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Response of hybrid rice to scheduling of nitrogen and irrigation during dry season

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ABSTRACT

Field experiment were conducted to study the performance of hybrid rice to scheduling of irrigation and nitrogen level. Nitrogen scheduling of 40+20+30+10 percent at basal, active tillering, panicle initiation and flowering reduced the sterility percentage and increased effective tillers and grain yield of hybrid rice. Irrigation, one day after disappearance of water proved as good as continuous submergence for yield components, grain yield and N content in stem and leaf at early stages, flag leaf, grain and straw. The irrigation schedule of one day after disappearance of ponded water required 604 mm less irrigation water than that of maintaining continuous submergence.

Key words: *hybrid rice, irrigation schedule, nitrogen, grain yield*

Hybrid rice technology provides 15-20 percent yield advantage over the best inbred (Lin and Pingali, 1994). Besides other inputs, nitrogen and water are extremely important and high yields are possible when N uptake is sufficient to maintain dry matter accumulation and sink formulation throughout crop growth. Therefore nutrient and water use efficiency and yield potential are the major concern for hybrid rice. Hybrid rice has more dry matter accumulation in the early (transplanting to panicle initiation) and middle growth stages (panicle initiation to heading) so more fertilizer should be applied at early stages for hybrid rice (Zhende, 1988). Luo and Zheng (1989) reported that late maturing hybrid rice absorbed 19% of total N after full heading, therefore yield and N fertilizer recovery were increased with application of N fertilizer at late growth stage. However, it is important to find out appropriate amount of N at particular crop stages to fulfill crop needs. In hybrid rice, higher percent of unfilled grains are commonly seen unless soil nutrient supply can cope up with the crop demands. Thus, delayed application of N coinciding with flowering can help to realize the full potential of hybrid rice. Moreover, the application of N in splits improves efficiency of N utilization as compared to whole amount applied as basal but adequate amount required at different stages needs to be worked out to meet the crop requirements.

Water is mainly used for production purpose (transpiration) but in rice water uses in a wide variety of ways, both beneficial and non beneficial (Ramanjaneyulu and Rajitha, 2006). Luikham and Krishnarajan (2005) also noted lower sterility of hybrid rice when the interval between irrigation was reduced. However, Chandra *et al*. (2008) reported higher yield of hybrid rice with continuous submergence of water than that of intermittent irrigation. Furthermore, the increasing cost of irrigation water and the associated decline in return are encouraging producers to use water more efficiently (Penman, 1984). It is therefore, essential to find out proper irrigation schedule especially during dry season to maintain proper growth and yield of hybrid rice. Hence, the present investigation was planned to find out proper nitrogen and irrigation schedule for hybrid rice cultivation during summer season.

MATERIALS AND METHODS

A field experiment were carried out during dry seasons with 3 irrigation schedules i.e. continuous submergence (CS) of 5±2 cm water at all the stages; submergence of 7 cm water at 1 day after disappearance (DAD) of ponded water and submergence of 7 cm water at 3 DAD of ponded water were accommodated in main plot and 4 nitrogen schedules i.e. N 20% as basal (B)+40% at active tillering (T)+40% at panicle initiation (PI); 20% as B+30% at T+30% at PI+20% at flowering (F); 30% as B+40% at T+30% at PI; and 40% as B+20% at T+30% at PI +10% at F in sub plots with rice hybrid Proagro 6111 in split plot design was adopted with 3 replications. The soil of the experimental field was clayey in nature having 218 kg ha^{-1} available N, 34 kg ha^{-1} available P_2O_5 and 308 kg ha^{-1} exchangeable K having pH 7.2 and organic matter content 0.52%. The fertilizer of 150:75:60 kg N, P_2O_5 and K_2O was uniformly given to the crop. The whole amount of P and K was given as basal and N was applied as per the treatments and irrigation treatments were imposed ten days after transplanting. The amount of effective rainwater also added to total amount of water used by the crop. The water use efficiency (WUE) has been expressed as the ratio of grain yield (kg ha^{-1}) to water requirement (cm) of crop. Nitrogen content in stems, leaves, flag leaf, grain and straw was determined by Micro-kjedahl.

RESULTS AND DISCUSSION

The highest grain yield (7.0 t ha^{-1}) of summer hybrid rice was obtained with maintaining continuous submergence (CS) of 5±2 cm of water which remained on par with that obtained under irrigation given at 1 day after disappearance (DAD) ponded water (Table 1). The yield increase in hybrid rice under continuous submergence due to the fact that hybrid rice possessed superior yield attributes like number of filled grains panicle^{-1} and panicle m^{-2} (Chandra *et al.*, 2008). The irrigation given under 3 DAD of ponded water reduced the grain yield by 9.26% and 5.98% as compared to that of CS and 1 DAD, respectively. The reduction in grain yield was mainly associated with significant reduction in effective tillers m^{-2}, grains earhead^{-1} and test weight. The significant increase in sterility percent was noted under the application of irrigation at 3 DAD of ponded water. The irrigation given under 3 DAD might be failed to meet the evaporative demand during dry season thus reduced yield component and grain yield of rice.

The N concentration in stem and leaf at 30 and 60 DAT and in flag leaf and straw remained comparable under CS and 1 DAD (Table 2). The N concentration in leaf at 90 DAT and in grains improved significantly under CS as compared to other irrigation schedules. This is probably due to higher mobility of inorganic N in soil solution and its absorption by plants. On the other hand, irrigation under 3 DAD of ponded water, unavailability of sufficient moisture in the root zone might have caused the plant root to spend more energy to extract the unit amount of N. The results are in conformity with the findings of Luikham and Krishnarajan (2005).

The water and irrigation requirement were the highest under irrigation schedule of CS followed by

Table 1. Effect of irrigation and nitrogen schedules on yield components and grain yield of hybrid rice during dry season

Treatments	Effective tillers m^{-2}		Panicle length (cm)		Grains panicle^{-1}		Test weight(g)		Sterility(%)		Grain yield (t ha^{-1})	
	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year	1st Year	2nd Year
Irrigation schedules												
CS	313	317	26.85	24.29	119	120	22.24	21.19	28.46	20.77	7.0	7.1
1 DAD	310	316	25.89	24.08	117	117	22.12	20.93	30.67	21.16	6.8	6.8
3 DAD	297	303	24.74	22.7	104	108	21.75	20.26	36.87	25.34	6.4	6.4
CD at 5%	6.89	4.56	1.45	0.67	2.92	6.15	0.7	0.51	0.89	1.81	3.0	3.2
Nitrogen schedule B: T: PI: F												
20%:40%: 40%: 0%	297	309	25.68	23.11	111	112	21.97	20.42	32.99	26.3	6.5	6.7
20%:30%: 30%: 20%	304	306	26.36	23.81	116	118	22.12	21.86	30.51	25.24	6.6	6.8
30%:40%:30%: 0 %	309	313	24.84	22.92	107	117	21.84	20.36	34.62	22.59	6.8	6.9
40%:20%:30%:10%	317	319	26.48	24.2	119	121	22.21	22.15	30	16.5	7.1	7.2
CD (P=0.05)	4.45	5.67	1.28	0.71	4.28	3.82	0.13	0.39	1.36	2.18	2.27	2.52

irrigation given under 1 and 3 DAD of ponded water (Table 3). The irrigation at 3 DAD of ponded water gave the highest water use efficiency (WUE) (88.51 $kgha^{-1}days^{-1}$) but grain yield was also reduced substantially as compared to both the irrigation schedules. The irrigation schedule of 1 DAD of ponded water although gave WUE less than 3 DAD, the grain yield was similar to that of CS. As compared to CS, reduction in irrigation requirement at irrigation schedule of 1 DAD of ponded water was to the extent of 507 mm and 700 mm, respectively during first and second year. The water requirement was in general higher during second year due to more evaporative demand of the crop due to climatic conditions.

The scheduling of nitrogen 40% B+20% T+30%PI+10%F significantly reduced sterility percentage and increased the effective tillers and grain yield as compared to other N schedules (Table 1). The application of N 40% B+20% T+30%PI+10%F was capable to meet the intensity and capacity of the soil to supply nitrogen to the crop favorable for yield components and grain yield. Similar finding has also been reported by Venketasawamy *et al*. (1997). The N schedule of either 30% B + 40% T + 30% PI or 20% B + 40% T + 40% PI or 20% B + 30% T + 30% PI + 20% F found to be equally effective for grain yield and yield components of hybrid rice. The N schedule of 40% B + 20% T + 30% PI + 10% F increased N concentration in stem and leaf at 30 DAT (Table 2). Whereas, at 60 DAT, N schedule of 20% B + 40% T + 40% PI gave the highest N concentration in stem and leaves, which was comparable to N schedule of 30% B + 40% T 30% PI for N concentration in leaf. The N schedule of 20%B+30%T+30%PI+20%F increased N concentration in stem and leaf at 90 DAT and flag and grain in straw, which remained comparable to that of N schedule of 40%B+20%T+30% PI+10%F especially for N content in flag leaf, grain and straw. It is established that before panicle initiation, the leaves are the most important location for N and thereafter panicle be comes increasingly dominant. However, in the present study 10 to 20% N applied at flowering increased N concentration in flag leaves, grain and straw and finally grain yields. This also indicates that an activity of root was continued to absorb nutrients at later stages of growth.

Table 2. Effect of irrigation and nitrogen schedules on N content in different plant parts of hybrid rice during summer season

Treatments	N concentration in stem (%)						N concentration in leaf (%)						N content in flag leaf(%)		N content in grain(%)		N content in straw(%)	
	30 DAT		60 DAT		90 DAT		30 DAT		60 DAT		90 DAT							
	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
Irrigation schedules																		
CS	1.96	1.85	1.21	1.13	0.69	0.67	3.66	3.83	2.86	2.94	0.83	1.02	3.13	3.21	1.61	1.47	0.35	0.31
1 DAD	1.92	1.83	1.17	1.11	0.64	0.65	3.61	3.78	2.81	2.88	0.78	0.94	3.07	3.14	1.53	1.39	0.34	0.30
3 DAD	1.68	1.67	0.91	0.83	0.39	0.55	3.26	3.33	2.55	2.64	0.67	0.88	2.69	2.81	1.41	1.3	0.29	0.26
CD at 5%	0.06	0.02	0.06	0.02	0.03	0.02	0.06	0.08	0.06	0.08	0.03	0.06	0.08	0.11	0.03	0.05	0.02	0.02
Nitrogen schedule																		
B: T: PI: F																		
20%:40%: 40%: 0%	1.74	1.69	1.15	1.1	0.54	0.61	3.45	3.51	2.76	2.83	0.72	0.91	2.87	2.93	1.5	1.35	0.3	0.27
20%:30%: 30%: 20%	1.76	1.73	1.07	1	0.63	0.67	3.46	3.54	2.71	2.73	0.82	1.04	3.1	3.16	1.58	1.44	0.36	0.32
30%:40%:30%: 0 %	1.91	1.84	1.13	1.05	0.51	0.56	3.52	3.63	2.75	2.81	0.71	0.88	2.83	2.88	1.42	1.29	0.31	0.26
40%:20%:30%:10%	1.99	1.87	1.04	0.97	0.61	0.66	3.6	3.72	2.63	2.69	0.79	0.98	3.04	3.1	1.57	1.42	0.34	0.3
CD (P=0.05)	0.04	0.02	0.02	0.02	0.02	0.02	0.04	0.06	0.04	0.06	0.02	0.04	0.06	0.09	0.02	0.04	0.02	0.03

Table 3. Effect of irrigation schedules on irrigation, water requirement and water use efficiency of hybrid rice during summer season

Irrigation schedules	Effective rainfall (mm)		Irrigation requirement (mm)		Water requirement (mm)		Water use efficiency (kg $ha^{-1}cm^{-1}$)	
	1999	2000	1999	2000	1999	2000	1999	2000
CS	35.5	37.2	1277.5	1643	1313	1680.2	53.37	42.33
1 DAD	64.6	37.2	770	943	834.6	980.2	82.31	69.63
3 DAD	64.6	37.2	630	733	694	770.2	93.23	83.78

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