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Interaction effect of submerged water levels seedling of boro Rice (*Oryza sativa* L.)

Md. Maksudul Haque[1, *], Hasina Khatun[1], Elora Pervin[2] and Md. Anisuzzaman[1]

[1]Scientific Officer, Plant Breeding Division, Bangladesh Rice Research Institute, Gazipur 1701, Bangladesh
[2]Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh

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ABSTRACT

The field experiment was conducted in boro season with a view to find out the influence of water level and seedling number hill^{-1} on growth and yield of boro rice. The experiment was carried out in split-plot design with 3 replications. It reveals that continuous submerged condition (2-5 cm standing water) gave the highest performance in respect of plant height, tiller number hill^{-1}, leaf area index, dry matter and duration of flowering. Continuous submerged condition showed significantly taller plant height all the growing period except 30 days after transplanting. Tiller numbers hill^{-1} significantly influenced at 30, 45, 75 DAT and at harvest. Leaf area index (LAI) significantly influenced by water levels all the growing period except at early and harvesting time. Duration of flowering significantly earlier (103.83) at submerged condition compare to saturated condition (105.75). Among the growth characters tiller numbers hill^{-1} and leaf area index significantly influenced by the different number of seedling hill^{-1} whereas plant height, dry matter production and duration of flowering was unaffected. Considering the tiller production hill^{-1} was significantly similar from 2 to 4 seedlings hill^{-1} in which single seedling hill^{-1} showed lowest performance up to 75 DAT but at harvest there was no significant variation among the treatments. Leaf area index was significantly differed upto 45 DAT, whereas 2 to 4 seedlings hill^{-1} showed significantly highest value compare to single seedling hill^{-1}.
KEY WORDS*:* Submerged, Interaction, Leaf Area Index, Dry Matter, Boro Rice (*Oryza Sativa* L.)

INTRODUCTION

Rice (*Oryza sativa* L.) is the primary food for half the people in the world. In many regions it is eaten with every meal and provides more calories than any other single food. Rice is a nutritious food, providing about 90 percent of calories from carbohydrates and as much as 13 percent of calories from protein **(Anon., 2005)**. Rice contributes more than 70% of total production and 60-94% of daily calorie intake in China, India, Pakistan, Bangladesh and Nepal **(Prasad *et al*., 1999)**.

Rice is the 1st ranking cereal crop in terms of area and production in Bangladesh though the average yield of 2.82 t ha^{-1} is very low as compared to that of Egypt (8.4 tha^{-1}) and USA (6.6 t ha^{-1}) **(BBS, 2010**). There are many reasons for this low yield. The important one is use of unsuitable aged seedlings and different water levels by farmers. The combined effect of these factors usually produces high seedlings mortality just after transplanting. Seedlings age at transplanting is an important factor for uniform stand of rice and regulating its growth and yield **(Bassi *et al.,* 1994)**. Tiller dynamics of the rice plant greatly depends on the age of seedlings at transplanting **(Pasuquin *et al.,* 2008)**. Tillering and growth of rice proceed normally when optimum aged seedlings are transplanted at the right time **(Mobasser *et al.,* 2007)**. Though about one-third of the country's land area is submerged by monsoon flood in a normal year, no boro crop can be grown without irrigation **(Das, 2005)**.On the other hand, submerging rice field brings a series of physical, chemical and microbial changes in the soil, which profoundly affects growth of rice plant as well as availability, loss and absorption of nutrients **(Ghildyal, 1978)**. Inefficient water use not only increases cost of irrigation, but declines the water table, increases arsenic contamination and may emit the green house gases from submerged rice field that lead to climate change in the world **(Wang *et al.,* 2002)**. Most farmers maintained standing water in the rice crop to control weeds, but this benefit comes at the expense of substantial water loss by percolation and seepage. The gap between the "true need" and "current use" of water producing rice is very large **(Bhuiyan, 1999)**.

***Correspondents Author**: Md. Maksudul Haque, Scientific Officer, Plant Breeding Division, Bangladesh Rice Research Institute, Gazipur 1701, Bangladesh. *maksudulhq@gmail.com*

Irrigated area can be extended from its current one-third of the cultivated area to more than one-half. But water is costly resource and its efficient use means bringing additional area under irrigation without making extra investments **(Das, 2005)**.

Seedling(s) per hill is an important factor for the growth and yield of rice. Optimum population density and leaf area influences the availability of sunlight and nutrients for growth and development. Competition within the hill is an integral part of the physical environment and the competition by neighbors often create the complexity. **Obulamma *et al.* (2002)** recorded the highest grain yield, crop growth rate and net assimilation rate from one seedling hill^{-1}. **Panda *et al.* (1999)** found that grain yield was highest with 4 seedlings hill^{-1}. **Biswas and Salokhe (2001)** revealed similar yield of rice by planting 2-4 vegetative tillers per hill. Because of these conflicting reports about the effect of water level and population density on growth and yield of boro rice, a study has under taken with the following objectives to find out the effect of water level and seedling number hill^{-1}on growth and yield of boro rice, to identify the optimum water level and seedling(s)/hill for boro rice cultivation and to find out the water use efficiency.

MATERIALS AND METHODS

The experiment was carried out in split-plot design with 3 replications having two levels of water in main plot and 4 levels of seedling number hill^{-1} in the sub plot. There were 8 treatment combinations. The total numbers of unit plots were 24. The size of unit plot is 5 m x 3 m. The distances between plot to plot and replication to replication were 1 and 1.5 m respectively. The water levels were continuous saturated (S_1) & continuous submerged (S_2) condition as well as seedling numbers were 1 (T_1), 2 (T_2), 3 (T_3) & 4 (T_4) seedlings hill^{-1}. At the time of first ploughing cowdung at the rate of 10 t ha^{-1} was applied. The experimental area was fertilized with 120, 80, 80, 20 and 5 kg ha^{-1} N, P_2O_5, K_2O, S and Zn in the form of urea, triple superphosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate respectively. The entire amounts of triple superphosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate were applied at final land preparation. The first one-third urea was top dressed at 7 days after transplanting (DAT). The rest of urea was top dressed in three equal splits- one at 23 days after transplanting (DAT), second at 38 days after transplanting (DAT), and the other at panicle initiation stage (52 DAT).

Two sets of treatments included in the experiment were as follows:

A. Irrigation water levels (2): S_1= Saturated (No deficit or stagnation of water) and S_2= Submerged (Continuous 2-5 cm standing water)

B. Seedling(s) number hill^{-1} (4): T_1= 1 seedling hill^{-1}, T2= 2 seedlings hill^{-1} ,T_3= 3 seedlings hill^{-1} and T_4= 4 seedlings hill^{-1}

Recording of data of Crop growth characters: Plant height (cm) at 15 days interval, Number of tillers hill^{-1} at 15 days interval, Leaf area index at 15 days interval and Dry weight of plant at 30 days interval and Time of flowering.

The data collected on different parameters were statistically analyzed to obtain the level of significance using the IRRISTAT (Version 7.2, IRRI, Philippines) computer package program developed by IRRI. The mean differences among the treatments were compared by least significant difference test at 5% level of significance.

RESULTS AND DISCUSSION

Plant height at different days after transplanting

Effect of water level

The plant height of boro rice was significantly influenced by water levels at 15, 45, 60 & 75 days after transplanting (DAT) and at harvest, but it was insignificant at 30 days after transplanting (Table 1). The results revealed that at 15 DAT, the tallest plant (24.98 cm) was obtained from continuous submergence (2-5cm standing water) and the shortest plant (20.20 cm) was at continuous saturation. At 30 DAT, there was no significant difference in plant height due to water levels was observed. The tallest plant height (72.81cm) was recorded at 45 DAT maintaining water continuously submergence followed by irrigation applied at saturated condition. Similar trend of plant height was observed at 60 & 75 DAT and even at harvest. At harvest, the tallest plant height was 109.88 cm and the shortest plant height was 105.10 cm. These results were agreement with the findings of **Cruj *et al.* (1975)** who concluded that plant height was greater under submerged condition than other treatments. Decreased plant height in saturated condition might be due to enormous weeds which suppressed plant growth and development and such trend was higher at early stage due to highest infestation of weed as suggested by **Reddy and Raju (1987)**.

Effect of seedling numbers hill^{-1}

Number of seedlings hill^{-1} had no significant effect on plant height (Table 1). Plant height was unaffected by the different number of seedlings hill^{-1} at 15, 30, 45, 60 & 75 DAT and even at harvest. At harvest, the tallest plant (108.32 cm) was obtained from 4 seedlings hill^{-1} and the shortest plant (106.70 cm) was obtained from 1 seedling hill. The result was similar to the findings of **Zhang and Huang (1990), Shrirame *et al.* (2000) & Hushine (2004)** who reported that plant height was not significantly affected by seedlings per hill. The result was conflict with that of **Miah *et al.* (2004)** who stated that plant height increased with decrease in seedling number hill^{-1}.

Table1. Influence of water level, seedling number hill^{-1} and their interaction on plant height of boro rice

Treatment	Plant height (cm) at different days after transplanting					
	15	30	45	60	75	At harvest
Water level						
S_1	20.20	40.11	63.56	77.25	99.69	105.10
S_1	24.98	45.13	72.81	85.94	106.65	109.88
LSD (0.05)	4.64	ns	5.62	4.88	3.96	2.63
Seedling numbers hill^{-1}						
T_1	23.05	42.43	67.13	81.35	103.24	106.70
T_2	23.70	42.95	70.78	83.27	103.33	107.15
T_3	23.28	44.07	67.86	81.18	103.30	107.78
T_4	20.32	41.02	66.96	80.59	102.81	108.32
LSD (0.05)	ns	ns	ns	ns	ns	ns
Interaction of water level and seedling number hill^{-1}						
S_1 T_1	20.83	40.60	62.00	76.27	99.64	104.03
S_1 T_2	21.20	40.10	67.70	78.70	99.08	103.43
S_1 T_3	21.83	42.17	64.07	77.80	101.43	107.13
S_1 T_4	16.93	37.57	60.47	76.23	98.58	105.80
S_2 T_1	25.27	44.27	72.27	86.43	106.83	109.37
S_2 T_2	26.20	45.80	73.87	87.83	107.57	110.87
S_2 T_3	24.73	45.97	71.64	84.57	105.17	108.43
S_2 T_4	23.70	44.47	73.45	84.94	107.03	110.83
LSD (0.05)	ns	ns	11.25	9.75	7.91	5.26
CV (%)	23.1	13.4	9.3	6.7	4.3	2.7

S_1= Saturated (No deficit or stagnation of water), S_2= Submerged (Continuous 2-5 cm standing water), T_1= 1 seedling hill^{-1}, T_2= 2 seedlings hill^{-1}, T_3= 3 seedlings hill^{-1}, T_4= 4 seedlings hill^{-1}

Interaction effect of water level and seedlings number hill^{-1}

There was a significant variation in plant height observed due to interaction between water level and population density at 45, 60, 75 DAT and at harvest but insignificant at 15 and 30 DAT (Table 1). At 45 DAT, the longest plant was obtained in continuous submergence with 2 seedlings hill^{-1} (73.87 cm) which was statistically similar with the interaction of continuous submergence and 4 seedlings hill^{-1}(73.45 cm). The similar plant height was recorded with transplanting 2 or 3 seedlings hill^{-1} irrespective of their water levels. The shortest plant height (60.47 cm) was observed when 4 seedlings hill^{-1} was planted at saturated condition. At 60 DAT, the tallest plant (87.83cm) was recorded at submerged condition having 2 seedlings hill^{-1} that followed by same water level with 1 seedling hill^{-1}. The shortest plant height (76.23 cm) was obtained by continuous saturation and 4 seedlings hill^{-1} which was statistically similar to continuous saturation with 1 seedling hill^{-1}. At 75 DAT, the longest plant was obtained from continuous submergence with 2 seedlings hill^{-1} (107.57 cm) that followed by continuous submergence and 4 seedlings hill^{-1} and the shortest plant (98.58 cm) was obtained in saturated condition with 4 seedlings hill^{-1}. At harvest longest plant height (110.87 cm) was recorded at submergence condition with 2 seedlings hill^{-1} which was similar to continuous submergence with 1 and 4 seedlings hill^{-1}. The intermediate plant height was obtained by 3 seedlings hill^{-1} irrespective of water levels and also in continuous saturation with 4 seedlings hill^{-1}. The shortest plant height (103.43 cm) was recorded in continuous saturation and 2 seedling hill^{-1} which was statistically similar to saturated condition with 1 seedlings hill^{-1}. From the findings of experimental result it is apparent that planting of 2 seedlings hill^{-1} at submerged condition showed significantly highest plant height from 45 days after transplanting to harvest.

Number of tiller hill^{-1} at different days after transplanting

Effect of water level

The production of total tiller hill^{-1} was significantly influenced by water level at 30, 45, 75 days after transplanting and at harvest but insignificant at 15 and 60 days after transplanting (Table 2). At 30 days after transplanting, significantly maximum number (16.26) of tillers hill^{-1} was recorded from continuous (3-5 cm) standing water and the minimum number (12.28) observed in saturated condition. At 45 days after transplanting, maximum (21.07) and minimum (18.80) number of tiller was observed from submerged and saturated condition respectively. The highest number of tiller hill^{-1} was counted in this stage comparing the entire growing period. Such opinion was also given by **Biswas (2001)** who mentioned that tillering in rice increases up to 30 to 40 days after transplanting depending upon the age of seedlings and tillering ability of rice variety. Statistically maximum (17.34) and minimum (15.78) tillers hill^{-1} at 75 DAT was recorded under submerged and saturated condition, respectively. At harvest, significantly higher (14.78) number of tiller hill^{-1}was counted at irrigation applied in continuous standing (3-5 cm) water and lower (13.39) number was at saturated condition. The percent variation of tillers number hill^{-1} at submerged condition over saturated condition was 10.00% over the minimum. This result was in agreement with the findings of **Islam (1997)** who showed that in submergence condition 7.06 % more tiller was produced over saturated condition. Tiller mortality from maximum vegetative stage (45 DAT) to harvesting was 29.00% and 30.00% under saturated and submerged condition respectively.

Effect of seedlings number hill^{-1}

Tiller number hill^{-1} was significantly influenced by the different number of seedlings hill^{-1} at 15, 30, 45, 60 and 75 DAT but insignificant at harvest (Table 2). At 15 DAT, the highest number of tillers hill^{-1} (4.58) was recorded with transplanting 4 seedlings hill^{-1} which was statistically similar (4.07) to 3 seedlings hill^{-1} and the lowest number (1.98) was in 1 seedling hill^{-1} which was statistically similar to 2 seedlings hill^{-1}. At 30 DAT, maximum number of tillers hill^{-1} was counted with transplanting 4 seedlings hill^{-1} (16.22) and it was followed by transplanting 3 and 2 seedlings hill^{-1} and minimum number of tillers hill^{-1} (11.57) was counted with transplanting 1 seedling hill^{-1}. At 45 DAT, the maximum number of tillers hill^{-1} (21.45) was obtained with transplanting 4 seedlings hill^{-1} which was statistically similar to 2 seedlings hill^{-1} (20.75) and 3 seedlings hill^{-1} (19.68). The minimum number of tillers hill^{-1} (17.85) was obtained at 1 seedling hill^{-1}. The similar trend of tiller production was also observed at 60 and 75 DAT.

Interaction effect of water levels and seedling numbers hill^{-1}

Tiller number hill^{-1} was significantly influenced by the interaction effect between water level and seedling numbers hill^{-1} at 15, 30, 60 and 75 DAT but insignificant at harvest (Table 2). At 15 DAT, the maximum number of tillers hill^{-1} (4.97) was obtained from continuous submergence with 4 seedlings hill^{-1} which was followed by 3 and 4 seedlings hill^{-1} at continuous saturated condition. At 30 DAT, the magnitude of tiller production was to some extent changed where the highest number of tillers hill^{-1} (18.67) was counted at submerged condition with 4 seedlings hill^{-1} which was similar to continuous submergence with 3 seedlings hill^{-1} (17.10) and 2 seedlings hill^{-1} (16.30) along with saturated conditions having 3 to 4 seedlings hill^{-1}. At 45 DAT, maximum number of tillers hill^{-1} (22.40) was obtained with 2 to 4 seedlings per hill^{-1} irrespective of their water levels and the minimum number of tillers hill^{-1} (16.53) was recorded at saturated condition with 1 seedling hill^{-1}. Similar trend was also continued at 60 and 75 DAT where 4 seedlings hill^{-1} revealed higher tiller production that followed up to 2 seedlings hill^{-1} both the water levels. At harvest, no significance variation was recorded in tiller production due to variation of water level and seedlings number hill^{-1}.

Table 2. Influence of water level, seedling number hill^{-1} and their interaction on tiller numbers hill^{-1} of boro rice.

Treatment	Tiller number hill^{-1} at different days after transplanting					
	15	30	45	60	75	At harvest
Water level						
S_1	3.32	12.28	18.80	17.51	15.78	13.39
S_1	3.26	16.26	21.07	18.56	17.34	14.78
LSD(0.05)	ns	2.51	1.59	ns	1.28	1.11
Seedling number hill^{-1}						
T_1	1.98	11.57	17.85	16.65	15.28	13.62
T_2	2.52	13.48	20.75	18.33	17.25	14.30
T_3	4.07	15.82	19.68	17.72	16.35	13.92
T_4	4.58	16.22	21.45	19.43	17.67	14.50

LSD (0.05)	0.91	3.55	2.24	1.91	1.82	**ns**
Interaction of water level and seedling number hill^{-1}						
S_1 T_1	2.17	10.17	16.53	16.23	14.83	13.03
S_1 T_2	2.40	10.67	19.33	17.80	16.70	13.47
S_1 T_3	4.50	14.53	18.83	17.43	15.40	13.23
S_1 T_4	4.20	13.77	20.50	18.57	16.20	13.83
S_2 T_1	1.80	12.97	19.17	17.07	15.73	14.20
S_2 T_2	2.63	16.30	22.17	18.87	17.80	15.13
S_2 T_3	3.63	17.10	20.53	18.00	17.30	14.60
S_2 T_4	4.97	18.67	22.40	20.30	18.53	15.16
LSD(0.05)	1.28	5.02	3.17	2.71	2.57	ns
CV (%)	21.9	19.8	9.0	8.4	8.7	8.9

S_1= Saturated (No deficit or stagnation of water), S_2= Submerged (Continuous 2-5 cm standing water), T_1= 1 seedling hill^{-1}, T_2= 2 seedlings hill^{-1}, T_3= 3 seedlings hill^{-1}, T_4= 4 seedlings hill^{-1}

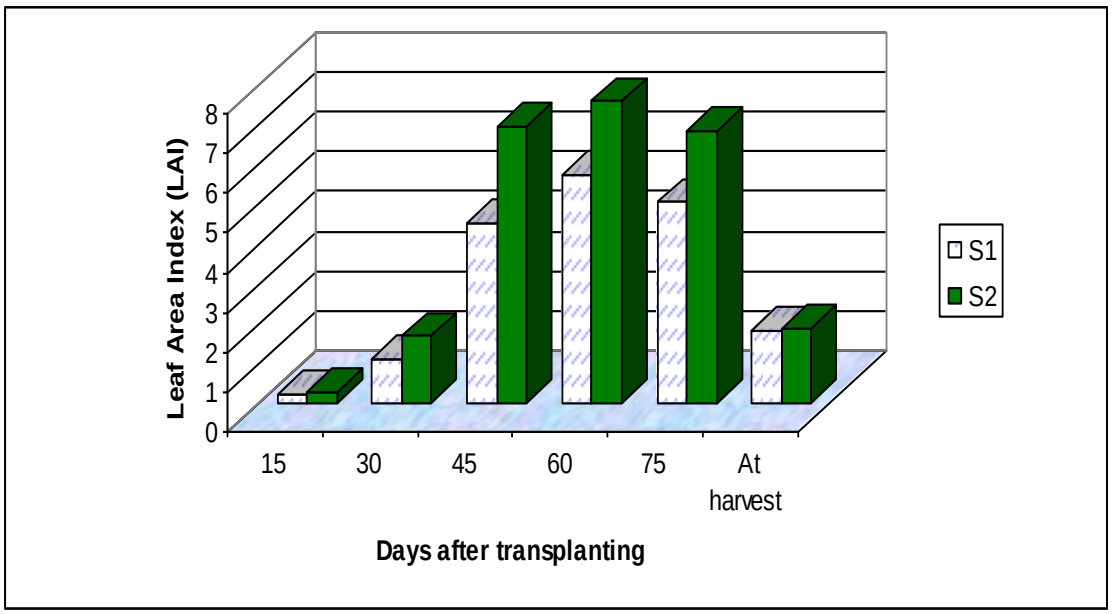

Figure 1: Influence of water level on leaf area index of boro rice at different days after transplanting

Leaf area index (LAI) at different days after transplanting

The leaf area of plant is one of the major determinants of its growth. The net dry matter production by a plant in an interval time is more dependent on the size of its total assimilating system than on the photosynthetic rate of a single leaf which is just-one of the parameters determining the total photosynthetic production of the crop.

Effect of water level

Leaf area index (LAI) of boro rice was significantly influenced by the treatment of water level at 30, 45, 60, and 75 days after transplanting but insignificant at 15 days after transplanting and at harvest. At 30 DAT, significantly higher (1.70) LAI was recorded in continuous standing (3-5 cm) water and lower (1.13) was at saturated condition. Significantly maximum (6.95) and minimum (4.54) LAI at 45 DAT was observed from submerged and saturated condition respectively. Leaf area index (LAI) increased up to 60 DAT and decreased thereafter for both the water levels (Figure 1**).** This result agreed with **Tanaka (1976), Amano *et al.* (1993) and Faruque (1996)** who showed that leaf area index (LAI) was maximum in heading stage (61 DAT) and then decreased. At 60 DAT, significantly higher (7.57) and lower (5.72) LAI was found under submerged and saturated condition respectively.

At 75 DAT, similar trend was found where higher (6.82) LAI was observed in continuous submergence and lower (5.04) LAI was at saturated condition. Increasing leaf area index from initial stage to 60 DAT was associated with tillering, increased leaf number and leaf size. The decline of LAI due to senescence of leaves in succession

proceeded from the base of the stem upward. The higher leaf number and large leaf size might have caused increased rate of production of leaves from each growing points which was dependent on water supply.

Effect of seedling number hill^{-1}

Leaf area index (LAI) was significantly influenced seedling numbers hill^{-1} at 15, 30 and 45 DAT but insignificant at 60, 75 DAT and at harvest. The diagrammatic representation of the data on leaf area index has been given in a linear graph (Figure 2). At 15 DAT, maximum leaf area index (0.35) was obtained from 4 seedlings hill^{-1} which was similar to 3 seedlings hill^{-1} (0.33) that followed by 2 seedlings hill^{-1}(0.23). Minimum leaf area index (1.16) was counted at single seedling hill^{-1} (0.16) which was similar to 2 seedlings hill^{-1}. The similar trend was also continued up to 45 DAT where single seedling showed significantly lowest LAI. At 30 DAT, statistically maximum LAI was recorded from 3 seedlings hill^{-1}(1.69) which was similar to 2 & 4 seedlings hill^{-1}.The findings are agreement with **Miah *et al.* (2004) and Obulamma *et al.* (2002)** who stated highest LAI at 4 and 3 seedlings hill^{-1} respectively whereas **Shrirame *et al.* (2000)** recorded no significant difference of LAI among 1, 2, and 3 seedlings hill^{-1}.

Table 3. Interaction effect of water level and seedling number hill^{-1} on leaf area index of boro rice at different days after transplanting

Treatments	Leaf area index at different days after transplanting					
	15	30	45	60	75	At harvest
$S_1 T_1$	0.16	0.85	4.15	5.02	4.68	1.69
$S_1 T_2$	0.23	1.20	4.81	5.56	5.09	1.96
$S_1 T_3$	0.30	1.43	4.52	6.04	4.95	1.75
$S_1 T_4$	0.30	1.03	4.66	6.28	5.44	1.93
$S_2 T_1$	0.16	1.24	6.11	6.98	6.75	1.89
$S_2 T_2$	0.24	1.64	7.61	8.37	7.41	1.91
$S_2 T_3$	0.37	1.94	6.32	6.74	6.14	1.88
$S_2 T_4$	0.40	1.98	7.74	8.21	6.99	1.92
LSD (0.05)	0.20	0.83	1.26	1.92	1.24	ns
CV (%)	40.9	33.1	12.4	16.2	11.8	11.6

S_1= Saturated (No deficit or stagnation of water), S_2= Submerged (Continuous 2-5 cm standing water), T_1= 1 seedling hill^{-1}, T_2= 2 seedlings hill^{-1}, T_3= 3 seedlings hill^{-1}, T_4= 4 seedlings hill^{-1}

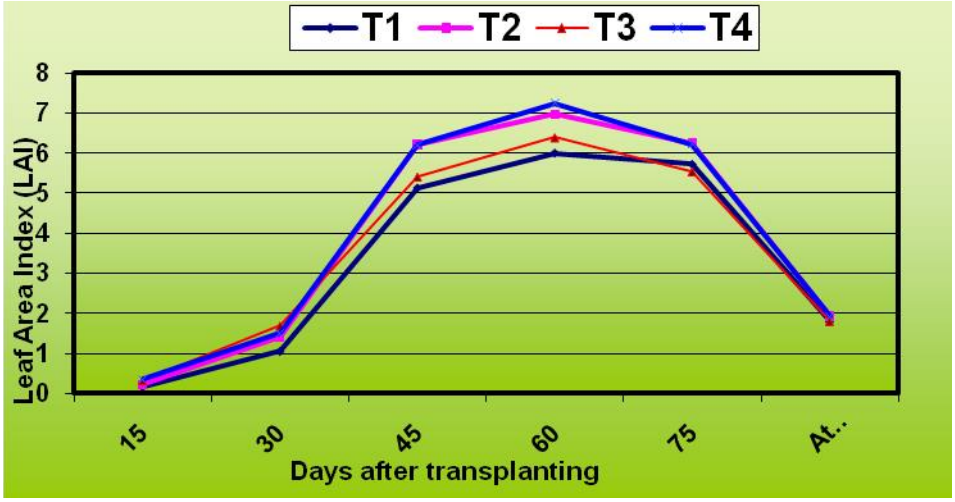

Figure 2. Changes in leaf area index of boro rice as influenced by varying population density

Interaction effect of water levels and seedlings number hill^{-1}

Leaf area index or boro rice was significantly influenced by the interaction between water levels and seedlings number hill^{-1} at 15, 30, 45, 60, 75 DAT but insignificant at harvest (Table 3).

At 15 DAT, Maximum LAI was obtained at continuous submergence having 4 seedlings hill^{-1} (0.40) which was similar to submerged condition having 2 & 3 seedlings hill^{-1} along with saturated condition having 2 to 4 seedlings hill^{-1}. Minimum LAI was recorded with single seedling hill^{-1} irrespective of their water levels. At 30 DAT,

the maximum LAI (1.98) was obtained at continuous submergence with 4 seedlings hill^{-1} which was similar to submerged condition with any seedlings number hill^{-1} along with saturated condition having 2 & 3 seedlings hill^{-1} LAI. Minimum LAI was recorded under continuous saturation with 1 & 4 seedling.

The findings also indicated that interaction effect of continuous saturation having sigle seedling hill^{-1} gave significantly minimum LAI up to 75 DAT. At 45 DAT, the highest LAI was produced from interaction effect between submerged condition and 4 seedlings hill^{-1} (7.74) which was statistically similar to same water level having 2 seedlings hill^{-1} (7.61) and the lowest value of LAI was counted at continuous saturated condition with any population density. At 60 DAT, the trend of LAI was some extend changed in which maximum LAI was observed at submerged condition with 2 seedlings hill^{-1} which was statistically similar with interaction effect of continuous submergence with 4 seedlings hill^{-1}. This trend was also observed at 75 DAT, where 2 seedlings hill^{-1} at continuous submergence showed upper value of LAI (7.41).

Dry matter production

Effect of water level

The dry matter production of different plant part at harvesting time was recorded in which only dry weight of leaf was statistically influenced by water levels. The dry matter production of different plant part always higher at submerged condition compared to saturated condition (Figure 3).

Significantly maximum (10.21g) and minimum (7.55 g) dry weight of leaf was counted under continuous submerged and saturated condition respectively. **Jayasankar *et al.* (1993)** also revealed that the specific leaf weight increased when the plants were subjects to submergence treatment.

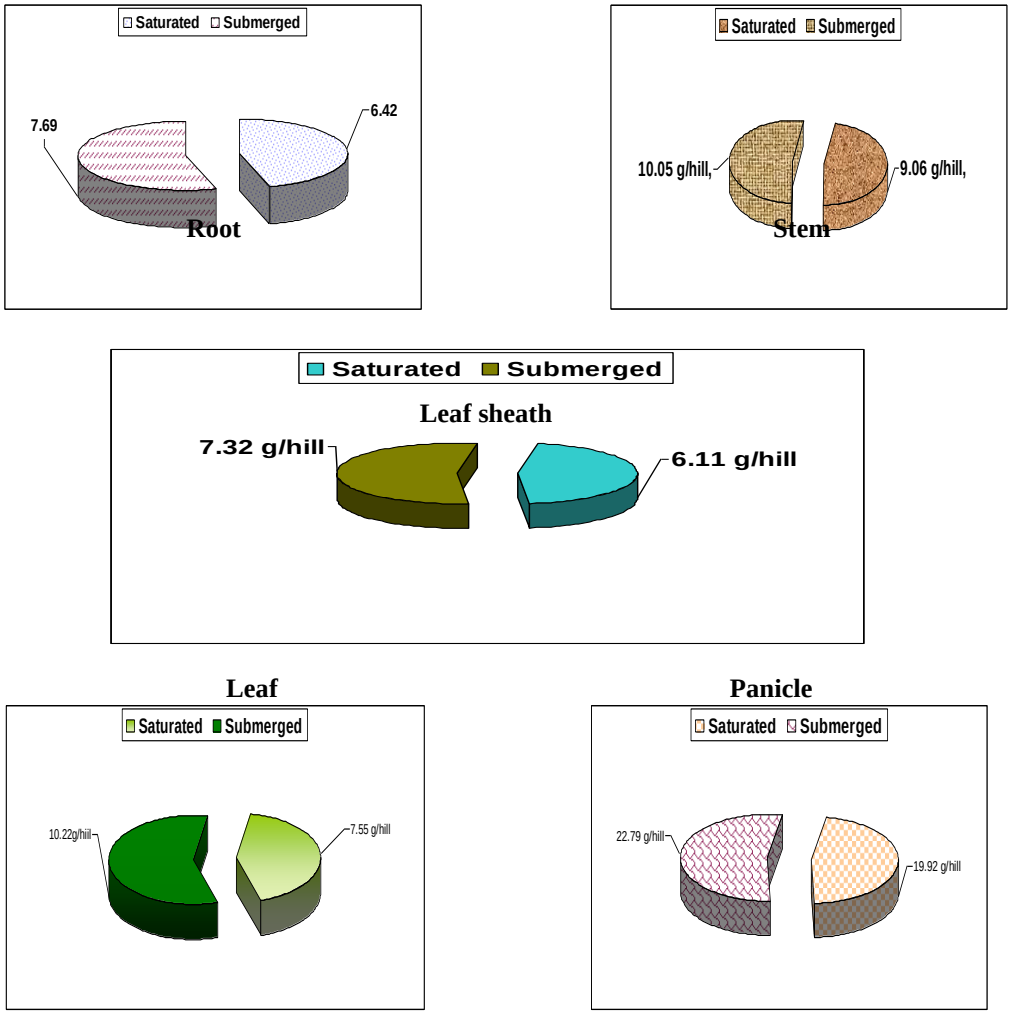

Figure 3. Influence of water level on dry matter production of different plant parts at harvest

Effect of seedling number hill^{-1}

Dry matter production was not significantly influenced by different seedling number hill^{-1} at 30 & 60 DAT and at harvest (Table 4) Dry matter partitioning of root, stem, leaf sheath, leaf and also panicle of boro rice also showed non-significant at harvest (Table 4) The result was contrary with **Miah *et al.* (2004), Obulamma *et al.* (2002)** who showed that total dry matter increased significantly with increased seedlings number hill^{-1}.

Table 4. Influence of seedling number hill^{-1} on dry matter partitioning of boro rice at harvest

Treatment	Dry weight, g/hill				
	Root	Stem	Leaf sheath	Leaf	Panicle
1 Seedling hill^{-1}	6.91	9.45	7.08	8.92	22.71
2 Seedlings hill^{-1}	7.50	9.21	5.62	8.96	21.57
3 Seedlings hill^{-1}	7.52	8.99	7.71	8.22	21.68
4 Seedlings hill^{-1}	6.84	10.58	6.46	9.43	19.46
LSD (0.05)	ns	ns	ns	ns	ns
CV (%)	42.7	29.0	33.7	22.5	18.7

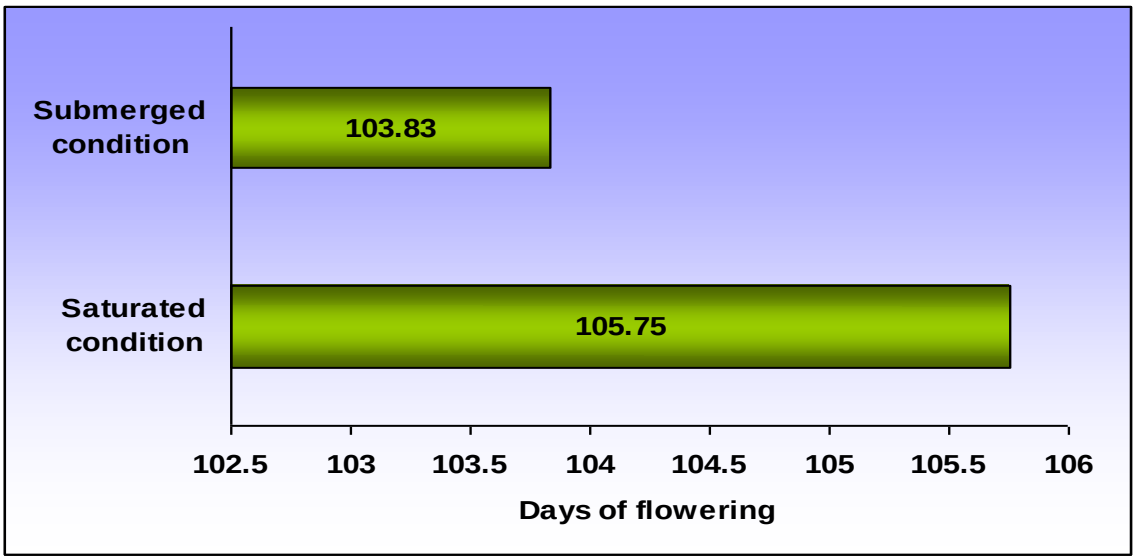

Figure 4. Duration of flowering as influenced by water level

Time of flowering

Effect of water level

Days to flowering was significantly influenced by water levels. Duration of flowering was earlier (103.83 DAT) at submerged condition whereas maximum duration (105.75 DAT) was taken at continuous saturated condition (Figure 4).

Effect of seedling number hill^{-1}

Duration to flowering was not significantly influenced due to different seedling numbers hill^{-1}. The days required to flower production at 1, 2, 3 and 4 seedlings hill^{-1} was 105.67, 104.33, 104.33 and 104.83 respectively (Figure 5). The result was in agreement with **Biswas (2001)** who observed similar duration to flower production with transplanting different number of clonal tiller hill^{-1}.

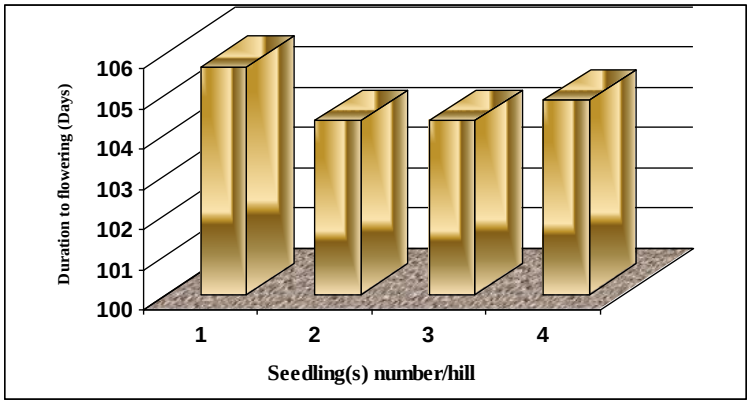

Figure 5 Duration to flower production as influenced by population density

CONCLUSIONS

From the overall results it may be concluded that transplanting of younger seedlings in combination with intermittent submerge performed the best in tiller production, growth dynamics, yield contributing characters and produced more productive tillers hill^{-1}. Intermittent submerge was suitable for exploring the physiological potentials of rice seedlings on effective tillers for increasing grain yield.

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