Water use efficiency in rice hybrid under different water intervals and nitrogen levels

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Abstract: Shortage of water in rice cultivation area of Iran is going to be a major problem in near future therefore water use in rice production systems has to be reduced and water use efficiency increased. Experiment was conducted in a split plot based on completely randomized block design with 3 replications during 2007-2008. Four levels of nitrogen (N1=0, N2= 90, N3= 120 and N4= 150 kg/ha) were splited on 4 different irrigation managements (I1=continuous submergence, I2= 5, I3= 8 and I4= 11 days interval). Grain yield was 7342, 7079, 7159 and 5168 kg/ha in I1 to I4 and 5303, 6628, 7398 and 7418 kg/ha in N1 to N4 respectively. Water use efficiency was 1.41, 1.53, 1.68 and 1.31kg m3 in I1 to I4 and 1.16, 1.48, 1.67 and 1.63 kg/m3in N1 to N4 respectively. Water used was 5190, 4630, 4270 and 3950 m3 in I1 to I4 and 4590, 4470, 4440 and 4540 m3 in N1 to N4 respectively. The results clearly showed that continuous submergence irrigation is not essential for rice production and we can use irrigation interval 8 days. The application of 120 and 150 kg/ha nitrogen produce same grain yield, therefore consumption of 120 kg/ha nitrogen for rice hybrid advised.
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1. Introduction

Rice is the most important staple in Asia, providing on average 32% of total calorie uptake (MacLean et al., 2002). Iran with near 165 million hectare of land area and amount of rainfall equal to 300mm in 67% of its territorial land is considered as a semi-dry region in the world. About 75% of the global rice volume is produced in the irrigated lowlands (MacLean et al., 2002). Decreasing water availability for agriculture threatens the productivity of the irrigated rice ecosystem and ways must be sought to save water and increase the water productivity of rice (Guerra et al., 1998). Conventional water management in lowland rice aims at keeping the fields continuously submerged. Water inputs can be reduced and water productivity increased by introducing periods of none submerged conditions of several days (Bouman and Tuong, 2001).Although in recent years the growth of consumption rate of fertilizers in Iran has increased sharply and a large amount of fertilizer in addition to domestic productions has been imported from abroad nevertheless unfortunately during this period not only yield of crops has not increased in accordance with the consumption growth rate of fertilizers but also yield in hectare of crops has declined to many reasons such as water shortage, different irrigation methods, lack of scientific knowledge by farmers and method of fertilizer usage. It is worth mentioning utilization especially usage of nitrogen fertilizer is very significant factor in growth of rice. When nitrogen fertilizer used in tillering, paddy yield increased (Bacon, 1989).

Biomass and yield did not significantly differ between ASNS and CS, but water productivity was significantly higher under ASNS than under CS.grain yields were 4.1–5.0 t ha^{-1} with 0 kg N ha^{-1} and 6.8–9.2 t ha^{-1} with 180 kg N ha^{-1} (Belder et al., 2004). Panicles with a low percentage of sterile flowers permit the application of higher doses of nitrogen and produce better yields (Yoshida, 1981). Rice grain yield was recorded highest in case the N application ranged between 90-250 kg per ha (Bali et al., 1995).

Belder et al (2004) investing compared continuous submerge method and interval irrigation methods in China and the Philippines through different nitrogen levels, water saving in interval irrigation methods was 18-15 % higher than submerge method, they also found the water productivity amount in the Philippines and China, 0.73- 1.48 and 0.5 – 1.3 kg yield for $1m^3$ of input water. Tabbal et al (2002) in a research in the Philippines compared the conditions of submerge and interval irrigation in direct and transplanting plantation and concluded that the water productivity in saturated situation for direct and transplanting plantation is less than other treatments. Bouman and Tuong (2001) for watered farms of India and Philippine reported the water productivity as 0.2-1.1.

The purposes of this experiment determine the best appropriate level for usage of nitrogen fertilizer and irrigation management.

2. Material and Methods

In order to investigating the effect of different regimes of irrigation and nitrogen fertilizer on yield of hybrid rice an experiment was conducted at rice research institute of Iran during crop season 2008. experiment was arranged in split plot based on completely randomized block design with 3 replications in which water regimes were main factor included continuous submergence and alternately submergence (irrigation intervals of 5, 8 and 11days) and nitrogen fertilizer levels were sub factor included 0, 90, 120 and 150 kg/ha. For all treatments, drainage basins have been mounted from which waste water belonging to each replicate treatments were exited. Each experimental plot had 15 lines with five meter in length and the planting method was considered to be 25×25 cm. The nursery construction took place in April and transplanting to the field happened in early may. In order to use fertilizer, based on the soil test and instructions of the technicians the rice investigation organization the amount of P and K was calculated and applied to every plot. The amount of irrigation water applied was monitored at each plot from transplanting till maturity, by using flow meters installed in the irrigation pipes. Yield was measured with $6m^2$ harvesting of every plot. The yield and yield components were analyzed by using MSTATC software. The Duncan's multiple range tests was used to compare the means at 5% of significant.

3. Results

Water interval had significant effect on grain yield, biomass, harvest index, water used and water use efficiency (table 1). Nitrogen level had significant effect on grain yield, biomass and water use efficiency (table 1). Grain yield was 7342, 7079, 7159 and 5168 kg/ha in I1 to I4 (fig1a) and 5303, 6628, 7398 and 7418 kg/ha in N1 to N4 (fig2a) respectively.I1N3, I3N4, I1N4, I2N3, I3N3 and I4N1produced maximum and minimum grain yield (table 2).

Continuous submergence, irrigation interval 5 and 8 days had no differences on grain yield and produced same grain yield. Irrigation interval 11 days decreased grain yield to 27%. The consumption of 120 and 150 kg/ha nitrogen fertilizer produced same grain yield. Minimum grain yield obtained in 0 kgN/ha. Reported that application of N fertilizer increased grain yield of rainfed lowland rice even when the rice crop was exposed to water deficit (Castillo et al, 1992). Also, reported that grain yield and dry matter increased as the applied N rate was increased (Zhong and Huang, 2002).

Biomass was 13369, 13653, 13111 and 12046 kg/ha in I1 to I4 (fig1b) and 10328, 12635, 14139 and 15077 kg/ha in N1 to N4 (fig2b) respectively.I1N4, I2N4, I3N3 and I4N1produced maximum and minimum biomass (table 2).

Harvest index was 50, 50, 51 and 46 percentage in I1 to I4 (fig1c) respectively and nitrogen level was not effective on harvest index (fig2c).

Water used was 5190, 4630, 4270 and 3950 m3 in I1 to I4 (fig1d) and 4590, 4470, 4440 and 4540 m3 in N1 to N4 (fig2d) respectively. Amount of irrigation in 8 days interval compare to continuous submergence decreased 18% (4270 and 5190 m3 respectively).

I1N4 and I4N3, had maximum and minimum water used respectively (table 2). Water use efficiency was 1.41, 1.53, 1.68 kg/m3 and 1.31 in I1 to I4 (fig1e) and 1.16, 1.48, 1.67 and 1.63 kg/m3 in N1 to N4 (fig2e) respectively. I3N4, I3N3, I1N3 and I4N1 had the highest and lowest WUE respectively (table2).

4. Discussions

Shortage of water in rice cultivation area of Iran is going to be a major problem in near future therefore water use in rice production systems has to be reduced. The results clearly showed that continuous submergence irrigation is not essential for rice production and we can use irrigation interval 8 days in paddy fields of north of Iran. The application of 120 and 150 kg/ha nitrogen produce same grain yield, therefore consumption of 120 kg/ha nitrogen for rice hybrid advised.

Water saving irrigation can lead to reduce water consumption in paddy fields and conservation of natural water resources of which is important goal of achieving sustainable development in agriculture**.**

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Table 1. Analysis of variance in some parameters of rice

S. O. V	df	Yield	biomass	Harvest Index	amount of irrigation	Water use efficiency
I	3	12452331**	5364477.1*	333.7**	33888.8**	0.375*
E	6	1077622	885869.2	21.1	1735.3	0.09
N	3	11838173**	44436179.4**	33.6 ns	580.5 ns	0.669**
I*N	9	1211276*	4554914.2*	43.1 ns	4127.3**	0.125**
E	24	501150	1882779.7	22.6	795.1	0.43
CV (%)		10.59	10.93	9.48	6.25	10

Table 2. Effects of water interval and nitrogen levels on some parameters of rice

water interval	Nitrogen level	Yield (kg/ha)	biomass (kg/ha)	Harvest index (%)	Water used (m3)	Water use efficiency(kg/m3)
I1	0	5495d	10340f	49.3abcd	5440a	1.01cd
	90	7117bc	13370bcde	53.3abc	4697f	1.52bc
	120	8912a	15400bc	58.0a	5327b	1.67ab
	150	8247ab	18000a	45.7cde	5480a	1.50bc
I2	0	5971cd	10370f	57.3a	5160c	1.16c
	90	7074bc	14530bcd	49.0abcd	4950d	1.43bc
	120	7730ab	13960bcde	55.3ab	5000d	1.54bc
	150	7543b	15760ab	47.7bcde	4717f	1.60b
I3	0	5344d	10390f	51.3abcd	4410g	1.21c
	90	7328b	13770bcde	53.3abc	5063d	1.45bc
	120	7679ab	15680ab	49.0abcd	4587f	1.67ab
	150	8284ab	14990bc	55.3ab	4597f	1.80a
I4	0	4004e	10300f	43.0de	4057j	0.98d
	90	4994d	12890cdef	39.0e	4840e	1.03cd
	120	5274d	12240def	43.3de	4033j	1.31c
	150	5600d	12970cde	44.0de	4173j	1.34c

a b

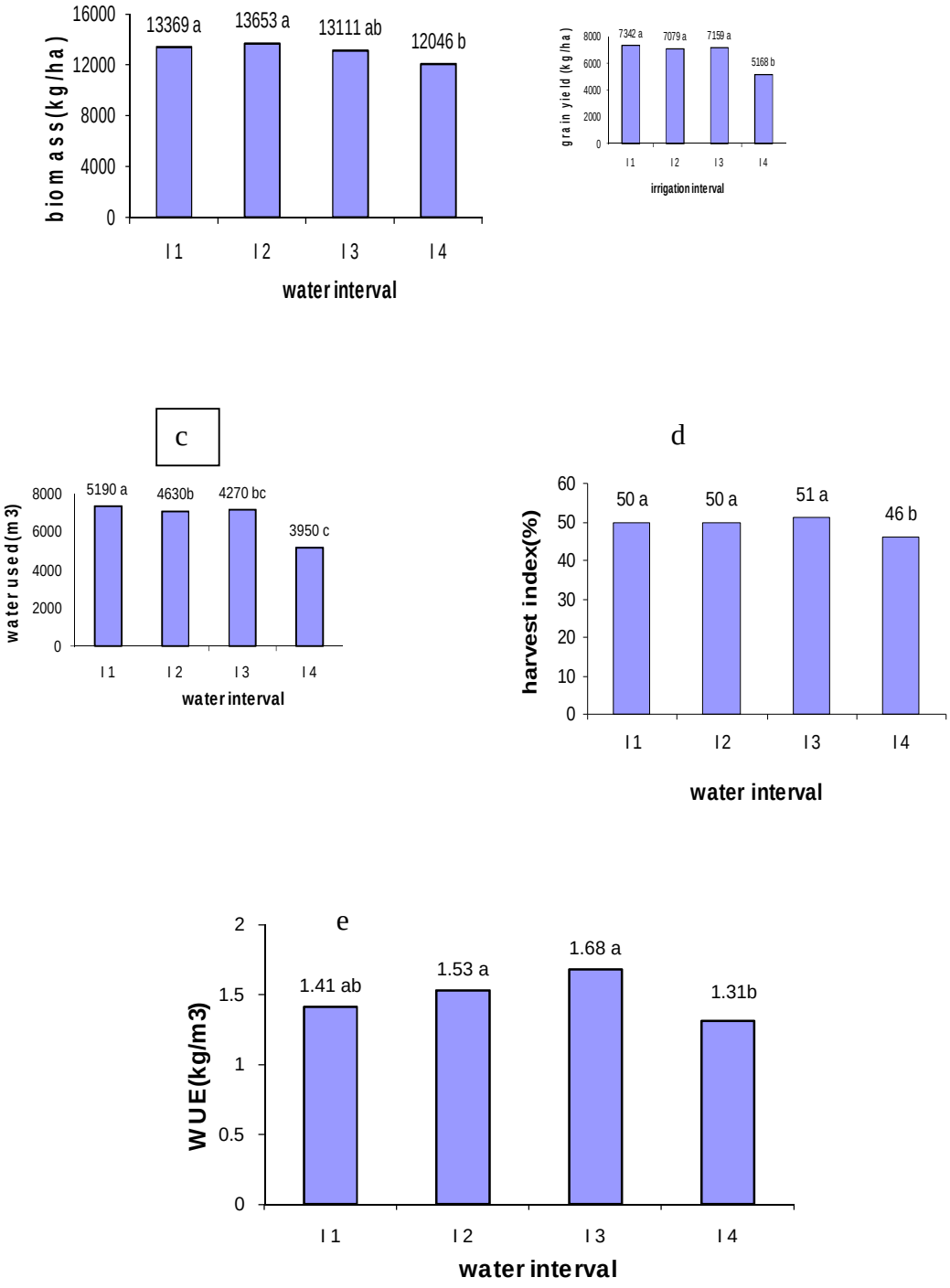

Fig 1- effect of nitrogen levels on grain yield (a), biomass (b) harvest index (c), water used (d) and WUE (e).

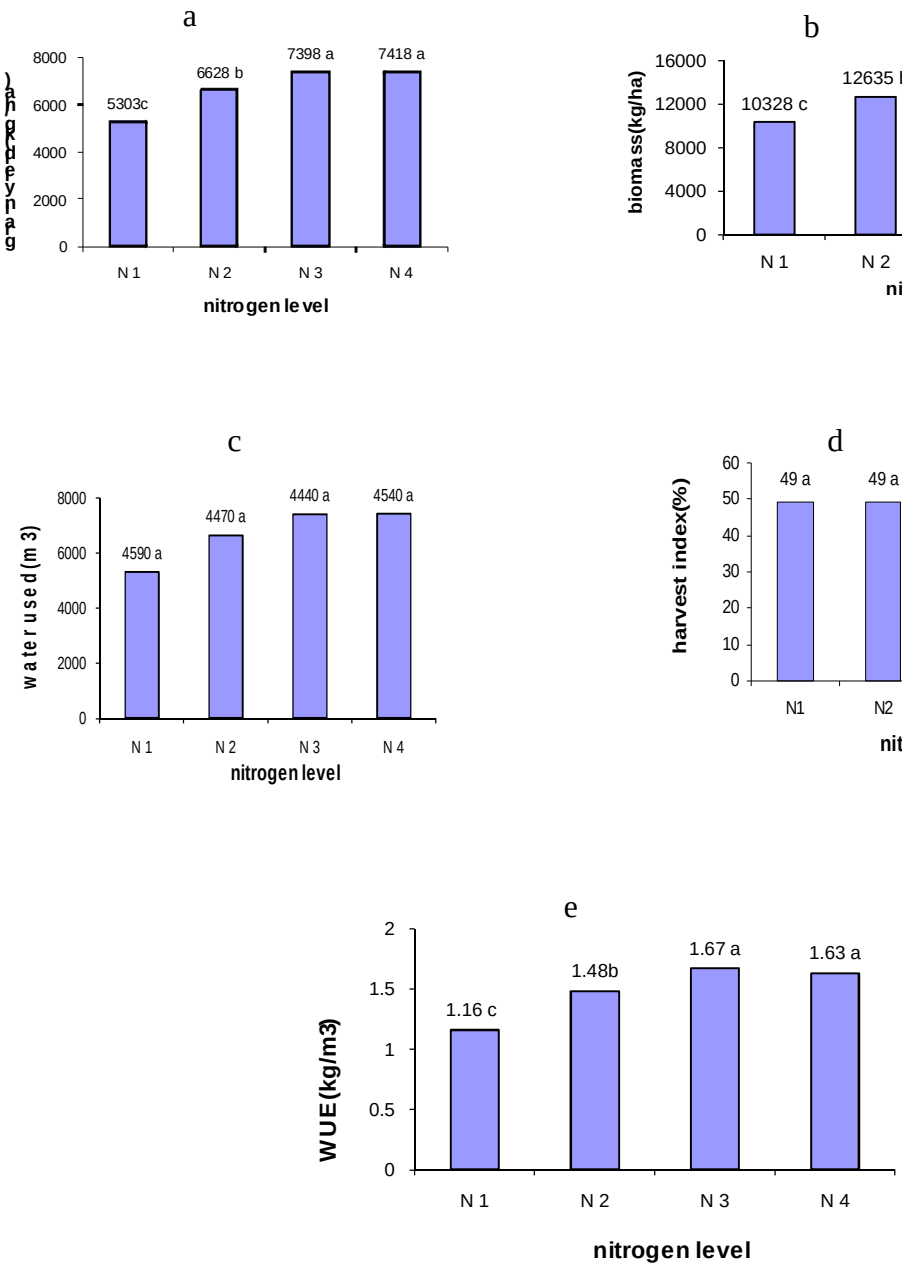

Fig 2- effect of nitrogen levels on grain yield (a), biomass (b) harvest index (c), water used (d) and WUE (e).

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