International Journal of Agricultural Technology 2019 Vol. 15(1): 103-112
Available online http://www.ijat-aatsea.com
ISSN: 2630-0613 (Print) 2630-0192 (Online)

Effect of seedlings numbers per hill on the growth and yield of Kum Bangpra RiceVariety (*Oryza sativa* L.)

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Promsomboon, P., Sennoi, R., Puthmee, T., Marubodee, R., Ruanpan, W. and Promsomboon, S. (2019). Effect of seedlings number per hill on the growth and yield of Kum Bangpra rice variety (*Oryza sativa* L.). International Journal of Agricultural Technology 15(1): 103-112.

Abstract The influence of seedlings number per hill on the growth and yield of rice (*Oryza sativa* L.) Kum Bangpra rice variety was examined at the Plant Science Research Plots in Chonburi province, Thailand, during November 2016 to March 2017. The different treatments of transplanting were performed with the number of 1, 2, and 3 seedlings per hill and 30 x 30 cm spacing. Results revealed that transplanting with 3 seedlings compared with 1 and 2 seedlings per hill was significantly differed in plant height at the age of 15, 30 and 45 days after transplanting. At the age of 60 days, there was no statistical difference in plant height between transplanting with 2 and 3 seedlings per hill. The shortest plant was observed with 1 seedling per hill. In addition, at the age of 60 days, transplanting with 3 seedlings per hill produced the highest numbers of 21.33 tillers per hill, while 1 seedling per hill produced the lowest number of 12.28 tillers per hill, suggesting the highest tillering capacity of this variety at a ratio of 1:12 when transplanting with 1 seedling per hill. Yield components including number of panicles per hill, panicle length, number of filled grain per panicle, 100-grain weight, and width and length of un-husked grains showed no statistical difference. The filled grain weight per hill indicated that transplanting with 3 seedlings per hill produced maximum weight of 39.55 gm. per hill, while 1 seedling per hill produced minimum weight of 27.90 gm. per hill. As a result, highly statistically significant difference was observed in yield/Rai at 15% moisture; the highest yield per Rai was 703 kg with 3 seedlings per hill, and the lowest one was 496 kg with 1 seedling per hill. The current experiment therefore suggested that Kum Bangpra rice variety transplanted with 3 seedlings per hill was the most suitable to produce the highest yield.

Keywords: seedling per hill, rice, growth, yield

Introduction

Dark purple of pericarp is anthocyanin pigment. Cyanidin-3 -glucoside as anthocyanin is commonly found in rice. Anthocyanin is known for numerous

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health benefits with antioxidant activity to protect against the development of cancer cells and metabolic disorder (Guo *et al*., 2007). It also helps prevent allergies, diabetes heart disease, inflammatory bowel disease, as well as promotes vision health. Dark purple rice has thus now become one among health foods. Kum Bangpra rice variety used in this study was collected to include 100 panicles from farmer paddy fields in 2013 and later in the farming season of 2014 were planted in the exhibition plots of local rice varieties where a sample of 200 panicles were collected subsequent farming season of 2015, panicle to row, pure line selection was conducted to obtain 30 lines of dark purple pericarp rice. In 2016, a trial of these lines were undertaken in farmer paddy fields. Selection of the line with good agronomic characteristics and yielding stability was carried out until Kum Bangpra rice variety was obtained. The dominant traits of this variety include well adaptation and growth, standing hill, strong stem with approximately 130 cm high, and resistance to diseases and insects. With non-photosensitivity property, it can be grown either in-season or off-season and either in transplanting or upland condition, so it can be called "amphibious rice". Kum Bangpra rice variety is an early variety with 110 days of harvesting period and average yields of 600 kg/Rai. Un-husked grains when fully ripen are straw-colored, with long-slender shape. Its dark purple pericarp contains anthocyanin and gamma oryzanol, as well as many essential nutritious substances for health. Moreover, it can also be processed in a wide variety of products (Promsomboon and Promsomboon, 2016). Rice cultivation in Thailand was done with several methods but the most common methods at present are 1) direct seeding of germinated seed, and 2) transplanting. Rana *et.al.* (2014) examined the effect of planting methods on the yield of 3 rice varieties and found that direct seeding of sprouted seedling yielded better than transplanting, with an average yield of 710.50 kg and 673.20 kg, respectively. However, Javaid *et al.* (2012) reported that transplanting of IR6 rice variety produced higher yield of 801.60 kg compared with direct seeding of germinated seed yielding 556.8 kg. For transplanting method, seedling age, number of seedling per hill and spacing might affect rice yield and yield components differently for different varieties. The current research was therefore intended to determine the optimum number of seedling per hill for cultivating Kum Bangpra rice variety in transplanting condition in Thailand.

Materials and methods

The experiment was carried out at the plant science research plots in Chonburi province, Thailand, during November 2016 to March 2017. The experiment was conducted in a randomized complete block design (RCBD) with

2 repeated experiments, and included different treatments with the number of 1, 2, and 3 seedlings per hill, 30 x 30 cm. spacing with 4 replications, 12 hills per row, and 5 rows per 1 experimental unit. To prepare Kum Bangpra rice seedlings, the seeds were soaked in water for 12 hours, kept wrapped in shade for 24 hours, and were sown in the seedling plots. The 30 day seedlings were then removed and transplanted in the field. Fertilizers were applied including ammonium phosphate (16-20-0 formula) 20 kg/Rai, urea (46-0-0 formula) 10 kg/Rai at 15 and 35 days, respectively after transplantation. Weed control in the field was undertaken at 15 and 35 days, respectively after transplantation. Agronomic characteristics of rice were recorded using the method of Yoshida (1981) which included plant height. number of tillers per hill, number of panicles per hill, panicle length, number of filled grains per panicle, 100-seed weight, width and length of un-husked grain, filled grain weight per hill, and yield per Rai. The data were statistical computed analysis of variance and treatment means were compared using Duncan's Multiple Rang Test (DMRT) at 95 % confidence level.

Results

Plant Height

Examination of the plant height at 15 days after transplanting suggested a statistically significant difference. Maximum plant height of 61.58 cm was observed when transplanting with 2 seedlings per hill, followed by 60.70 cm and 55.58 cm with 3 seedlings and 1 seedling per hill, respectively (Table 1). Plant height at 30 days after transplanting showed a statistical difference. Maximum plant height of 95.28 cm was observed when transplanting with 2 seedlings per hill. However transplanting with 3 seedlings and 1 seedling per hill showed no statistical difference in plant height of 93.03 cm and 89.78 cm, respectively (Table 1). Plant height at 45 days after transplanting suggested highly statistically significant difference. Maximum plant height of 137.68 cm was observed when transplanting with 2 seedlings per hill. No difference of plant height was found when transplanting with 2 seedlings and 3 seedlings per hill with the latter producing 136.75 cm. of plant height. Transplanting with 1 seedling per hill produced minimum plant height of 129.35 cm (Table 1). Plant height at 60 days after transplanting suggested a statistical significant difference. Maximum plant height of 142.28 cm. was obtained when transplanting with 2 seedlings per hill. No difference of plant height was found when transplanting with 2 seedlings and 3 seedlings per hill with the latter producing 140.73 cm of plant height. Transplanting with 1 seeding per hill produced minimum plant height of 135.30 cm (Table 1).

Table 1. Plant height of Kum Bangpra rice variety at 15, 30, 45 and 60 days after transplanting with different numbers of seedling

Treatment	Age (Days)			
	15	30	45	60
1 Seedling per hill	55.88[b]	89.78[b]	129.35[b]	135.30[b]
2 Seedlings per hill	61.58[a]	95.28[a]	137.68[a]	142.28[a]
3 Seedlings per hill	60.70[a]	93.03[ab]	136.75[a]	140.73[ab]
Mean	59.38	92.69	133.84	139.25
F-test	*	*	**	*
C.V. (%)	3.76	2.43	1.94	2.53

* Statistical difference at 95% confidence level

** Highly statistically significant difference at 99% confidence level

In the same column, different letters signify statistical difference when comparisons were made with DMRT method.

Table 2. Tillering capacity of Kum Bangpra rice variety at 15, 30, 45 and 60 days after transplanting with different numbers of seedling

Treatment	Age (Days)				
	15	30	45	60	Tillering Ratio
1 Seedling per hill	2.48[c]	11.18[c]	11.50[c]	12.28[c]	1:12.00
2 Seedlings per hill	4.20[b]	17.00[b]	17.15[b]	17.88[b]	1:8.94
3 Seedlings per hill	5.53[a]	19.80[a]	19.80[a]	21.33[a]	1:7.11
Mean	4.07	15.99	16.15	17.16	-
F-test	*	**	**	**	-
C.V. (%)	17.16	4.91	11.66	8.60	-

* Statistical difference at 95% confidence level

** Highly statistically significant difference at 99% confidence level

In the same column, different letters signify statistical difference when comparisons were made with DMRT method.

Tillering Capacity

The number of tillers per hill was compared at 15 days after transplanting and a statistical difference was observed. Highest number of 5.53 tillers per hill was obtained from transplanting with 3 seedlings per hill, whereas 4.20 and 2.48 tillers per hill were obtained from transplanting with 2 seedlings and 1 seedling per hill, respectively (Table 2). Tillering at 30 days after transplanting showed highly statistically significant difference. Transplanting with 3 seedlings per hill gave the highest number of 19.78 tillers per hill, followed by 2 seedlings and 1 seedling per hill with 17.00 and 11.78 tillers per hill, respectively (Table 2). Tillering at 45 days after transplanting showed highly statistically significant difference. Transplanting with 3 seedlings per hill offered the highest number of 19.80 tillers per hill, followed by 2 seedlings and 1 seedling per hill with 17.15

and 11.50 tillers per hill, respectively (Table 2). Tillering at 60 days after transplanting showed a highly statistically significant difference. Transplanting with 3 seedlings per hill produced the highest number of 21.33 tillers per hill, followed by 2 seedlings and 1 seedling per hill with 17.88 and 12.28 tillers per hill, respectively (Table 2).

Number of Panicle per Hill

No statistical difference was observed but transplanting with 3 seedlings per hill tended to produce highest numbers of 20.88 panicles per hill, i.e., followed by 2 seedlings and 1 seedling per hill with 17.55 and 12.00 panicles per hill, respectively (Table 3).

Table 3. Number of panicle/hill, panicle length, number of filled grain/panicle, and 100-seed weight of Kum Bangpra rice variety

Treatment	Number of Panicle per Hill (panicle)	Panicle Length (cm)	Number of Filled Grain per Panicle (grain)	100-Seed Weight (gm)
1 Seedling per hill	12.00	22.80	97.00	2.47
2 Seedlings per hill	17.55	22.83	100.85	2.44
3 Seedlings per hill	20.88	22.43	98.45	2.44
Mean	19.01	22.68	98.76	2.45
F-test	ns	ns	ns	ns
C.V. (%)	11.93	3.02	6.48	1.83

ns : No statistical difference

Panicle Length

The experimental result reported no statistical difference in panicle length; transplanting with all of the 3 treatments demonstrated very similarly in panicle length with an average of 22.68 cm (Table 3).

Number of Filled Grain per Panicle

The number of filled grain per panicle of Kum Bangpra rice variety showed no statistical difference between the numbers of seedling transplanted; with 2 seedlings per hill tended to produce the highest numbers of filled grain per panicle, i.e. 100.85 grains, followed by 3 seedlings and 1 seedling with 98.45 and 97.00 grains, respectively (Table 3).

100-Seed Weight

Transplanting with different numbers of seedling per hill showed no statistical difference in 100-seed weight; they were reported with similar 100-seed weights of 2.5 gm. on average (Table 3).

Width of Un-Husked Grain

No statistical difference was reported among the 3 treatments of transplanting in the width of un-husked grain of Kum Bangpra rice variety; an average width of un-husked grains was 2 mm (Table 4).

Length of Un-Husked Grain

The 3 treatments did not show statistical difference in the length of un-husked grain of Kum Bangpra rice variety; an average length of un-husked grains was 9.4 mm (Table 4).

Table 4. Grain width, grain length, weight of filled grain/hill, and yield/Rai of Kum Bangpra rice variety

Treatment	Grain Width (mm)	Gain Length (mm)	Weight of filled grain per Hill (gm)	Rough grain yield/Rai (kg)
1 Seedling per hill	2.00	9.3	27.90[b]	496.00[b]
2 Seedlings per hill	2.00	9.5	35.16[a]	625.10[a]
3 Seedlings per hill	2.00	9.4	39.55[a]	703.09[a]
Mean	2.00	9.4	34.20	608.06
F-test	ns	ns	**	**
C.V. (%)	-	-	9.02	9.02

ns : No statistical difference

** Highly statistically significant difference at 99% confidence level

In the same column, different letters signify statistical difference when comparisons were made with DMRT method.

Weight of Filled Grain per Hill

Highly statistically significant difference was found in weight of filled grain per hill among the 3 treatments of transplanting with different numbers of seedling per hill for Kum Bangpra rice variety. Transplanting with 3 seedlings per hill gave a maximum weight of 39.55 gm. of filled grains per hill, whereas 2 seedlings and 1 seedling per hill gave 35.16 and 27.90 gm., respectively (Table 4).

Rough Grain Yield

Kum Bangpra rice variety transplanted with different numbers of seedling per hill showed highly statistically significant difference in grain yield per Rai at 15 % moisture. Maximum grain yield of 703.09 kg/Rai was obtained from transplanting with 3 seedlings per hill, followed by 625.10 kg/Rai with 2 seedlings per hill, and minimum yield of 496 kg./Rai with 1 seedling per hill (Table 4).

Discussion

Comparisons of stem and leaf growth when transplanting Kum Bangpra rice variety with different numbers of seedling per hill found that taller plants were obtained more from 2 seedlings per hill than 3 seedlings and 1 seedling per hill at the seedling age of 15, 30, 45 and 60 days. The growth of rice plant in all of the 3 treatments followed Sigmoid growth curve; the growth was slow during the early period of 15 days after transplanting, and became faster when reaching 30 days and 45 days, and faster but relatively stable at 60 days as it is the time the stem and leaf stop growing and entering reproductive stage (Promsomboon, 2004). Investigation of tillering by counting the numbers of tiller at the basal node indicated statistical differences in the numbers of tiller at the ages of 15, 30, 45 and 60 days. The numbers of tiller continued to grow with increased ages especially at the age of 30 days after transplanting, with 4-fold increases in number of tillers compared to that at the age of 15 days. Moreover, after 30 days, tillering began to decline and end at 60 days which conformed to the report of Chongkid (2014). With respect to tillering capacity of Kum Bangpra rice variety in comparison between the numbers of seedling transplanted, it was observed that transplanting with 1, 2, and 3 seedlings per hill can give 12, 18, and 21 tillers per hill or at the ratio of 1:12, 1:9, and 1:7, respectively. It agreed to Chongkid (2014) reporting that transplanting with higher numbers of seedling per hill will decrease the number of tillers as a result of increased plant competition. No statistical difference was observed but transplanting with 3 seedlings per hill tended to produce highest numbers of 20.88 panicles per hill. It is likely that rice varieties with high yield potential possess good yield components including number of tiller per hill and number of panicle per hill. (Department of Rice Thailand, 2006).

The experimental result reported no statistical difference in panicle length. Panicle length was indicated for rice yields. If the panicle length was very high, it likely that the number of seeds per panicle will increase. (Chang and De Datta, 1975). The number of filled grain per panicle of Kum Bangpra rice variety showed no statistical difference between the numbers of seedling

transplanted. Number of filled grain per panicle is another indicator of yield; high numbers of filled grain per panicle, high yield is more likely (Adams and Grafins, 1971).

Transplanting with different numbers of seedling per hill showed no statistical difference in 100-seed weight; they were reported with similar 100-seed weights of 2.5 gm. on average. According to the Department of Rice Thailand (2006), rice varieties grown in Thailand produce 2 sizes of grain; large sized grain with 100-seed weight between 2.40 - 2.90 gm. and small sized grain with 100-seed weight between 2.10 - 2.39 gm. No statistical difference was reported among the 3 treatments of transplanting in the width of un-husked grain of Kum Bangpra rice variety; an average width of un-husked grains was 2 mm. The width of un-husked grain were more controlled by genetics than the environment. (Promsomboon, 2004) Therefore, the number of stem per hill did not affect width of the un-husked grain. The 3 treatments did not show statistical difference in the length of un-husked grain of Kum Bangpra rice variety; an average length of un-husked grains was 9.4 mm. The length of un-husked grain are more controlled by genetics than the environment. (Promsomboon, 2004) Therefore, the number of stem per hill did not affect length of the un-husked grain. There was no statistical difference in yield components with respect to number of tillers per hill, number of filled grain per panicle, 100-seed weight, and the width and length of un-husked grain since these characteristics were controlled by genotype rather than environment (Promsomboon, 2004).

In comparison, transplanting with 3 seedlings per hill gave 78 kg and 207 kg more grain yield per Rai than 3 seedlings and 1 seedling per hill, respectively, suggesting maximum grain yield per Rai of Kum Bangpra rice variety produced by transplanting with 3 seedlings per hill. In contrast, an experiment by Gupta *et al*. (2010) to determine the effect of transplanting with 1, 2, and 3 seedlings per hill on the yield of rice variety Pusa Basmati conducted during 2006-2007 found no effect of the seedling number per hill on rice yield. However, our results corresponded to Sarutayophat *et al*. (2016) reporting that transplanting Japan rice variety DOA.1 with 1, 2 and 3 seedlings per hill showed no statistical difference in rice yield but transplanting with 3 seedlings per hill tended to offer higher yield than other treatments. According to Rana *et al.* (2014), suitable method of rice cultivation might differs ecologically across regions and varieties since different rice varieties differ in their response to particular planting areas and tillering capacity.

It ios conclused that Kum Bangpra rice variety transplanted with 3 seedlings per hill demonstrated the highest tillering capacity of 21.33 tillers per hill. Transplanting with 1, 2 and 3 seedlings per hill did not differ in yield

components and agronomic characteristics including number of panicle per hill, panicle length, number of filled grain per panicle, 100-seed weight, and grain width and length. Transplanting with 3 seedlings per hill produced maximum yield of 703 kg/Rai, while transplanting with 1 seedling per hill produced minimum yield of 496 kg/Rai.

Acknowledgements

This research is financially supported by the Rajamangala University of Technology Tawan-Ok, Thailand.

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(Received: 2 October 2018, accepted: 25 December 2018)