t/ha during 2014–15 and 2015–16) and harvest index (0.497 and 0.477 during respective season). Seed rate of 125 kg/ha resulted in significantly the highest plant height (82.7 cm), effective tillers/m^2 (416.66), spike length (14.62 cm), spikelets/spike (17.53), grains/spike (40.20), grain weight/spike (2.06 g), 1,000-grain weight (47.80 g), grain yield (3.63 t/ha during 2015–16) and harvest index (0.496 and 0.456 during respective year). Sowing depth of 10 cm resulted in significantly the highest plant height (82.2 cm), effective tillers/m^2 (382.64), spike length (13.94 cm), spikelets/spike (16.44), grains/spike (38.21), grain weight/spike (1.90 g), 1,000-grain weight (46.24 g), grain yield (3.95 and 3.49 t/ha during both the years) and harvest index (0.456 and 0.443 during both the years).

Key words: Depth of sowing, Late-sown wheat, Limited irrigation, Seed rate

Wheat is one of the world's most widely cultivated food crops. It contributes 40% in the total foodgrain production in the country, next to rice. It is grown in 29.1 million ha in India with the production of 102.2 million tonnes and productivity of 3.51 tonnes/ha (MoF, 2019). The wheat productivity greatly depends on availability of nutrients and moisture, besides the climatic factors. A field experiment conducted at Department of Agronomy, Bangladesh Agricultural University revealed that, the seed rate of 140 kg/ha with 1 irrigation given at crown-root initiation (CRI) stage may be practiced for better performance of wheat cv. Gourab (Kabir *et al*., 2003). In another experiment conducted at Department of Agronomy, Bahauddin Zakariya University, Multan, Pakistan, it was concluded that late-sown wheat crop planted in 11.0 cm wide rows under conventional tillage, irrigated at 100% ETo may serve as an appropriate technology for enhancing the wheat productivity of late-sown wheat crop under limited water supplies (Hakoomat Ali *et al*., 2013). In another experiment conducted under irrigated ecosystem at Research Farm of Adharatal, Jabalpur, Madhya Pradesh, it was observed that performance of wheat was superior with seed rate of 80 kg/ha being at par with 100 kg/ha. Similar findings were also reported by Sen *et al*. (2003). These results supported the findings of Kumar *et al*. (2002) and Singh *et al*. (2006). Farmers in Kymore plateau and Satpura plateau, Madhya Pradesh often faced problem in late-sown *rabi* crop due to delayed harvesting of *kharif* crop. The study showed that changing seeding rates and sowing depths was helpful in achieving higher yield of wheat. Plant population affected wheat yield considerably. Therefore, the optimum seeding rate was crucial for getting high yield of wheat in various

[1]**Corresponding author's Email:** lkidnani@yahoo.com
[1]Principal Scientist, Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi 110 012

regions (Lloveras *et al.,* 2004). Sowing depth significantly influenced the emergence and vigour of seedlings contributing greatly to crop stand and yield (Roy *et al*., 2011). Hence this experiment was conducted with the objectives to study the effect of limited irrigation, seed rate and depth of sowing on growth, yield, water use parameters and economics of late sown wheat.

MATERIALS AND METHODS

A field experimental trial was conducted during the winter (*rabi*) season of 2014–15 and 2015–16 on sandy-loam soil with adequate drainage system at Research Farm of Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi. The soil of the experimental field was low in organic carbon (0.42 and 0.41%), total and available nitrogen (0.041 and 0.041% and 208.0 and 216.0 kg/ha), medium in P (11.32 and 12.11 kg/ha) and K (227 and 239 kg/ha), electrical conductivity (0.38 and 0.38 dS/m at 25°C) and alkaline in reaction (7.4 and 7.3 during the respectively years). The experiment comprised of 3 factors, viz. 3 irrigation levels (I_1, irrigation at CRI stage; I_2, irrigation at CRI stage + 0.2 IW : CPE ratio and I_3, irrigation at CRI stage + 0.4 IW : CPE ratio), 3 seed rates (S_1, 75, S_2, 100 and S_3, 125 kg/ha) and 2 depths of sowings (D_1, 5 cm and D_2, 10 cm. The field experiment comprising 18 treatment combinations, replicated thrice, was laid out in strip-plot design. Depth of irrigation was applied as per the moisture depleted from each treatment. The rainfall received during the crop season was 315.8 and 22.0 mm during 2014–15 and 2015–16, respectively.

Two rows on either side of each plot were left as border rows. Third and fourth rows on either side of each plot were used for plant sampling. Fifty cm row length was picked up at random from third and fourth row on either side of each plot, leaving 50 cm on either end of the sampling rows. Grain yield was taken from net plot harvest. Calculation of consumptive use of water was done as suggested by Dastane (1967).

Observations on plant growth and yield were taken as per standard procedures. Gross and net returns were calculated based on the grain and straw yields and their prevailing market prices of wheat during the respective crop season. The 2 years data obtained from experiment on plant height and yield attributes were averaged and statistically analysed using the *F*-test as per standard procedure and LSD values at P=0.05 were used to determine the significance of difference between treatment means.

RESULTS AND DISCUSSION

Growth and yield attributes

Irrigation levels, seed rates and depth of sowing significantly affected the plant height (Table 1). Irrigation at CRI + 0.4 IW : CPE recorded significantly highest plant height (86.3 cm), seed rate of 125 kg/ha recorded significantly highest plant height (82.7 cm) and depth of sowing of 10 cm recorded significantly higher plant height (82.2 cm).

Irrigation levels affected the yield attributes significantly (Table 1). Irrigation at CRI + 0.4 IW : CPE resulted in sig-

Table 1. Yield attributes of wheat as influenced by irrigation, seed rates and depth of sowing (pooled data of 2 years)

Treatment	Plant height (cm)	Effective tillers (No./m²)	Spike length (cm)	Spikelets/ spike	Grains/ spike	Grain weight/ spike (g)	1,000-grain weight(g)
Irrigation levels							
I_1, Irrigation at CRI stage	74.8	337.3	13.4	14.9	29.6	1.4	40.73
I_2, Irrigation at CRI + 0.2 IW: CPE	80.1	344.5	13.4	16.1	35.4	1.8	44.78
I_3, Irrigation at CRI + 0.4 IW: CPE	86.3	407.8	14.4	17.4	44.2	2.1	48.95
SEm±	1.4	13.5	0.2	0.3	1.7	0.8	1.04
CD (P=0.05)	5.6	52.9	0.9	1.3	6.6	0.3	4.09
*Seed rates (*kg/ha*)*							
S_1, 75	78.1	307.7	12.8	14.8	32.6	1.4	41.84
S_2, 100	80.4	364.3	13.7	16.1	36.4	1.7	44.82
S_3, 125	82.7	416.7	14.6	17.5	40.2	2.1	47.80
SEm±	0.7	14.4	0.2	0.2	1.1	0.1	0.92
CD (P=0.05)	2.2	45.3	0.5	0.7	3.4	0.3	2.91
Depth of sowing (cm)							
D_1, 5	78.6	343.8	13.5	15.8	34.6	1.6	43.39
D_2, 10	82.2	382.6	13.9	16.4	38.2	1.9	46.24
SEm±	0.6	11.7	0.1	0.2	0.9	0.1	0.75
CD (P=0.05)	1.87	36.9	0.4	0.6	2.8	0.3	2.37

CRI, Crown-root initiation; IW: CPE, irrigation water: cumulative pan evaporation

nificantly higher effective tillers (407.82/m^2), spike length (14.40 cm), spikelets/spike (17.43), grains/spike (44.20), grain weight/spike (2.05 g) and 1,000-grain weight (48.95 g). This could be attributed to better overall growth of the crop and better source to sink passage of the water and nutrients receiving irrigation at all the physiological stages, especially including crown root initiation (CRI) stage. Optimum moisture at CRI stage due to establishment of crown roots played a positive role in this significant increase, which otherwise did not play a significant role where the irrigation at CRI stage was missing.

Seed rates also affected the yield attributes significantly (Table 1). Seed rate of 125 kg/ha resulted in significantly the highest effective tillers (416.6/m^2), spike length (14.62 cm), spikelets/spike (17.53), grains/spike (40.20), grain weight/spike (2.06 g) and 1,000-grain weight (47.80 g). Seed rate of 125 kg/ha proved the best because the performance of yield attributes under higher seed rates was high due to desired make over because of higher seed rate for the loss due to late sowing.

Depth of sowing as well affected the yield attributes significantly (Table 1). Depth of sowing of 10 cm resulted in significantly the highest number of effective tillers (382.64/m^2), spike length (13.94 cm), spikelets/spike (16.44), grains/spike (38.21), grain weight/spike (1.90 g) and 1,000-grain weight (46.24 g). This could be attributed to optimum moisture and germination conditions available at 10 cm sowing depth to the late-sown wheat under limited irrigation.

Interactions

Interaction of irrigation levels and seed rates on grain yield was significant. Irrigation at CRI + 0.4 IW : CPE with a seed rate of 125 kg/ha resulted in significantly the highest grain yield (5.02 t/ha) (Table 5). This could be attributed to the best utilization of water and environment (plant density) under these treatments combination. Further, interaction of irrigation levels and depth of sowing on grain yield was also significant. Irrigation at CRI + 0.4 IW: CPE with a depth of sowing of 10 cm resulted in significantly the highest grain yield (4.53 t/ha) (Table 6). This could be attributed to optimum moisture and germination conditions available at 10 cm sowing depth due to the present irrigation level under late-sown wheat under limited irrigation. Similar findings were observed by Kumar *et al.* (2002), Singh *et al.* (2006) and Roy *et al.* (2011).

Yield and harvest index

Yield was significantly affected by irrigation levels (Table 2). Irrigation at CRI + 0.4 IW : CPE resulted in significantly the highet grain yield (4.22 and 3.75 t/ha), straw yield (4.27 and 4.11 t/ha) and harvest index (0.497 and 0.477) during both the years. This could be attributed to significantly higher yield attributes under this treatment and all the reasons for their better performance under this treatment. Similar findings were also reported by Sen *et al.* (2003).

Seed rates affected the yield significantly (Table 2). Seed rate of 125 kg/ha resulted in significantly the highest

Table 2. Grain and straw yields and harvest index (HI) of wheat as influenced irrigation levels, seed rate and depth of sowing

Treatment	Yield (t/ha)				Harvest index	
	Grain		Straw		2014–15	2015–16
	2014–15	2015–16	2014–15	2015–16		
Irrigation levels						
I_1, Irrigation at CRI stage	3.37	3.00	5.00	4.59	0.40	0.395
I_2, Irrigation at CRI + 0.2 IW: CPE	3.60	3.37	4.82	4.47	0.43	0.430
I_3, Irrigation at CRI + 0.4 IW: CPE	4.22	3.75	4.27	4.11	0.49	0.477
SEm±	0.137	0.095	0.171	0.099	0.007	0.009
CD (P=0.05)	0.539	0.373	0.278	0.391	0.03	0.04
*Seed rates (*kg/ha*)*						
S_1, 75	3.24	3.12	4.80	4.45	0.40	0.41
S_2, 100	3.71	3.37	4.73	4.40	0.44	1.43
S_3, 125	4.23	3.63	4.29	4.32	0.49	0.46
SEm±	0.144	0.078	0.173	0.061	0.007	0.006
CD (P=0.05)	NS	0.245	NS	NS	0.02	0.02
Depth of sowing (cm)						
D_1, 5	3.51	3.25	4.86	4.40	0.42	0.43
D_2, 10	3.95	3.49	4.71	4.39	0.46	0.44
SEm±	0.117	0.063	0.141	0.050	0.006	0.005
CD (P=0.05)	0.370	0.200	NS	NS	0.02	0.02

CRI, Crown-root initiation; IW: CPE, irrigation water: cumulative pan evaporation

grain yield (3.63 t/ha) during 2015–16 and harvest index (0.496 and 0.456) during both the years. This could also be attributed to significantly higher yield attributes under this treatment and all the reasons for their better performance under this treatment.

Depth of sowing as well affected the yield significantly (Table 2). Depth of sowing of 10 cm resulted in significantly higher grain yield (3.95 and 3.49 t/ha) and harvest index (0.456 and 0.443) during both the years. Similarly, this could be attributed to significantly higher yield attributes under this treatment and all the reasons for their better performance under this treatment. Similar findings were also reported by Sen *et al*. (2003).

Water-use parameters

Irrigation at CRI + 0.4 IW : CPE resulted in the highest water-use efficiency (118.2 and 103.6 kg/ha cm) during both the years. This could be attributed to significantly the highest grain yield under this treatment and relatively little increased consumptive use of water (35.7 and 36.2 cm) during both the years. The consumptive use of water was the lowest (31.6 and 32.1 cm) during both the years in the treatment where irrigation was applied only at CRI stage (Table 3). This could be attributed to obviously less water applied under this treatment and the lowest soil moisture depleted under this treatment.

Seed rate of 125 kg/ha resulted in the highest water-use efficiency (118.2 and 100.0 kg/ha-cm). This could again be attributed to significantly highest grain yield under this treatment and relatively little increased consumptive use of water (35.8 and 36.3 cm) during both the years. The consumptive use of water was the lowest (31.2 and 32.3 cm) during both the years with seed rate of 75 kg ha (Table 3). This could be attributed to the lowest soil moisture depleted under this treatment.

Depth of sowing of 10 cm resulted in higher water-use efficiency (116.5 and 101.2 kg/ha-cm) during both the years. This could again be attributed to significantly higher grain yield under this treatment and relatively little increased consumptive use of water (33.9 and 34.5 cm) during both the years. The consumptive use of water was lower (33.1 and 33.9 cm) during both the years with depth of sowing of 5 cm (Table 3). This could be attributed to a lower soil moisture depleted under this treatment.

Economics

Irrigation at CRI + 0.4 IW: CPE resulted in the highest net return (₹36,269/ha and ₹34,288/ha) and benefit: cost (B : C) ratio (2.59 and 2.45) during both the years (Table 4). This could be attributed to significantly higher grain yield and lower cost incurred under this treatment.

Seed rate of 125 kg/ha resulted in the highest net return (36,973/ha and 32,981/ha) and benefit: cost (B : C) ratio (2.64 and 2.36) during both the years (Table 4), owing significantly the highest grain yield and the lowest cost incurred under this treatment.

Depth of sowing of 10 cm resulted in higher net return (34,182/ha and 32,840/ha) and benefit: cost (B : C) ratio (2.44 and 2.35) during both the years (Table 4) and could be attributed to significantly highe grain yield and the lower cost incurred under this treatment.

Increased seed rate and depth of sowing gave better results under limited irrigation in late-sown wheat. A combination of irrigation at CRI + 0.4 IW : CPE with seed rate of 125 kg/ha and a combination of irrigation at CRI + 0.4 IW: CPE with depth of sowing of 10 cm resulted in significantly the highest grain yield.

Irrigation at CRI + 0.4 IW: CPE resulted in significantly the higher grain yield, straw yield, harvest index, effective tillers/m^2, spike length, spikelets/spike, grains/spike, grain

Table 3. Consumptive use and water use efficiency in wheat as influenced by irrigation level, seed rate and depth of sowing.

Treatment	Consumptive use of water (cm)		Water-use efficiency(kg/ha-cm)	
	2014–15	2015–16	2014–15	2015–16
Irrigation levels				
I_1, Irrigation at CRI stage	31.6	32.1	106.6	93.5
I_2, Irrigation at CRI + 0.2 IW: CPE	33.2	34.4	108.4	97.9
I_3, Irrigation at CRI + 0.4 IW: CPE	35.7	36.2	118.2	103.6
Seed rates (kg/ha)				
S_1, 75	31.2	32.3	103.8	96.6
S_2, 100	33.5	34.1	110.7	98.8
S_3, 125	35.8	36.3	118.2	100.0
Depth of sowing (cm)				
D_1, 5	33.1	33.9	106.0	95.9
D_2, 10	33.9	34.5	116.5	101.2

CRI, Crown-root initiation; IW: CPE, irrigation water: cumulative pan evaporation

Table 4. Net returns and benefit : cost ratio of wheat as influenced by irrigation levels, seed rates and depth of sowing

Treatment	Net returns ($\times 10^3$/ha)		Benefit: cost Ratio	
	2014-15	2015-16	2014-15	2015-16
Irrigation levels				
I1, Irrigation at CRI stage	31.2	28.8	2.23	2.05
I2, Irrigation at CRI + 0.2 IW: CPE	32.7	30.3	2.33	2.17
I3, Irrigation at CRI + 0.4 IW: CPE	36.3	34.3	2.59	2.45
Seed rates (kg/ha)				
S1, 75	30.3	29.6	2.16	2.11
S2, 100	33.3	30.5	2.38	2.18
S3, 125	37.1	33.0	2.64	2.36
Depth of sowing (cm)				
D1, 5	32.0	31.0	2.28	2.21
D2, 10	34.2	32.9	2.44	2.35

CRI, Crown-root initiation; IW: CPE, irrigation water: cumulative pan evaporation

Table 5. Interaction of irrigation levels and seed rates on wheat grain yield (2014–15)

Treatment	Grain yield (t/ha)		
	Irrigation levels		
	I_1, Irrigation at CRI stage	I_2, Irrigation at CRI+ 0.2 IW: CPE	I_3, Irrigation at CRI+ 0.4 IW: CPE
*Seed rates (*kg/ha*)*			
S_1, 75	3.12	3.19	3.41
S_2, 100	3.42	3.49	4.23
S_3, 125	3.57	4.09	5.02
SEm±		0.138	
CD (P=0.05)		0.406	

CRI, Crown-root initiation; IW: CPE, irrigation water: cumulative pan evaporation

Table 6. Interaction of irrigation levels and depth of sowing on wheat grain yield (2014–15)

Treatment	Grain yield (t/ha)		
	Irrigation levels		
	I_1, Irrigation at CRI stage	I_2, Irrigation at CRI+ 0.2 IW: CPE	I_3, Irrigation at CRI + 0.4 IW : CPE
Depth of sowing (cm)			
D_1, 5	3.29	3.32	3.91
D_2, 10	3.45	3.87	4.53
SEm±		0.124	
CD (P=0.05)		0.332	

CRI, Crown-root initiation; IW: CPE, irrigation water: cumulative pan evaporation

weight/spike and 1,000-grain weight. Seed rate of 125 kg/ha resulted in significantly the highest grain yield, harvest index, effective tillers/m^2, spike length, spikelets/spike, grains/spike, grain weight/spike and 1,000-grain weight. Depth of sowing of 10 cm resulted in significantly higher grain yield, harvest index, effective tillers/m^2, spike length, spikelets/spike, grains/spike, grain weight/spike and 1,000-grain weight. These treatments had similar effect on water-use efficiency and economics.

REFERENCES

Dastane, N.G. 1967. *A practical manual for water use research*. Navbharat Prakashan, Poona, (now Pune), Maharashtra, p. 105.

Hakoomat, Ali, Nadeem, Iqbal, Shakeel, Ahmad, Ahmad, Naeem

Shahzad and Naeem, Sarwar. 2013. Performance of late sown wheat crop under different planting geometries and irrigation regimes in arid climate at Department of Agronomy, Bahauddin Zakariya University, Multan, Pakistan, *Soil and Tillage Research* **130**: 109–119.

Kabir, N.A.M.E., Khan, A.R., Islam, M.A. and Haque, M.R. 2003. Effect of seed rate and irrigation level on the performance of wheat cv. Gourab. Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh. Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh-2200, *Journal of Bangladesh Agricultural University* **7**(1): 47–52, 2009. ISSN 1,810–3,030

Lloveras, J., Manet, J., Viudas, J., Lopez, A. and Santiveri, P. 2004. Seeding rate influenced yield and yield components of irrigated winter wheat in a mediteranean climate. *Agronomy Journal* **96**: 1,258–1,265.

Roy, J., Biswas, P.K., Ali, M.H. and Rahman. A. 2011. Effect of sowing depth and population density on yield attributes and yield of wheat. *Technical Journal of Engineering and Applied Sciences* **1**(4): 125–133.

MoF, 2019. Economic Survey 2019–20. (In) *Statistical Tables, Selected Indicators 1990–91 to 2018–19*. Ministry of Finance, Government of India.

Sen, A., Pandey, M.D., Sharma, S.N., Singh, R.K., Kumar, A. Shukla, P. and Srivastava, V.K. 2003. Surface seeding of wheat (*Triticum aestivum* L.) as affected by seed rate and nitrogen level. *Indian Journal of Agricultural Sciences* **73**(9): 509–511.

Kumar, R., Agarwal, S.K., and Nanwal, R.K. 2002. Economics of bread wheat as affected by planting system, seed rate and nitrogen fertilization in sandy loam soils of Haryana. *Journal of Research,* Chaudhary Charan Singh Haryana Agricultural University **32**(1): 23–25.

Singh, S., Uppal, H.S., Mahal, S.S. and Singh, A. 2006. Water use, water use efficiency and yield of bed planted wheat (*Triticum aestivum* L.) in relation to various seed rate, spacing and irrigation levels. *Environment and Ecology* **24**(2): 476–79.