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Influence of Irrigation Schedule and Nutrient Management on Soil Properties, Growth and Yield Attributes of Wheat in Alluvial Soils of Bihar

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ABSTRACT

A study was under taken to recommend a suitable irrigation schedule along with integrated fertilizer combination and also to under stand plant, water and nutrient relationship in wheat. The study revealed that the more than 50% soil moisture is available only from 0-30 cm soil profile. Soil physical properties improved with FYM application. The availability of nitrogen and potassium contents improved in surface horizons. Crop Growth Rate, Relative Growth Rate and Net Assimilation Rate had a positive relation to yield and yield parameters. The highest grain yield obtained with irrigation scheduled at CRI + Late tillering + milking + dough stages. While incase of nutrient combination 125% NPK gave highest grain yield. However, the critical yield level across all irrigation and nutrient combinations in relation to crop growth arrived with the treatment combination of irrigation scheduled at 0.9 IW/CPE ratio with 75% NPK and FYM @ 15 t/ha.

Key words: *irrigation scheduling, nutrient management, wheat, and heavy soil.*

INTRODUCTION

After rice as kharif crop, wheat is the major winter crop of south Bihar where irrigation is being done mainly through canal and in some areas through ground water resource. The crop in this region is being applied 2-3 irrigations of 8-10 cm depth. Scheduling of irrigation is done for wheat crop as per its critical growth stages, IW/CPE ratio as well as on 50% depletion of available soil moisture in many parts of the country. Even though there are several media, which are advising to use balance dose of nutrients, the resourceful farmers are using unbalanced higher dose while poor are using the same in lower amount. The larger community of the farmers having poor socio-economic conditions are advised to use even 50 to 75% of recommended dose but in balanced

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form. Recent findings in AICRP on cropping system have also proved to apply 25 to 50 per cent NPK through organic sources as integrated nutrient management for sustainable and efficient use of natural resources. With the proper combination of irrigation scheduling along with economically feasible nutrient management a sustained productivity in wheat can be achieved in this region. Keeping in view this objective the experiment was laid out to know the influence of irrigation schedule and nutrient management on growth and yield attributes of wheat.

MATERIALS AND METHODS

The present investigation was carried out at experimental farm of ICAR Research Complex for Eastern Region, Patna for three consecutive years from 1999-2000 to 2001-02 in Rabi season. Twenty treatment combinations in split plot design having four irrigations scheduled at (i) Critical stages of crop (ii) 50 per cent available soil moisture (iii) 0.9 IW/CPE ratio and (iv) Three irrigations with high depth at C+J+F (Control) as main plot treatments. Five nutrient management levels i.e. (i) 50 per cent NPK + FYM @ 15 t/ha, (ii) 75 per cent NPK, (iii) 75 per cent NPK + FYM @ 15t/ha (iv) 100 per cent NPK (100:60:40) control and (v) 125 per cent NPK as sub plot treatments replicated four times. The wheat variety PBW 443 was sown on 26th, 8th and 19th December in 1999, 2000 and 2001, respectively. The Plot size was: 8.5 x 5.5 m^2.

The soils are *Usti Psamments* under Gangetic alluvium plains. Texture is clayey with almost neutral pH (1:2 ratio) 7.2 and Electrical Conductivity (1:2) was 0.314 dS/m while organic carbon was 0.56 %. The soils are poor in available nitrogen (256 kg/ha) while available phosphorus (28.5 kg/ha) and potassium (390 kg/ha) are in medium range. The observations and measurements were taken on quantitative, growth and yield parameters of wheat at different stages of crop growth. Soil physical analysis was done using standard laboratory methods. Total N was estimated using Kjeldhal method as described by Jackson (1958). Available K was determined N normal Ammonium acetate extraction method. Critical yield in relation to growth parameters was arrived using critical level approach (Cate and Nelson, 1971). Data was analyzed statistically for its significance (SAS, 1989).

RESULTS AND DISCUSSION

Soil Characteristics

Soil physical characteristics

Soil parameters like bulk density, moisture characteristics were significantly affected by moisture regime and nutrients levels. Bulk Density varied from 1.3 to 1.5 g/cc, initial soil moisture during infiltration varied from 13–16% and infiltration rate varied between 0.3 to 0.6 cm/hr (Tab: 1). In FYM treated plots, moisture content and infiltration rate was found to be higher than other nutrient treatments. Better aggregation of soil due to FYM might facilitated in improving the bulk density and water movement and retention.

Among the irrigation treatments moisture content and infiltration rate was observed to be higher in Farmers Practice (3 irrigation treatments). Soil moisture content was

found decreased with depth as well as with time after irrigation. However, there was variation at different depths among the treatments. Highest moisture content in the soil profile (43%) was observed under heavy depth of irrigation (8-10 cm) (farmers' practice). Most of the soil moisture was found in 0-30 cm of the soil profile from which wheat plant extracts the water (Fig. 1). Similar observations were also found by Igbadun and Mudiare, (2002) and Panda et al, (2003). The studies regarding moisture depletion revealed that with increasing levels of nitrogen there was a higher utilization of moisture.

Table 1
Effect of Irrigation and Nutrient Management on Bulk Density and Infiltration Rate in Wheat Crop (2001-02)

Treatment	*50% NPK + FYM 15t/ha*	*75% NPK*	*75% NPK + FYM 15t/ha*	*100% NPK (120:60:40) control*	*125% NPK*	*Mean*
Bulk Density (g/cc)						
Irrigation at Critical (CRI+LT+M+D) stage	1.4	1.5	1.4	1.4	1.5	1.44
Irrigation at 50% ASM	1.5	1.5	1.5	1.4	1.4	1.42
Irrigation at 0.9 IW/CPE	1.3	1.4	1.4	1.5	1.5	1.42
Farmers practice (3 irrigations with high depth at C+J+F)	1.3	1.5	1.4	1.4	1.4	1.40
Mean	1.37	1.47	1.37	1.42	1.45	—
Infiltration rate (cm/hr)						
Irrigation at Critical (CRI+LT+M+D) stage	0.5	0.4	0.5	0.3	0.3	0.40
Irrigation at 50% ASM	0.4	0.4	0.5	0.3	0.3	0.38
Irrigation at 0.9 IW/CPE	0.5	0.4	0.5	0.3	0.3	0.40
Farmers practice (3 irrigations with high depth at C+J+F)	0.6	0.4	0.5	0.4	0.3	0.44
Mean	0.50	0.40	0.50	0.32	0.30	—

Soil nutrient levels

Total nitrogen content in general showed an increasing trend with depth. However, soils with higher fertilizer treatments (100% and 125% NPK) showed high amount of total nitrogen (0.046 and 0.048%) in the surface horizons both at 50% ASM and 0.9 IW/CPE ratio irrigation treatments. Similarly, the available nitrogen is also showed an increasing trend with depth and with increasing fertilizer nitrogen the availability ncreased in surface horizons. It varied from 307 kg/ha to 439 kg/ha (Fig. 2). The ncrease in available nitrogen content in surface horizons was mostly due to fertilizer itrogen.

The available potassium content of the soil after the crop increased in plots with ncrease in fertilizer potassium. Highest available potassium was observed in surface orizons (438 kg/ha). It decreased with depth in all the treatments. Average available

Fig. 1: Redistribution of Moisture in the Soil Profie under Different Irrigation Schedules

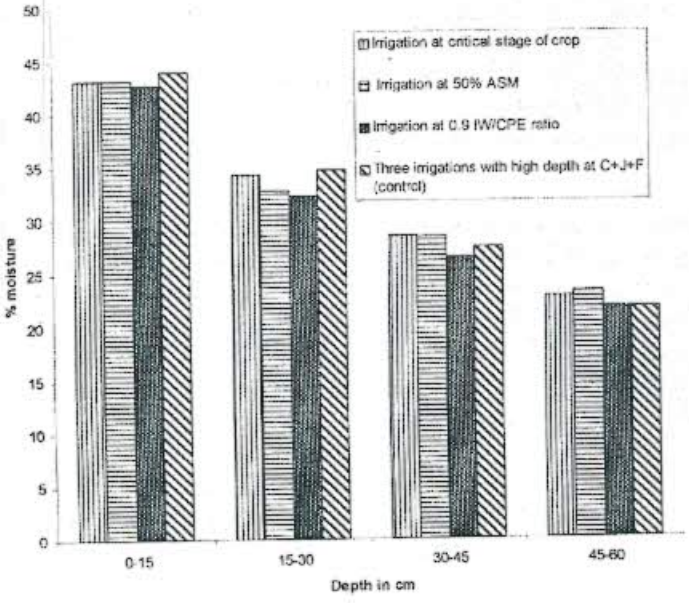


Fig. 2: Available Nitrogen Content with Depth under 0.9 IW/CPE Ratio Irriogation and Various levels of Fertiliser Nitrogen

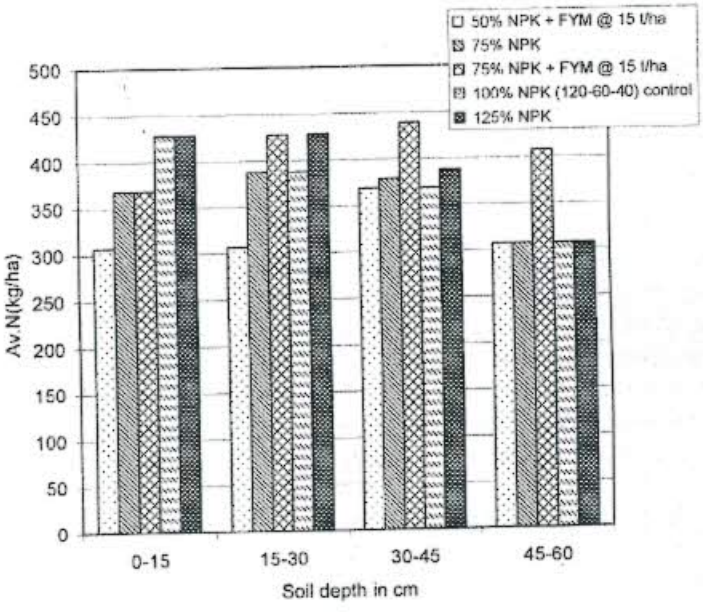
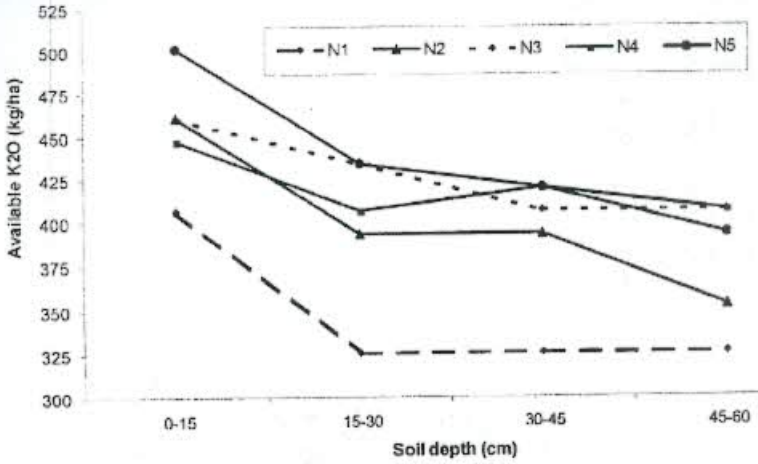


Table 2
Depth wise Variation of Available Potassium in Profile under Various Fertilizer Nutrient levels

Nutrient level	*Available K2O (kg/ha) in soil profile*														
	0 – 15			*15 – 30*			*30 – 45*			*45 – 60*			*Av.profile*		
	1999-00	*2000-01*	*2001-02*	*1999-00*	*2000-01*	*2001-02*	*1999-00*	*2000-01*	*2001-02*	*1999-00*	*2000-01*	*2001-02*	*1999-00*	*2000-01*	*2001-02*
50% NPK + FYM 15t/ha	429.7	422.7	406.6	406.8	420.1	325.2	410.9	420.1	325.2	320.5	406.6	325.2	392.0	417.4	345.6
75% NPK	447.2	449.2	460.8	420.2	433.7	393.0	423.4	420.1	393.0	350.2	352.4	352.4	410.3	413.9	399.8
75% NPK + FYM 15t/ha	454.9	457.2	460.8	435.1	449.2	433.7	436.3	422.7	406.6	405.5	406.6	406.6	433.0	433.9	426.9
100% NPK (120:60:40) control	464.9	460.8	447.2	449.2	422.7	406.6	423.3	422.7	420.1	403.2	406.6	406.6	435.2	428.2	420.1
125% NPK	478.0	475.2	501.4	457.2	449.2	433.7	426.2	420.1	420.1	390.0	393.0	393.0	437.9	434.4	437.1

Fig. 3: Available Potassium (kg/ha) in Soil Profile under Various NPK use After Wheat Harvest (2001-02)



potassium in the soil profile was high in case of 125% NPK. There was little reduction after three years in available potassium except incase of 125 % (Tab. 2, Fig. 3). The increase in available potassium in surface horizons might be due to added inorganic fertilizer potassium. Variation in lower horizons could be attributed to potassium movement along with water within the soil profile.

Physiological Parameters

Canopy temperature

The pooled data of consecutive three years revealed that the canopy temperature (Tc) in different irrigation scheduling varied from 28.9 to 29.7(Dtc = 0.8) and 26.8 to 27.0°c (Dtc = 0.2) at 55 and 65 DAS, respectively while due to nutrient management it varied from 28.6 to 29.5 (Dtc = 0.9) and 26.3 to 27.2°c (Dtc = 0.9) at above stages. The canopy temperature reduced from 55 and 65 DAS. However, the differential temperature of canopy was uniform when it related to nutrient management than irrigation schedules. (Tab. 3)

Crop Canopy Air Temperature Difference (CCARD)

CCARD varied from 0.76 to 0.84 and 0.77 to 0.83 at 55 and 65 DAS respectively. It was quite contrary that the maximum value at 55 DAS was recorded in irrigation at 0.9IW/CPE ratio and the minimum in irrigation at initial stages of crop, while at 65 DAS it was minimum in irrigation at 0.9 IW/CPE ratio and maximum irrigation at 50 per cent ASM. In case of nutrient management level the differences were quite larger with the maximum value of 0.94 in 100 per cent NPK and minimum in 75 per cent NPK + 150 q/ha FYM (0.76) at 55 DAS while it was maximum (1.00) in the same at 65 DAS. The lowest value at this stage was under 100 per cent NPK (Table 3).

Table 3
Changes in Canopy Temperature and Crop Canopy Air Temperature Difference (CCATD) in wheat under Different Irrigation and Nutrient Management (1999-00 and 2000-01)

Treatments	*Canopy Temp. (°C)*				*CCATD (°C)*			
	55 DAS		*65 DAS*		*55 DAS*		*65 DAS*	
	1999-00	*2000-01*	*1999-00*	*2000-01*	*1999-00*	*2000-01*	*1999-00*	*2000-01*
Irrigation Scheduling								
1. Irrigation at critical stages of the crop	28.85	29.4	26.80	27.3	0.75	0.76	0.77	0.78
2. Irrigation at 50% ASM	28.75	29.3	26.78	27.3	0.80	0.81	0.82	0.83
3. Irrigation at 0.9 IW/CPE ratio	28.63	29.2	26.72	27.2	0.83	0.84	0.76	0.77
4. Three irrigations with high depth at C+J+F	29.44	30.0	26.62	27.1	0.77	0.78	0.76	0.77
Nutrient Management Level								
1. 50% NPK + FYM @ 150q/ha	28.75	29.3	26.68	27.2	0.79	0.80	0.80	0.81
2. 75% NPK	29.20	29.7	26.87	27.4	0.78	0.79	0.93	0.94
3. 75% NPK + 150q/ha FYM	29.26	29.8	26.05	26.5	0.75	0.76	0.99	1.01
4. 100% NPK (120:60:40) control	28.40	28.9	26.68	27.2	0.93	0.94	0.77	0.78
5. 125% NPK	28.98	29.5	26.92	27.4	0.87	0.88	0.80	0.81

Plant Growth Parameters

Among the four irrigation schedules, the relative growth rate was recorded the highest (23.51 mg/day) under irrigation at 0.9 IW/CPE and the lowest (16.93 mg/day) under irrigation at critical stage. In case of leaf area ratio, it was highest (28.84 cm2/g) under irrigation at 50 per cent ASM and lowest (15.96 cm2/g) under irrigation at critical stages. (Fig. 4). Water stress do not affect the specific leaf area, but reduces leaf weight ratio and leaf area ratio (Ahmadi and Sio Se Mardeh, 2003). It was highest (24.96) under 125 per cent NPK. Specific leaf weight varied from 2.74 to 5.43 g/cm^2 in case among of different the irrigation scheduling while it was 2.37 to 4.31 g/cm^2 among the nutrient levels.

Crop growth rate (g/m2/day) was highest (44.21) under irrigation at 0.9 IW/CPE while the lowest (33.35) under irrigation at critical stages. The highest value in previous treatment might be due continuous availability of optimum irrigation while lowest value might be due to availability of at critical stages only (Fig. 4) Net assimilation rate (NAR) and relative growth rate (RGR), measured before flowering in wheat cultivars were reduced by water stress (Ahmadi and Sio Se Mardeh, 2003). It was highest at under 125 per cent NPK (47.36) and lowest under 50 per cent NPK + FYM 150 q/ha (36.32). Crop growth rate and net assimilation rate, measured at different stages of wheat increased significantly with balanced NP fertilizer application (Singh, et al 2003).

Growth Characters

The growth characters of wheat like plant height at tillering stage (cm), final plant height (cm), tillers per meter square at 40 DAS, maximum tillers per meter square were found to be not affected with various type of irrigation schedule (Table 4). Only the graining period (days) varied significantly due to irrigation scheduling with its highest value of 35.7 under irrigations at 0.9 IW/CPE and significantly lowest under farmers practice (33.7).

Quite contrary to irrigation scheduling under However, the nutrient levels all the growth parameters were found be significantly affected. The plant height of 11.2 cm was recorded at tillering stage under 125 per cent NPK application which was significantly highest over the 50 per cent NPK + FYM (10.3). Final plant height recorded maximum in 100 per cent NPK (84.3 cm) followed by 84.1 cm in 125 per cent NPK and both being at par to each other were significantly highest over 50 per cent NPK (81.7 cm). Significantly highest number of tillers per meter square at 40 DAS of 391.2 was recorded in case of 125 per cent NPK followed by 100 per cent (373.2) which was significantly superior to its lower doses. The lowest value of 292.7 was registered in case of 50 per cent NPK + FYM @ 150q/ha. Similar was the trend in case of maximum tillers per Meter Square. The graining period was highest (36.7 day) in case of 125 per cent NPK followed by its lower dose (35.9). The significantly lowest value of 32.7 day was registered in 50 per cent NPK + FYM (Tab. 4).

Yield Characters

Irrigation scheduling affected yield parameters of wheat like number of earhead per meter square, earhead length (cm), grain number per earhead, grain weight per earhead (g) and 1000 grain weight (g) but it was non significant. However, these parameters varied significantly due to variation in nutrient levels (Table 5).

Incase of all yield attributing parameters highest values were registered in case of 125 per cent NPK but it could not showed significant superiority over 100 per cent NPK and 75 per cent NPK + 150 q FYM. However, significantly lowest values were noticed in case of 50 per cent NPK + FYM but the values were at par with 75 per cent NPK. The results found are in comparison with the studies made by Singh, et al (2003).

Yield & Harvest Index

Grain and straw yields as well as in harvest index varied due to different irrigation scheduling treatments but the effect was not significant. However, the highest values (32.17 q grain, 43.76 q straw/ha and 42.66 per cent HI) were obtained under irrigation at critical stages while the lowest values (30.46q grain and 41.27 q straw/ha) of yields obtained under farmer's practice of three irrigations with high depth. Irrigation scheduling at physiological stages of wheat increased yield (Ghodpage and Gawande, 2001 and Behera,et al 2002). This might be due to at critical stages the plants need more water, which influenced the yields. Similar was the trend with the harvest index of the crop it varied from 42.32 to 42.66 per cent but the effect of change in irrigation schedule was non significant.

Table 4
Growth Characters in wheat Crops as Affected by Method of Irrigation Schedules and Nutrient level (1999-00 to 2001-02)

Treatment	*Plant height at Tillerin stage (cm)*			*Final plant height (cm)*			*Tillers/m2 at 40 DAS*			*Maximum tillers per m2*			*Graining period (days)*		
	I	*II*	*III*	*I*	*II*	*III*	*I*	*II*	*III*	*I*	*II*	*III*	*I*	*II*	*III*
Irrigation schedule															
Critical stage (I1) (CRI+LT+M+D)	10.33	11.8	10.3	8.27	89.5	81.4	402.5	386.7	289.5	507.5	471.3	352.8	34.1	36.3	36.4
Irrig. At 50% ASM (I2)	9 80	11.2	9.8	83.2	89.4	81.3	387.5	388.2	255.3	473.7	478.6	314.8	33.3	35.3	35.8
Irrig. At 0.9 IW/CPE (I3)	10.24	11.7	10.2	81.6	88.9	80.9	381.1	385.6	265.1	459.7	462.8	318.2	34.1	36.4	36.6
Farmers Practice (3 irrigations) (I4)	10.32	11.8	10.0	80.3	87.5	79.6	387.3	384.3	289.9	496.8	442.5	333.8	32.0	34.1	35.1
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.7	0.8	0.7
Nutrient level (NPK)															
50% NPK+FYM	9.82	11.3	9.9	80.2	86.4	78.6	325.1	319.2	233.7	439.9	417.6	305.7	31.2	33.4	33.6
75% NPK	9.89	11.4	10.0	80.6	86.8	79.0	367.8	371.6	272.2	457.4	439.2	321.7	32.3	34.5	34.7
75% NPK+FYM	10.05	11.5	10.1	81.4	87.7	79.8	405.9	396.8	281.3	494.0	478.7	322.4	33.5	35.7	35.9
100% NPK	10.32	11.8	10.1	82.8	89.2	80.8	416.4	417.6	285.7	507.8	486.8	333.1	34.4	36.5	36.7
125% NPK	10.61	12.2	10.3	82.4	88.8	81.1	432.1	427.7	313.7	523.1	499.7	366.5	35.3	37.3	37.5
C.D. (P=0.05)	0.72	0.8	0.3	2.13	2.29	2.1	4.32	5.62	4.61	60.7	62.5	40.2	0.9	0.9	0.9

I = 1999 – 2000, II = 2000 – 2001, III = 2001 – 2002