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Water requirement of late-sown wheat (*Triticum aestivum*) under limited water availability in Jharkhand plateau

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ABSTRACT

A field experiment was conducted during the winter seasons of 1995–97 at the university farm, Ranchi, in randomized block design, replicated thrice, to find out the water requirement of late-sown wheat (*Triticum aestivum* L. emend. Fiori & Paol.) under different irrigation schedules. Treatment consisted of 11 irrigation schedules based of frequency (4, 3 and 2) and time of application. Wheat with 4 irrigations at crown-root initiation, maximum tillering, boot and milk stages utilized 335.9 mm water @ 2.87 mm/day and produced 2,707 kg grain/ha with water-use efficiency of 8.06 kg grain/10^4 litres water use. Omission of irrigation at crown-root initiation had similar water use (333.9 mm @ 2.90 mm/day) and resulted in similar grain yield (2,523 kg/ha) with water-use efficiency 7.56 kg grain/10^4 litres water. Among 2 irrigation schedules, wheat irrigated at maximum tillering and milk stages utilize 288 mm water @ 2.69 mm/day and gave significantly higher grain yield (2,011 kg/ha) with water-use efficiency 6.98 kg grain/10^4 litres water. Daily consumptive water use increased with crop age and reached its peak during the second fortnight of February and declined thereafter. Crop coefficient (Cu/EP) also increased with crop age and reached its peak during February (0.64), whereas 'k' value of Blaney Criddle reached its peak during January (0.56) and remained steady during February (0.55) and thereafter gradually declined.

Key words : Wheat, Irrigation schedule, Yield, Water use, Crop coefficient

Wheat (*Triticum aestivum* L. emend. Fiori & Paol.) sowing is generally delayed in Jharkhand region due to late harvesting of rice, potato, *toria* and pigeonpea. In such a situation wheat is exposed to low temperature during early vegetative phase and high temperature during reproductive phase, which consequently reduces the productivity. These adverse conditions can be mitigated to some extent by providing favourable soil-moisture regime through proper scheduling of irrigation (Pal *et al.*, 1996a). In fact water requirement of late-sown wheat differs from that of timely sown wheat (Pal *et al.*, 1996b) and a comprehensive knowledge about the daily consumptive water use, moisture extraction from different soil depth as well as crop coefficient will provide a guideline for proper scheduling of irrigation to increase the water productivity and production potential of late-sown wheat. Hence this experiment was undertaken to find out productivity and water requirement of late-sown wheat under different irrigation schedules.

MATERIALS AND METHODS

A field experiment was conducted during the winter season of 1995–97 at the university farm, Ranchi, in randomized block design and replicated 3 times on a sandy-loam soil (60% sand and 21.5% silt), with low water-holding capacity (14.83 cm/m soil depth). The soil was slightly acidic in reaction (pH 6.2), low in available nitrogen (196 kg/ha) and medium in available phosphorus (15.3 kg/ha) and potassium (120.4 kg/ha). Treatments consisted of 11 irrigation schedules based on frequency and critical growth stages, viz. 4 irrigations at *(i)* crown-root initiation + maximum tillering + boot + milk; 3 irrigations at *(ii)* crown-root initiation + maximum tillering + boot; *(iii)* crown-root initiation + boot + milk; *(iv)* crown-root initiation + maximum tillering + milk; *(v)* maximum tillering + boot + milk and 2 irrigations at *(vi)* crown-root initiation + maximum tillering; *(vii)* crown-root initiation + boot; *(viii)* crown-root initiation + milk; *(ix)* maximum tillering + boot; *(x)* maximum tillering + milk; and *(xi)* boot + milk. 'HD 2285' wheat was sown in third week of December, spaced at 20 cm apart using 125 kg seed/ha and fertilized with 80 kg N, 17.6 kg P and 16.6 kg K/ha during both the years. Crop received 5±1 cm water during each irrigation as per treatment apart from 87.3 and 97.6 mm rainfall during the first and second year of experimentation respectively. Periodic soil sample (0–60 cm depth) from sowing to harvest at 15-day interval and before and after each irrigation was taken to determine consumptive water use. Crop coefficient (Cu/Ep) was calculated by dividing consumptive water use for a particular period with corresponding pan evaporation, and 'k' value for Blaney Criddle method was also calculated.

RESULTS AND DISCUSSION

Grain yield

Late-sown wheat receiving 4 irrigations at crown-root initiation, maximum tillering, boot and milk stages gave the maximum grain yield and was 27 and 64% higher than the crop receiving 3 and 2 irrigations, respectively, irrespective of timing of irrigation (Table 1). And the crop receiving 3 irrigations at maximum tillering, boot and milk stages gave similar grain yield with that of the crop receiving 4 irrigations and was significantly superior to rest of the combination of irrigation schedules comprising either 3 or 2 irrigations. Omission of irrigation at maximum tillering stage caused the maximum yield reduction (34.7%), followed by water stress at milk (25.9%), boot (18.2%) and crown-root-initiation stage (6.8%) under 3 irrigation schedules as compared to crop receiving 4 irrigations, indicating that maximum tillering followed by milk and boot are very critical with respect with water need of late-sown wheat. Among the 2 irrigation schedules, crop receiving irrigation at maximum tillering and milk stages showed maximum grain yield and was similar with the crop receiving ir-

Table 1. Grain yield, fortnightly and seasonal consumptive water use rate, consumptive water use and water-use efficiency of late-sown wheat under different irrigation schedules (pooled data of 3 years)

Treatment	Grain yield (kg/ha)	Fortnightly and seasonal consumptive water use rate (mm/day)									Consumptive water use (mm)	Water-use efficienncy (kg grain) (10^4 litres water)
		December	January		February		March		April	Seasonal (mm)		
		21–31	1–15	16–31	1–15	16–28	1–15	16–31	1-15			
CRI + maximum tillering boot + milk	2,707	1.51	2.10	3.14	3.42	3.97	3.61	2.78	2.13	2.87	335.9	8.06
CRI + maximum tillering + + boot	2,006	1.52	1.97	2.58	3.01	3.36	2.98	2.07	1.60	2.44	273.7	7.33
CRI + boot + milk	1,767	1.50	1.92	2.07	2.40	3.37	2.90	2.62	2.12	2.40	262.0	6.74
CRI + maximum tillering + milk	2,214	1.53	2.00	2.86	3.20	3.44	3.31	2.76	2.08	2.69	304.5	7.27
Maximum tillering + boot + milk	2,523	1.52	2.12	3.12	3.39	4.03	3.63	2.83	2.19	2.90	333.9	7.56
CRI + maximum tillering	1,670	1.42	1.92	2.00	2.51	2.88	2.33	1.91	1.80	2.13	232.4	7.19
CRI + boot	1,469	1.47	1.92	2.00	2.50	3.02	2.12	1.77	1.70	2.11	223.7	6.57
CRI + milk	1,239	1.41	1.91	1.96	2.27	2.57	2.03	1.97	1.58	2.03	210.7	5.88
Maximum tillering + boot	1,839	1.49	1.90	2.52	3.02	3.41	2.88	2.12	1.51	2.42	268.7	6.84
Maximum tillering + milk	2,011	1.51	2.01	2.79	3.18	3.39	3.16	2.74	2.06	2.69	288.0	6.98
Boot + milk	1,647	1.44	1.84	2.01	2.40	3.32	2.89	2.61	2.16	2.37	254.0	6.48
CD (P=0.05)	346											

CRI, crown-root initiation

rigation at maximum tillering and boot stages. Maximum yield reduction was observed in the crop exposed to water stress at maximum tillering and boot stages. This confirm the findings of Pal *et al.* (1996a).

Water-use efficiency

Late-sown wheat with 4 irrigations at crown-root initiation, maximum tillering, boot and milk stages utilized 335.9 mm water @ 2.87 mm/day, with water-use efficiency of 8.06 kg grain/10^4 litres water use (Table 1). Omission of irrigation at crown-root initiation showed similar water use (333.9 mm) at slightly higher rate (2.90 mm/day), but with slightly lower efficiency of 7.56 kg grain/10^4 litres water use. Whereas omission of irrigation either at maximum tillering or at milking stage drastically reduced the consumptive water use (262.0 and 273 mm) @ 2.40 and 2.44 mm/day with water-use efficiency of 6.74 and 7.33 kg grain/10^4 litres water use, respectively. This confirms the findings of Pal *et al.* (1996b). Among 2 irrigation schedule, wheat irrigated at maximum tillering and milk stages utilized maximum water (288 mm) @ 2.69 mm/day with water-use efficiency of 6.98 kg grain/10^4 litres water use indicating that maximum tillering and milk are very critical stages for water need of late-sown wheat. Daily consumptive water use increased with crop age and reached its peak during the second fortnight of February which coincided with heading stage of the crop and declined thereafter, indicating that heading stage of wheat must be matched with adequate water supply.

Moisture-extraction pattern

Late-sown wheat in general extracted more moisture from top soil (0–30 cm) layer throughout the growing season irrespective of level and time of irrigation. Crop receiving 4 irrigations at crown-root initiation, maximum tillering, boot and milk stages extracted 76.87% moisture from top 30 cm soil depth during its life-span (Fig.1). Similarly, wheat with 3 irrigations at maximum tillering, boot and milk stages extracted 77.06% moisture from top 30 cm soil depth. However, wheat with 2 irrigations at crown-root initiation and milk stages extracted 77.12% moisture from top 30 cm soil profile. Crop raised with adequate water extracted more water from surface soil than the crop grown under stress environment where the reverse was true from sub-surface layer. Under adequate supply of water plant spent less energy for root growth and its penetration into deeper layer, as it can meet its requirement from the surface soil itself, whereas under stress environment plant root goes to deeper layer in search of water to meet its requirement, This confirm the findings of Pal *et al.* (1996b).

Crop coefficient

Crop coefficient (Cu/Ep) increased with crop age and reached its peak during February and declined thereafter, as it was 0.47, 0.61, 0.64, 0.36 and 0.19 for December, January, February, March and April respectively (Table 2) indicating that water demand of late-sown wheat was maximum during February which coincided with heading stage of the crop. The monthly consumptive water-use coefficient 'k' of Blaney Criddle method was low during December (0.32) and increased sharply to

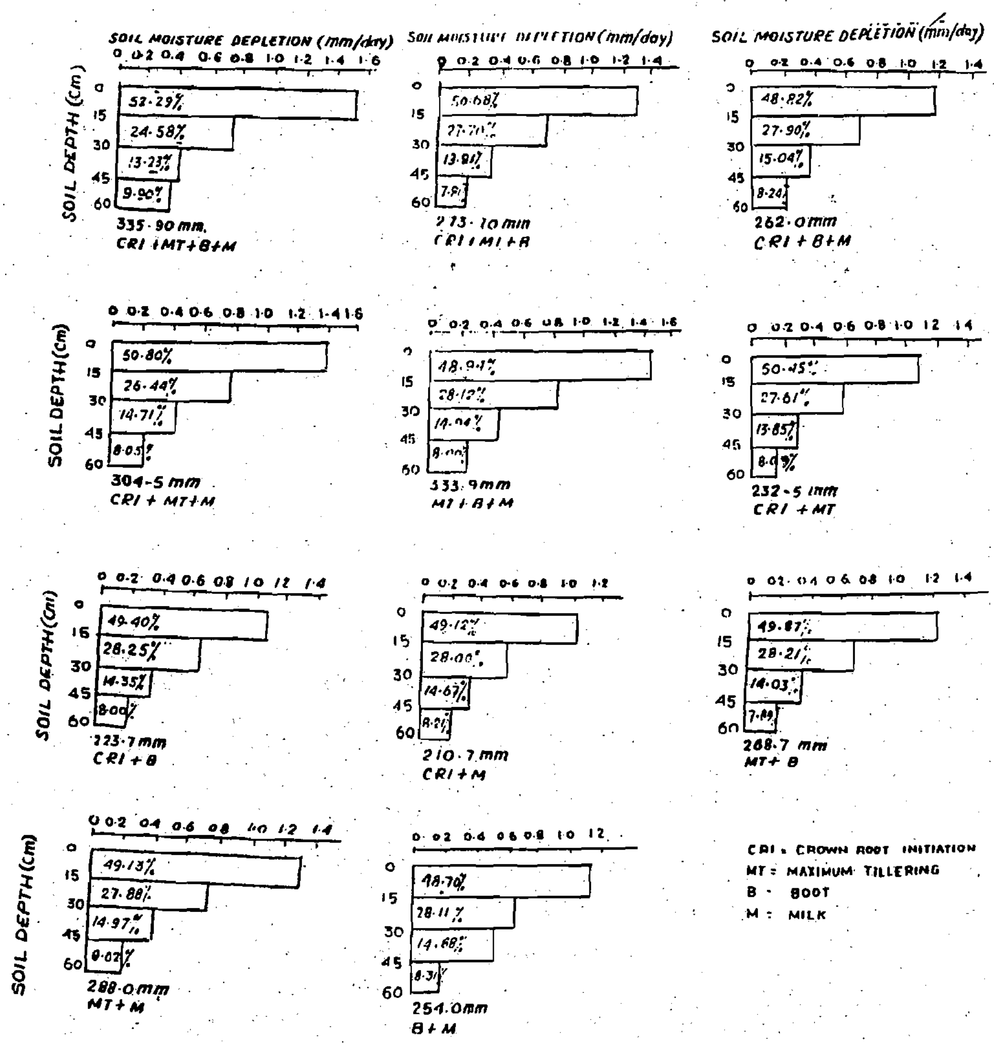

Fig. 1. Soil-moisture-extraction pattern of late-sown wheat between sowing and maturity as incluenced by different levels of irrigation

reach its peak during January (0.56) and remained steady during February (0.55) and declined gradually thereafter, as it was 0.46, and 0.34 during March and April respectively. Pal *et al.* (1996b) observed the maximum crop coefficient (Cu/Ep) of timely sown wheat in January. Irrigation frequency also influenced the crop coefficient, as the wheat receiving 4 irrigations had higher seasonal as well as month-wise crop coefficient than the crop with 3 or 2 irrigations. This confirm the findings of Singh

Table 2. Montly crop coefficient (Cu/Ep) and 'k' of Blaney Criddle method of late-sown wheat under different irrigation schedules

Treatment	December		January		February		March		April	
	Cu/Ep	k	Cu/Ep	k	Cu/Ep	k	Cu/Ep	k	Cu/Ep	k
CRI + maximum tillering boot + milk	0.47	0.33	0.72	0.69	0.77	0.64	0.44	0.54	0.21	0.36
CRI + maximum tillering + boot	0.48	0.33	0.62	0.60	0.66	0.55	0.35	0.43	0.16	0.27
CRI + boot + milk	0.47	0.33	0.54	0.52	0.60	0.50	0.38	0.47	0.21	0.36
CRI + maximum tillering + milk	0.48	0.34	0.67	0.64	0.69	0.58	0.41	0.51	0.21	0.35
Maximum tillering + boot + milk	0.48	0.33	0.72	0.69	0.77	0.64	0.44	0.55	0.22	0.37
CRI + maximum tillering	0.45	0.28	0.53	0.44	0.56	0.50	0.29	0.38	0.18	0.31
CRI + boot	0.46	0.29	0.54	0.43	0.57	0.50	0.27	0.37	0.17	0.33
CRI + milk	0.44	0.28	0.53	0.41	0.50	0.45	0.28	0.37	0.16	0.35
Maximum tillering + boot	0.47	0.33	0.60	0.58	0.67	0.56	0.34	0.42	0.15	0.26
Maximum tillering + milk	0.47	0.33	0.66	0.63	0.68	0.57	0.41	0.50	0.20	0.35
Boot + milk	0.45	0.32	0.53	0.50	0.59	0.50	0.38	0.47	0.21	0.37
Mean	0.47	0.32	0.61	0.56	0.64	0.55	0.36	0.46	0.19	0.34

CRI, crown-root initiation

and Hundal (1989).

Maximum tillering and milk stages are very critical with respect to water requirement of late-sown wheat, as omission of irrigation at these stages drastically reduced the grain yield. Timing of irrigation must be decided, depending on the availability of water as in case of 4 irrigations it can be scheduled at crown-root initiation, maximum tillering, boot and milk stages, whereas in case of 3 as well as 2 irrigations it can be scheduled at maximum tillering, boot and milk and maximum tillering and milk stages, respectively, for high yield and water productivity of late-sown wheat.

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