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Original Research Article

Effect of Water Management and Seeding Time on Water Productivity of Wheat

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A B S T R A C T

A two year experiment was conducted at Ranchi to study the effect of seeding time (30 October, 15 November, 30 November, 15 December and 30 December) and irrigation (3 at CRI + boot + milk, 5 at CRI+ late jointing + flowering + milk + dough and at IW: CPE ratio) on growth, development and productivity of wheat. Wheat crop receiving 5 irrigations recorded maximum grain yield (3.76 t/ha), straw yield (5.91 t/ha), harvest index (38.90 per cent) as well as higher net return (Rs 37070/ha) and benefit: cost ratio (1.5) with a higher consumptive water use of 459.03 mm/ha. Higher yield and economic returns with 5 irrigation was due to better growth parameters like dry matter accumulation at maturity (971.52 g/m^2), leaf area index at 70 DAS (3.85) and crop growth rate between 70 and 90 DAS (21.96 g/m^2/day) and higher yield attributing characters like number of spikes/m^2 (327.56) and number of grains/spike (45.30). Similarly, wheat crop sown on 15 November produced more grains (4.47 t/ha) and straw (6.71 t/ha) with a higher harvest index (39.79 per cent) and recorded higher net return (Rs. 48551/ha) and benefit: cost ratio (2.01) using more water (consumptive water use 429.56 mm/ha) with higher water use efficiency (10.45 kg grain/mm/ha). Higher yield and economic returns in the wheat crop sown on 15 November can be attributed to better growth (DMA at maturity 1157.37 g/m^2, LAI at 70 DAS 4.43, CGR between 70 and 90 DAS 24.70 g/m^2/day) and yield attributing characters (spikes/m^2 370.94, grains/spike 47.06 and 1000 grain weight 40.93g).

Introduction

Wheat is the most important food crop, grown extensively throughout the world over a range of environments. In India it is the second important crop after rice. Wheat compares well with other important cereals in its nutritive value as it contains more protein than any other cereal. However, productivity of wheat depends largely on the prevailing weather condition and soil moisture regime during crop growth period. Temperature, a key component of climate, determines seeding time and consequently the rate and duration of growth. High temperature reduces tillering during vegetative phase and grain filling duration during reproductive phase in normal sown conditions, thus shortens wheat growing period vis-à-vis yield (Swaminathan 2010). However, favorable soil moisture regime can be created by timely scheduling of irrigation which can take care of deleterious effect of low and high temperature during vegetative and reproductive growth phases respectively (Pal *et al.*, 2001). In the era of changing climate, especially increasing temperature will be the major challenge in the coming years as far as increasing wheat yield is concerned. In this situation, reassessment of seeding time is necessary for higher yield of wheat. In the light of above facts, an experiment was conducted to study the effect of seeding time and irrigation on growth, development and productivity of wheat, in agroclimatic conditions of Jharkhand.

Materials and Methods

Field experiments were conducted during winter seasons of 2010-11 and 2011-12 at the University farm of Birsa Agricultural University, Ranchi (23^o 17' N latitude, 85^o 10' E longitude and 625 m above mean sea level). The soil was sandy loam (Alfisol), low in available N (217.8 Kg/ha) and medium in available P (12.43 Kg/ha) and exchangeable K (153.04 Kg/ha). The main-plot treatments consisted of three irrigation levels, viz. three irrigations at crown root initiation, boot and milk stages, five irrigations at crown root initiation, maximum tillering, late jointing, flowering and milk stages and irrigation on the basis of IW: CPE ratio 0.9 and subplots consisted of 5 sowing dates, viz. 30 October, 15 November, 30 November, 15 December and 30 December laid out in split-plot design with four replications. Number of irrigations in IW: CPE ratio was different for sowing dates, 6 in 30 October, 5 each in 15 and 30 November and 4 each in 15 and 30 December. Wheat variety K9107 was sown at a spacing of 20 cm apart with a seed rate of 125 kg seed/ha and fertilized with 100:60:40 kg/ha $N:P_2O_5:K_2O$. Half N with full P and K were applied basal in furrows. Remaining half of N was applied in two equal splits at crown root initiation and maximum tillering stage. Periodic soil samples from sowing to harvest, before and after 24 hrs of each irrigation was taken for determination of consumptive water use.

Results and Discussion

Growth and development

Tillers per unit area increased with crop age and reached its peak at 60 days after sowing and thereafter decreased due to mortality of tillers. Mortality of tillers with crop age is a common phenomenon, which might be due to the fact that the amount of resources available to the plants is not sufficient to produce enough photosynthate to maintain all the tillers produced. Tillers per unit area was not affected by irrigation till 60 days after sowing, but thereafter crop with 5 irrigations recorded maximum number of tillers ($340/m^2$) due to higher tiller mortality in 3 irrigations (Table 1). Further, timely sown crop produced higher tillers per unit area ($490/m^2$ at 60 DAS) than early, moderately late, late and very late planted crop at all the growth stages. This might be due to decreasing temperature regime from timely sowing to late and very late caused delay in emergence of seedlings, as a result late and very late sown crops took more time to reach crown root initiation which consequently reduced the tillering phase. Although temperature was favorable for tillers production with delayed planted crops but sudden rise in temperature reduced the tillering duration of the crop, consequently reducing the production of less tillers. This confirms the findings of Verma *et al.*, (1997).

Applying irrigation 5 times or on the basis of IW: CPE ratio significantly increased the duration of each phenophase after maximum tillering, as compared to 3 irrigations. Similarly, timely planted crop took more days to attain various phenophases than moderately late, late and very late planted crops, except crown root initiation which was achieved early in timely planted crop (Table 1). Delayed planted crops completed their life cycle in lesser number of days at an accelerated pace leading to shortening of every phenophase.

This consequently gave more time to timely sown crop for completion of every phenophase, such as tillering and grain filling, resulting in higher tillers count, grain per spike and thousand grain weight, and ultimately the yield of timely sown crop. Similar results were found by Shivani *et al.*, (2003).

Yield and yield attributes

Grain as well as straw yield increased with increasing irrigation level. Mean grain yield of wheat with 5 irrigations at CRI, maximum tillering, late jointing, flowering and milk (3.76 t/ha) was 26 per cent more than irrigation applied on 3 growth stages viz. CRI, boot and milk, and 7 per cent more than irrigation on the basis of IW: CPE ratio (Table 3).

Similarly, crop with 5 irrigations (5.91 t/ha) gave 16 per cent higher straw yield than crop with 3 irrigations. Crop irrigated 5 times also gave higher harvest index (38.90 per cent). The higher grain yield was due to better expression of yield components (Table 2) viz. mean spikes per unit area (328), grains per spike (45) and 1000 seed weight (39.91 g) under favorable soil moisture condition (Nadeem *et al.*, 2007).

Timely planted (15 November) wheat gave mean grain yield of 4.47 t/ha which was 16 per cent higher than October 30 sowing and reduced by 24 per cent when sowing was delayed to 30 November, 33 per cent when delayed to 15 December, and 46 per cent when planting was delayed to 30 December (Table 3). This might be due to timely planted crop experienced relatively favorable temperature regime during pre and post anthesis which resulted in better growth and development and ultimately led to better yield components than delayed planted crops (Table 2) which was reflected in grain yield (Jhanji and Gill 2011 and Pandey *et al.,* 2010,). Mean spikes per unit area (371/m^2), grains per spike (47/spike) and more 1000 seed weight (40.93 g) than the crop planted early, moderately late, late or very late. Mean straw yield (6.71 t/ha when planted on 15 November) as well as harvest index (39.79 per cent when planted on 15 November) followed the trend of grain yield.

Economics

Performance of a production system must be evaluated, not only on the basis of yield but its economic values. Wheat crop with 5 irrigations resulted in higher net return (Rs 37070/ha) and benefit: cost ratio (1.5) than 3 irrigations and irrigation on IW: CPE ratio (Table 3).

This was because with same input cost the grain and straw yield increased with increase in frequency in irrigation resulting in higher monetary return. Similarly, benefit: cost ratio (2.01), were higher in timely sown crop than early, moderately late, late and very late sowing due to higher grain yield and straw yield with the same input cost in timely sown condition which decreased with delay in sowing.

Similarly, net return (Rs 48551/ha) as well as benefit: cost ratio (2.01), were higher in timely sown crop than early, moderately late, late and very late sowing due to higher grain yield and straw yield with the same input cost in timely sown condition which decreased with delay in sowing.

Table.1 Number of days taken to various phenophases and periodic tillers count of wheat influenced by irrigation and seeding date (mean of two years)

Treatment	Crown root initiation	Maximum tillering	Flowering	Maturity	Tillers/m^2		
					40 DAS	40 DAS	40 DAS
Irrigation level							
3 irrig.	22.78	46.78	85.60	121.68	407.06	427.63	299.94
5 irrig.	22.65	46.73	87.33	124.45	421.94	446.00	340.25
IW/CPE ratio 0.9	22.58	46.78	87.10	124.33	396.19	429.25	335.38
CD(P=0.05)	NS	NS	0.40	0.53	NS	NS	26.33
Seeding time							
30 Oct	21.21	46.08	87.67	137.88	402.81	406.35	353.33
15 Nov	21.88	45.83	89.13	132.75	466.88	489.58	380.94
30 Nov	21.88	46.04	90.50	125.79	458.96	485.63	358.44
15 Dec	25.67	52.29	87.67	117.17	388.44	401.15	291.35
30 Dec	22.71	43.54	78.42	103.83	324.90	388.75	241.88
CD(P=0.05)	0.26	0.39	0.36	0.61	36.49	38.12	29.76

Table.2 Yield attributes, yield, harvest index and economics of wheat influenced by irrigation and seeding date (mean of two years)

Treatment	Spikes /m^2	Grains/spike	1000 grain weight (g)	Yield (t/ha)		Harvest index (%)	Net return (Rs./ha)	Benefit :cost ratio
				Grain	Straw			
Irrigation level								
3 irrig.	289.21	43.08	39.20	36.41	11.81	36.41	27050	1.18
5 irrig.	327.56	45.30	39.91	38.90	11.29	38.90	37070	1.50
IW/CPE ratio 0.9	325.50	44.83	39.83	38.62	11.40	38.62	33583	1.37
CD(P=0.05)	27.65	0.89	NS	0.85	0.15	0.85	2630	0.11
Seeding time								
30 Oct	343.33	44.99	40.16	37.90	10.52	37.90	39498	1.62
15 Nov	370.94	47.06	40.93	39.79	10.44	39.79	48551	2.01
30 Nov	344.25	44.93	39.86	38.43	10.66	38.43	31976	1.32
15 Dec	278.87	43.05	39.10	37.95	11.94	37.95	26013	1.09
30 Dec	233.06	41.98	38.18	35.81	13.94	35.81	16799	0.70
CD(P=0.05)	28.48	0.65	1.09	1.80	0.27	1.80	2591	0.11

Table.3 Net return (Rs. /ha) of wheat influenced by Irrigation X Seeding time (Mean of two years)

	30 October	15 November	30 November	15 December	30 December
3 irrig.	35720	43632	27070	20648	8178
5 irrig.	46677	53077	36144	28580	20874
IW/CPE ratio 0.9	36098	48944	32716	28813	21346

CD 4782

Table.4 Benefit: cost ratio of wheat influenced by Irrigation X Seeding time (mean of two years)

	30 October	15 November	30 November	15 December	30 December
3 irrig.	1.56	1.90	1.18	0.90	0.36
5 irrig.	1.89	2.15	1.46	1.16	0.85
IW/CPE ratio 0.9	1.41	1.98	1.33	1.21	0.90

CD 4782

Table.5 Consumptive water use and water use efficiency of wheat influenced by irrigation and seeding time (mean of two years)

Treatments	Cunsumptive water Use (mm)	Water use efficiency (kg grain/ha-mm)
Irrigation level		
3 irrig.	346.37	8.66
5 irrig.	459.03	8.20
IW/CPE ratio 0.9	398.67	8.90
CD(P=0.05)	11.46	NS
Seeding time		
30 Oct	400.12	10.02
15 Nov	429.56	10.45
30 Nov	412.39	8.30
15 Dec	383.70	7.80
30 Dec	379.02	6.36
CD(P=0.05)	13.04	0.52

In interaction between irrigation and seeding time, maximum net return was recorded when wheat crop was sown on 15 November irrigated at 5 different stages of growth (53077 Rs/ha) while wheat sown on 15 November and irrigated on the basis of IW: CPE ratio also gave similar gross return. Maximum reduction in net return (Rs. 35454 /ha), when sowing was delayed from 15 November to 30 December, was recorded in the treatment receiving 3 irrigations which was lowered down to Rs. 8178/ha when irrigation was applied on the basis of IW: CPE ratio (Table 4). Similarly, consecutive reduction in benefit: cost ratio was 1.54 and 1.08 in 3 irrigation and irrigation based on IW: CPE ratio. However, maximum benefit: cost ratio (2.15) was recorded in the treatment where wheat was sown on 15 November and irrigated 5 times (Table 5).

Water use

Consumptive water use of wheat, an evapo-transpiration demand, depends upon various factors viz. varieties, climatic conditions coupled with irrigation schedules. It increases with increase in irrigation frequency because of direct relationship of evapo-transpiration to the amount of moisture present in the soil in timely or late planted wheat (Reddy and Bhardwaj 1982). Crop with irrigation at crown root initiation, maximum tillering, late jointing, flowering and milk recorded higher seasonal consumptive water use (459.03 mm) coupled with water use efficiency (8.19 kg grain/ha-mm) than the crop grown with 3 irrigations at crown root initiation, boot and milk stages and at IW: CPE ratio, owing to more leaf area index, crop growth rate and thus biomass production with increased availability of water (Table 6). Sharma *et al.,* (2007) also obtained higher consumptive water use with increasing soil moisture regime due to better soil moisture availability and higher plant canopy cover which led to more evapo-transpiration under higher frequency of irrigation.

Timely seeded wheat had higher seasonal consumptive water use (429.56 mm), as well as water use efficiency (10.45 kg grain/ha-mm water) which decreased with delay in sowing. The higher water requirement of timely sown crop was mainly due to its longer grain growth duration coupled with its higher biomass production rate because of its longer duration which led to higher water use efficiency as compared to delayed seeded crops. This confirms the findings of Shivani *et al.,* (2003).

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