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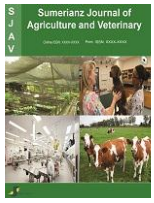

Original Article Open Access

Growth of Ichiban Boshi Rice Variety for Different Number of Seedlings Per Hill

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Abstract

One of the major constraints in the rice production for many African countries is the use of incorrect number of seedlings per hill. For example, in Tanzania, Uganda and Malawi; different plant numbers per hill are planted, calling the need to establish the common optimum number that will be recommended to farmers. In this study, three different numbers of seedlings per hill were planted; 2 seedlings per hill, 4 seedlings per hill and 8 seedlings per hill to assess their growth performance for plant height, number of tillers per hill and nitrogen content using leaf colour chart. Generally, the results did not show great variations for plant height, number of tiller per hill and leaf colour chart values in all treatments. However, the value of plant height and number of tiller per hill during early growth phases and that of leaf colour chart at late growth phase were significant higher ($p<0.05$) for 8 seedlings per hill compared to 2 seedlings per hill and 4 seedlings per hill. Therefore, planting 8 seedlings per hill led to irregular growth pattern which might have undesirable effect in rice yield. On the other hand, 2 seedlings per hill proved optimal for all the growth parameters observed.
Keywords: Rice; Seedlings; Plant height; Tillers; Ichiban boshi.

1. Introduction

Rice (*Oryza sativa* L.) is widely grown crop worldwide. Over 50% of the world population consumes rice as their main staple food. In many African countries such as eastern and central Africa however, the demand for the crop is by far above the production [1]. In countries like Tanzania, Uganda and Malawi the deficient is attributed to low yield. The challenge is attributed to low usage of inputs, pest and diseases and in large extent incorrect number of plants per hill (population density).

Planting density of a crop affects the interception of solar radiation, crop canopy coverage, dry matter accumulation and crop growth rate. The closer seedlings planting causes competition among plants for light, water, and nutrients which consequently slow down growth as well as the grain yield. Optimum number of planting ensures the proper growth of aerial as well as underground plant parts by efficient utilization of solar radiation, nutrients and water. Moreover, the tillering habit and formation of spikelets per panicle also is influenced by the planting density, which is responsible for the yield of rice per unit area, Mahato and Adhikari [2].

So, different approaches currently are being applied to tackle the problem of incorrect number of seedlings per hill. For instance, some governments have recommended a system of rice intensification (SRI) but adoption rate by small holder farmers is low. Moreover, some researchers have reported insignificant gains in yield during applying SRI [3]. In Tanzania and Malawi the SRI has been characterized with increased yield over the conventional methods. In addition some studies suggest less spacing could have more yield and therefore more researches are recommended in adopting proper seedlings spacing in SRI [4].

Similarly, application of the SRI has not been uniform in different countries leading to variations in yield realized. Both Eastern and central African countries recommend spacing of 30 cm by 15 cm. Nevertheless in Malawi single seed planting is promoted while in other countries more seedlings per hill are encouraged claiming high mortality rate in using a single seed per hill. For the east and central African countries, it remains unclear as to how many seedlings per hill would be recommended to optimize growth and yield while reducing labor intensiveness.

This work is aimed at contributing to the availability of data in the area through establishing optimum number of seedlings per hill to optimize growth thereby increasing yield while reducing labor intensiveness.

2. Material and Method

2.1. Description of the Experimental Site

A field experiment was conducted during the rice growing season of 2019 at Tsukuba International Center (TBIC), JICA JAPAN from April to August 2019 under irrigated condition. The experimental site was geographically situated at an altitude of 17.98 m above mean sea level, on latitude 36°1'45.19"N and longitude 140°7'40.98"E at A-1-4 paddy field area. The soil as analyzed in laboratory was found to be clay loam in texture,

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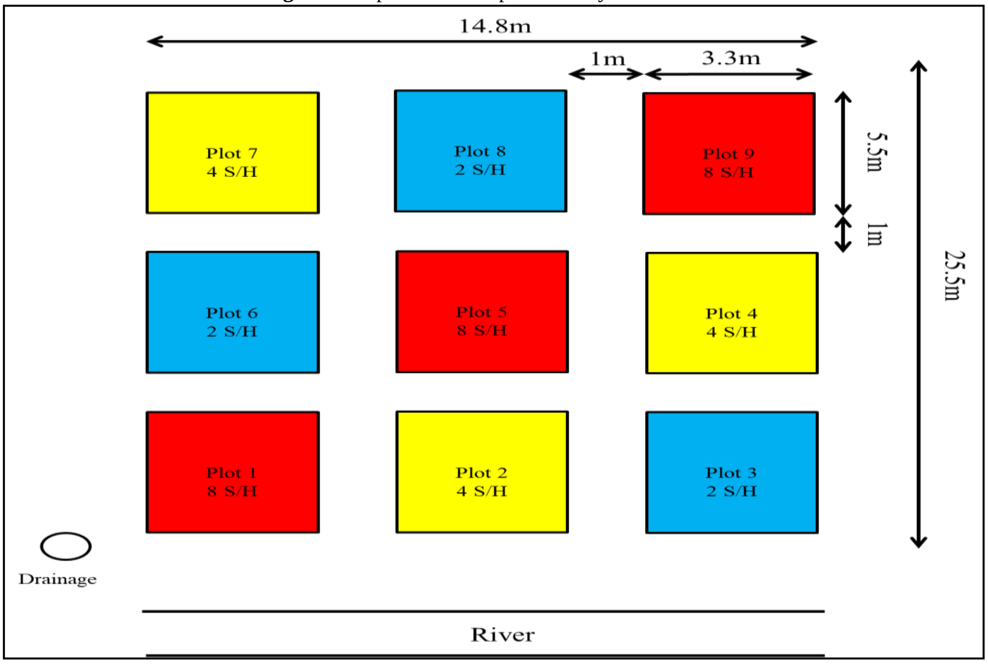
with a pH level of 5.7. The soil had total N of 5.28g kg^{-1}, available P of 615mg kg^{-1} and exchangeable potassium of 0.399 kg^{-1}.

2.2. Experimental Design

Three treatments viz; two seedlings per hill (2 S/H), four seedlings per hill (4 S/H) and eight seedlings per hill (8 S/H) were allocated in different plots in three replications using Randomized Complete Block Design (RCBD) as shown in Fig. 1. Each plot covered an area of $18.15m^2$, hence eleven rows per each.

Figure-1. Experimental map of field layout in RCBD



2.3. Seed Selection, Treatment and Pre-Germination

One japonica rice variety, ichiban boshi was selected. Seeds were obtained from Tsukuba International Center (TBIC) which originally secured them from Ibaraki Prefecture Experimental Station. Initially seeds were selected using salt water with specific gravity of 1.13 g/cm^3 so as to maintain uniform germination. Salt selected seeds after thoroughly washed with fresh water were disinfected by dipping them in Benlate-T (20% thirum and 20% benomyl) fungicide for 24 hours. The disinfected seeds were dried for 24 hours and then soaked in water for 7 days at temperature 17^oC for pre germination.

2.4. Raising Seedlings in Nursery

Nursery boxes were used for raising seedlings. The commercial soil was disinfected using Tachigare Ace (30.0% hydroxyisoxazole) fungicide before filling in the nursery boxes. The soil was watered before sowing, thereafter; 50g of pre-germinated seeds were sown in each box on 3rd May 2019. The seeds then were covered with by a small quantity of that soil. The nursery boxes were maintained in the net house where they were covered by a thin plastic sheet during night time to warm up temperature. The plastic sheet was removed during day time to allow sees/seedlings get enough sunlight. All of these were done to produce uniform growth and health seedlings. One week before transplanting the plastic sheet was completely removed to harden the seedlings until transplanting time. Few hours before transplanting, the seedlings were treated with V-Get admire (2% Imidacloprid, 12% Tiadinil) to control pests and diseases.

2.5. Field Preparation and Transplanting

Experimental field was plowed, tilled, puddled and leveled by a tractor. Seedlings of about five leaves age (4.5) were transplanted manually on 22nd May 2019 in well watered plots at 30 cm x 15 cm spacing in straight rows.

2.6. Fertilizer Application

Analysis of soil fertility in the experimental field showed good fertility and hence no need for basal application. Top dressing of fertilizer in form of N.P.K. (17:0:17) at the rate of 70kg/ha for each of N and K was applied in two splits; first 40kg/ha at 15 days after transplanting (15 DAT) and the remaining, during panicle initiation (PI).

2.7. Field Management

Weeding was done by both hand pulling and by herbicide application. Herbicide was applied on 8th July 2019 using HOKUTO granular (0.6% cyhalofop butyl, 1.5% pretilachor). Other management practices were followed as per TBIC recommendation.

2.8. Sampling and Data Collection

Random sample of six hills from each plot were selected for recording observations regarding to plant height (PH), number of tillers per hill (NTH) and leaf colour. All of these recordings were collected at about ten day's interval starting just tenth DAT and continued till after heading.

2.8.1. Plant Height (PH) in Cm

The height of the plant was obtained by measuring using meter ruler from the base of the hill to the highest leaf tip of the tallest tiller in a hill.

2.8.2. Number of Tillers per Hill (NTH)

Tillers were counted individually in a hill and total number of tillers was recorded in each hill.

2.8.3. Leaf Colour

Leaf colour was determined using standard colour chart (LCC); colour scale method developed by Fuji and commercialized by Fuji Film Co. 1980 [5].

2.9. Statistical Analysis

The data were statistically analyzed using analysis of variance (YAMADA ANOVA 10 software). Means for different traits were separated using least-significance difference (LSD) test at 5% probability level.

3. Results

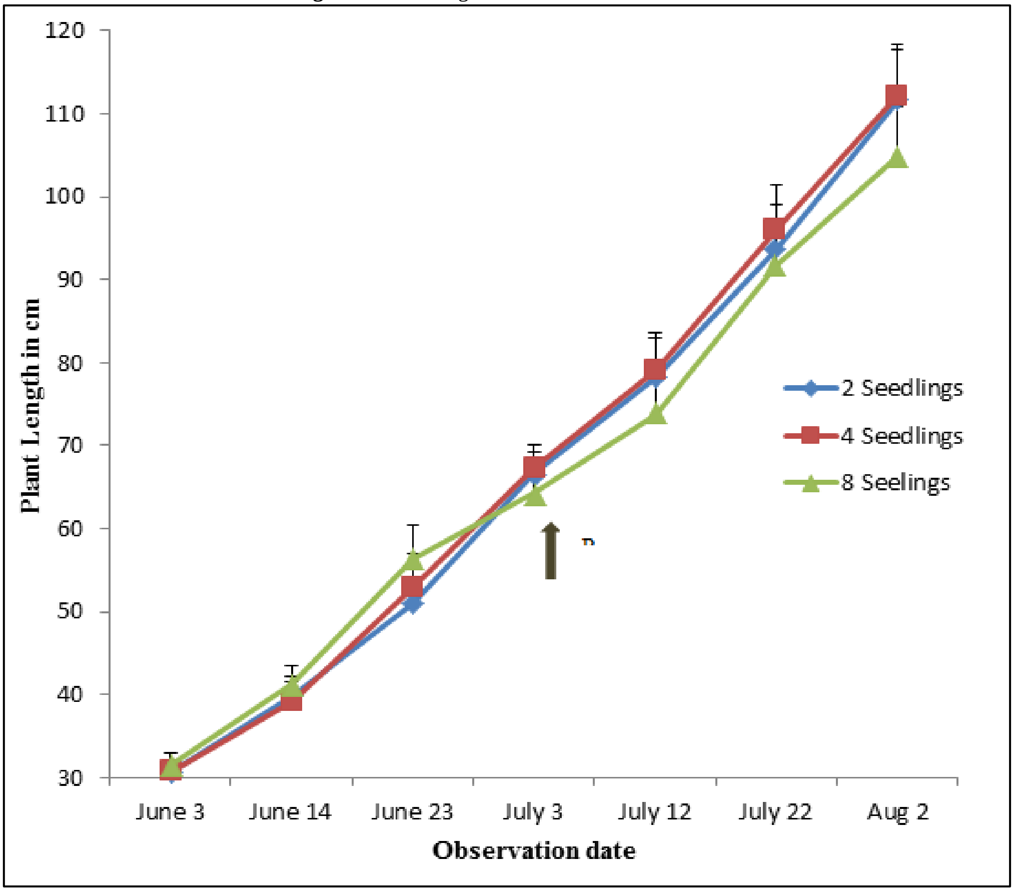
3.1. Plant Height in Cm (PH)

Data for plant height for all three treatments viz; 2 S/H, 4 S/H and 8 S/H are shown in table 1 and figure 2 below. The results revealed that the trend of growth showed no significant difference in plant height across all the treatments in all growth stages, except at 32 DAT (23rd June) where 8 S/H recorded significant ($p<0.05$) higher PH than 2 S/H only.

Table-1. Plant height for 2 S/H, 4 S/H and 8 S/H

Seedlings/hill	Plant length in cm						
	Jun-03	Jun-14	Jun-23	Jul-03	Jul-12	Jul-22	Aug-02
2 S/H	30.59	39.85	50.96	66.56	78.22	93.68	111.59
4 S/H	30.70	39.30	52.94	67.40	79.06	95.99	112.18
8 S/H	31.48	41.22	56.34	64.19	73.82	91.84	104.83

Figure-2. Plant height for 2 S/H, 4 S/H and 8 S/H



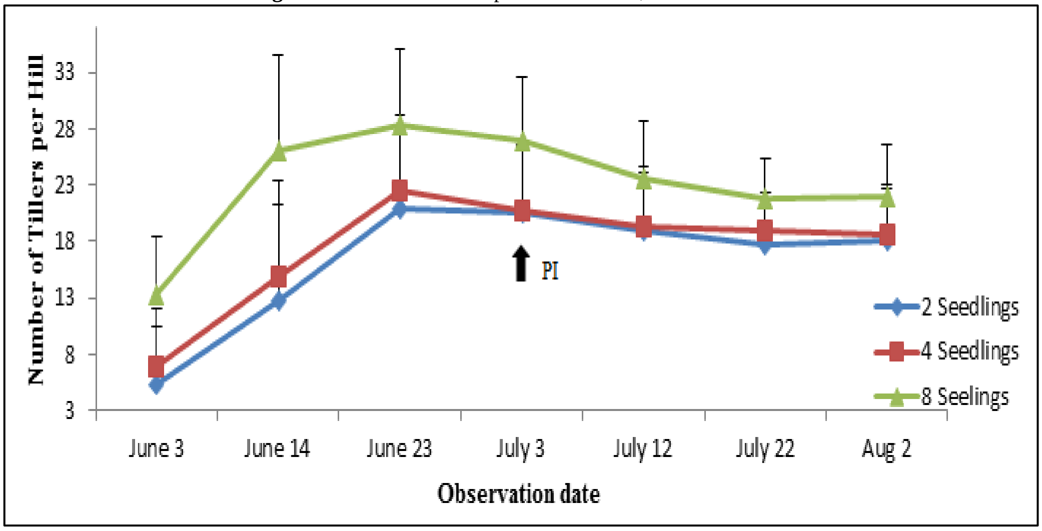
3.2. Number of Tillers per Hill (NTH)

Results of total number of tillers per hill for all three treatments viz; 2 S/H, 4 S/H and 8 S/H as shown in table 2 and figure 3 below indicated that, from the day of transplanting to 23 DAT, NTH for 8 S/H was significantly ($p<0.05$) higher compared to 4 S/H and 2 S/H. However, 42 DAT (panicle initiation) onward, there was no significant difference on NTH among all three treatments.

Table-2. Number of tillers per hill for 2 S/H, 4 S/H and 8 S/H

Seedlings/hill	Number of tillers per hill						
	Jun-03	Jun-14	Jun-23	Jul-03	Jul-12	Jul-22	Aug-02
2 S/H	5.28	12.72	20.89	20.61	18.94	17.78	18.06
4 S/H	6.89	14.83	22.44	20.72	19.39	18.94	18.56
8 S/H	13.28	26.11	28.39	26.89	23.50	21.83	22.00

Figure-3. Number of tillers per hill for 2 S/H, 4 S/H and 8 S/H



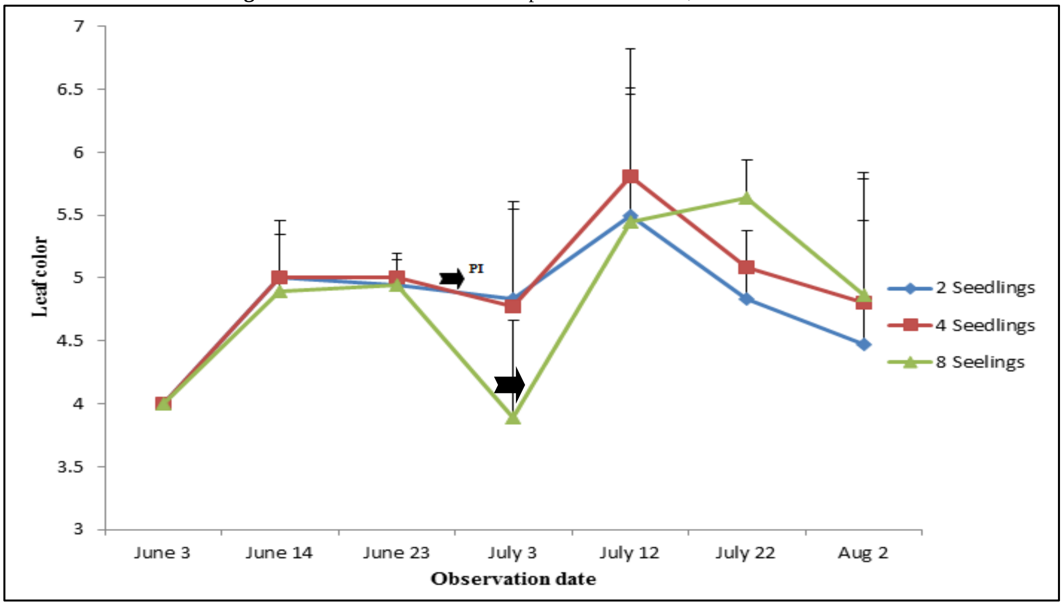
3.3. Leaf Colour as Determined by LCC

Table 3 and figure 4 shows records of leaf colour for 2 S/H, 4 S/H and 8 S/H. Values of LCC between all treatments did not show significant variations during early growth stages. However, the value for 8 S/H decreased sharply few days before PI and then showed steady increases during reproductive stage and attained significant ($p<0.05$) higher value during heading (61 DAT) and finally it declined in the same way as the rest of treatments.

Table-3. Leaf colour values for 2 S/H, 4 S/H and 8 S/H

Seedlings/hill	Leaf colour						
	Jun-03	Jun-14	Jun-23	Jul-03	Jul-12	Jul-22	Aug-02
2 S/H	4.0	5.0	5.0	4.8	5.5	4.8	4.5
4 S/H	4.0	5.0	5.0	4.8	5.8	5.1	4.8
8 S/H	4.0	4.9	5.0	3.9	5.4	5.6	4.9

Figure-4. Values for leaf colour as per LCC for 2 S/H, 4 S/H and 8 S/H



4. Discussion

4.1. Plant Length

The number of seedlings per hill has significant impact on plant height. Tamiru [6], reports the occurrence of tallest plants from 3 and 4 seedlings per hill over 2 seedlings per hill. The present study recorded significant ($p<0.05$) taller plants for 8 S/H over 2 S/H at 32 DAT. Similar results are reported by Mahato and Adhikari [2]. During this critical growth stage, light and nutrients competition might be the reason for the recorded higher PH in 8 S/H because of its high plant density; plants were competing in absorption of nutrients. The results further revealed that after top dressing (during panicle initiation) onward, no significant difference in PH was observed across all treatments indicating that the 8 S/H had absorbed enough nutrients for plant growth.

4.2. Number of Tillers per Hill

The average total number of tillers per hill for all three treatments increased sharply from transplanting up to 32 DAT, the time where maximum tillering was observed; thereafter it declined slightly in proceeding growth stages. The decreased NTH in late growth stages might be due to self thinning mechanism caused by nutrients and light competition. Similar results are reported by Sampath, *et al.* [7]. Initially, 8 S/H recorded significant ($p<0.05$) higher NTH than 2 S/H at 10 DAT. The results also showed that at 23 DAT, 8 S/H recorded significant ($p<0.05$) higher NTH than the rest of treatments. The significant higher value of NTH for 8 S/H in early growth ages (10 and 23 DAT) might be attributed to the higher number of seedlings per hill planted which contributed to high tillering proliferation in early growth stages. However, the results found no significant ($p>0.05$) difference on tiller numbers for all the treatments from 32 DAT onwards. This finding explains the fact that total NTH during reproductive stages is not determined by number of seedlings per hill transplanted.

4.3. Leaf Colour

Leaf colour as determined by LCC is direct proportional to chlorophyll content, total nitrogen content of rice plants as well as nitrogen concentration of leaf blades, [5]. The results of this study revealed that nitrogen content as indicated by LCC started increasing from transplanting up to maximum tillering stage (32 DAT) and then decreased up to PI for all treatments. Berhanu [8], reports similar trend of results. The increased value of LCC reading from transplanting up to maximum tillering might be caused by high rate of absorption of nitrogen fertilizer by the plants' roots. From maximum tillering to PI, most of the nitrogen fertilizer was already absorbed and utilized by plants and hence the value of LCC recorded decreased. During PI, top dressing of nitrogen fertilizer was applied and this might contributed to sharp increase of the value of LCC reading just 10 days after PI (Figure 4). LCC value started to further decrease after heading stage till ripening stage. This might be the period where most of the nitrogen applied by top dressing from PI has been absorbed by plants for reproduction. LCC for 8 S/H attained significant ($p<0.05$) higher value during heading (61 DAT) because in 8 S/H plants were competing in absorption of the scarce nitrogen. Despite of that trend, finally at late stages the value of LCC was not significant across all treatments.

5. Conclusion

Generally, the growth characteristics of Ichiban boshi rice variety as observed in this study did not show great variations for the variation of number of seedlings per hill (treatments). We observed 8 S/H to have significant ($p<0.05$) higher values of PH and NTH during early growth stages but not in late growth stages. In contrast, the values of LCC between all treatments did not show significant variations during early growth stages. Moreover, the LCC value for 8 S/H decreased sharply during PI and then showed steady increases during reproductive stage and attained significant ($p<0.05$) higher value during heading (61 DAT) before showing equal decreasing trends (Figure 4) with the rest of treatments at 72 DAT onward. Therefore, planting 2 S/H would be good option for farmers because it cut the cost of handling many seedlings, reduce labour intensiveness while having good growth performance.

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