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Study of Yield and Yield Components of Rice in Different Plant Spacings and Number of Seedlings per Hill

Naser Mohammadian Roshan, Ebrahim Azarpour and Maral Moradi

Department of Agriculture, Islamic Azad University,
Branch Lahijan, P.O. Box 1616, Lahijan, Iran

Abstract: To investigate the effects of plant density (plant spacing and number of seedling per hill) for select the best planting pattern in rice; variety Ali Kazemi, an experiment in factorial statistical format based on randomized complete block design in three replication in Lahijan Islamic Azad University researching field in Guilan province (north Iran) in farming year 2009 was conducted. the experiment consist of three plant spacing levels (a_1=15×15 cm, a_2=20×20 cm and a_3=25×25 cm) and four number of seedling per hill (b_1= 1 seedling per hill, b_2=3 seedlings per hill, b_3=5 seedlings per hill and b_4=7 seedlings per hill) were studied. In maturity time, grain yield, plant height, number of grains per panicle, number of bearer and non bearer tillers per square meter, panicle length, percentage of unfilled grains and 1000 grain weight were evaluated. It was observed that more studied traits were significantly influenced by both plant spacings and number of seedlings per hill in 1 % probability level. The plant spacing of 20×20 cm (a_2) with 5582 kg/ha grain yield was recorded the highest amounts of this trait. The 7 seedling per hill (b_4) with 5188 kg/ha was recorded the maximum grain yield. The interaction effect, plant spacing of 15×15 cm and 7 seedlings per hill (a_1b_4) with 6020 kg/ha was recorded the highest grain yield. With attention to results of this experiment due to higher grain yield in a_1b_4 treatment, this level suggest for planting pattern of Ali Kazemi variety.

Key words: Rice · Plant density · Plant Spacing · Number of Seedling per hill · Grain Yield · Iran

INTRODUCTION

Cereals are the world's major source of food. Rice (Oryza sativa L.) is the most important cereal crop in the world and it is the primary source of food and calories for about half of mankind [1]. Among various agronomic factors limiting yield, planting pattern is considered of great importance. Increase in yield can be ensured by maintaining appropriate plant population through different planting patterns [2]. The plant spacing and number of seedlings per hill are two effective factors in planting pattern design. The suitable plant density is an effective factor on yield increases [3]. Optimum plant spacing ensures the plants to grow properly both in their aerial and underground parts through different utilization of solar radiation and nutrients. The optimum plant density depends on different factors that most importance of this factors include: plant characteristics, growth period duration, planting time and methods, soil fertility, plant size, available moisture, sun shin, planting pattern and situation of weeds [4]. Maske *et al.* reported that plant height, leaf area index and yield and its components were higher with plant spacing of 15x10 cm than that of 15x15 cm or 15x20 cm [5]. Baloch *et al.* Found that wider spacing had linearly increasing effect on the performance of individual plants. The plants grown with wider spacing have more area of land around them to draw the nutrition and had more solar radiation to absorb for better photosynthetic process and hence performed better as individual plants [6]. Omina EL-Shayieb. Showed that narrow spacing of 10×20 cm gave the highest yield and yield components of Giza 177 rice cultivar compared with 20×20 cm or 30×20cm [7]. Number of seedling per hill is another important factor that it can play important roles in boosting yield of rice. Because it influences the tiller formation, solar radiation interception, total sunshine reception, nutrient uptake, rate of photosynthesis and other physiological phenomena and ultimately affects the growth and development of rice plant. In densely populated rice field the inter-specific competition between

Corresponding Author: Naser Mohamadian Roshan, Department of Agriculture, Islamic Azad University, Lahijan Branch, Lahijan, P.O. Box 1616, Iran, E-mail: nasermroshan@gmail.com.

the plants is high in which sometimes results in gradual shading and lodging and thus favour increased production of straw instead of grain. It is, therefore, necessary to determine the optimum plant spacing and number of seedling per hill for high yield (5 and 7). Faruk *et al*. reported that the highest grain yield was recorded from two seedlings per hill and the lowest one was recorded from single seedling per hill [8]. Ramasamy *et al*. with study of the effect plant spacing and number of seedling per hill on rice that in this experiment used 50, 66 and 80 hills in m^2 with 2, 4, 6 and 8 seedlings in hill, the highest yield was found from 80 hills in m^2. They found also that with increases number of seedling per hill more of 2 seedlings, yield decreases [9]. Kim *et al*. with study of planting density and nitrogen level on japonica rice show that Effective tiller rate decreased in dense planting or heavy nitrogen. Dry weight increased in dense planting or heavy nitrogen. Tiller numbers and panicle numbers were more increased by dense planting than heavy nitrogen, whereas spikelet numbers were more increased by heavy nitrogen than dense planting [10]. Amin *et al*. in an experiment that in order to study of effects increased plant density and fertilizer dose on the yield of rice variety IR-6 was carried, found that Increased plant density significantly increase number of panicles per square meter, sterility and straw yield [11]. The effect of plant density on insect pest abundance is varied and complex. Planting crops with high density change crop growth, development and microclimate, which in turn have an effect on pests and their natural enemies. Planting crops with low-density persuasions weeds and indirectly has an effect on insect abundance. Low tiller numbers per unit area can result in a higher percentage of tillers damaged by stem borers. On the other hand, closely spaced plants shade each other, making rice plants more vulnerable to brown planthopper due to increased humidity, greater plant surface area for oviposition and less crowded feeding conditions. A field with 10 × 10 cm hill spacing has greater chances of suffering hopperburn than a field with 20 × 20 hill spacing. Dense planting increases populations of planthoppers, leafhoppers, leaffolders, gall midges, black bugs and caseworms while whorl maggots, root aphids, root weevils and leaf beetles may become less abundant [12,13].

MATERIALS AND METHODS

For study of effect plant density (plant spacing and number of seedling per hill) and select the best planting pattern in rice variety Ali Kazemi, factorial experiment was conducted in randomized complete block design (RCBD) with 3 replications in 2009, in Lahijan Islamic Azad University researching field in Guilan province (north Iran), with 37°11' N latitude and 50°0' E longitude and 20 m above sea level. The climate of the area is mild and Mediterranean. The soil texture was loam with PH 6.9. the experiment consist of three plant spacing levels (a_1=15×15 cm, a_2=20×20 cm and a_3=25×25 cm) and four number of seedling per hill (b_1= 1 seedling per hill, b_2=3 seedlings per hill, b_3=5 seedlings per hill and b_4=7 seedlings per hill) were studied. The used variety in this experiment (Ali Kazemi) is one of the local rice varieties in north of Iran which it's cooking quality and yield is high. Sowing in nursery was done April 15 and transplanted to field May 22. According to soil analysis amount of fertilizers N, K and P were implemented. During growth period, cultivate cares were done ordinarily. In maturity time, according measurement instruction, grain yield, straw yield, Harvest index, plant height, number of grains per panicle, number of bearer and non bearer tillers per square meter, panicle length, percentage of unfilled grains and 1000 grain weight were measured. The yield and yield components were analyzed by using SAS software. The Duncan's multiple range tests was used to compare the means at %5 of significant.

RESULTS AND DISCUSSION

Effect of Plant Spacing: Results of variation analysis show that (Table 1), the effect of plant spacings on traits grain yield, plant height, number of grains per panicle and number of bearer and non bearer tillers per square meter had a significant difference in 1 % probability level. And traits Panicle length, percentage of unfilled grains and 1000 grain weight were not significantly influenced by the plant spacing. Comparison of Mean between plant spacings show that (Table 2), the highest grain yield and plant height was obtained of plant spacing 20×20 cm (a_2) respectively with 5582 kg/ha and 128.71 cm. the lowest grain yield with 4470 kg/ha and plant height with 123.56 cm was found from plant spacing of 25×25 cm (a_3). In plant spacing of 20×20 cm (a_2) due to create an optimum condition for light reception, water and nutrient consumption and less competition, the photosynthesis is high and as a result with more transition of photosynthetic matters for grains formation, yield of grains increases. Similar results were obtained by Hasanuzzaman *et al.* [14]. The maximum amounts of the number of bearer tillers with 362.67 and non bearer tillers with 37.25 tillers per square meter were recorded from

Table 1: Analysis of variance on studied traits of rice variety under different levels of plant spacing and number of seedling per hill

S.O.V	df	grain yield (kg/ha)	Plant height (cm)	panicle length (cm)	No.of Grains per panicle	unfilled Grains (%)	No. of bearer tillers	No. of non bearer tillers	1000 grain weight (g)
		MS							
Factor A	2	21662.4**	79.59**	3.25	1820.38**	13	590.81**	137.25**	0.18
Factor B	3	2304892.5	12.27	3.91**	781.73**	81**	7376.05**	77.58**	3.04**
AB	6	127097143**	32.64**	0.82**	199.45**	171**	18962.75**	70.58**	14.38**
Error	22	278026.54	12.55	0.77	1.59	4.72	11.93	3.9	0.6
C.V		11.33	2.80	2.74	1.27	24	1.45	5.85	2.52

** and * respectively significant in 1% and 5% area

Table 2: comparison of Mean Effect of plant spacing and number of seedling per hill

Treatment	grain yield (kg/ha)	Plant height (cm)	panicle length (cm)	No. of Grains per panicle	unfilled Grains per panicle (%)	No. of bearer tillers	No. of non bearer tillers	1000 grain weight (g)
Plant spacing								
a_1	5336 A	126.2 AB	32.02 A	89.17 C	8 A	362.7 A	37.25 A	30.52 A
a_2	5582 A	128.7 A	31.90 A	103 B	9 A	213.0 B	33.50 B	30.77 A
a_3	4470 B	123.6 B	32 A	105.3 A	10 A	138.0 C	30.50 C	30.65 A
No. seedling per hill								
b_1	4245 B	126.4 A	31.33 B	107.7 A	6.670 B	207.4 D	36.67 A	30.13 B
b_2	4764 AB	126 A	32.33 A	104.8 B	6.690 B	222.6 C	35.67 A	30.63 B
b_3	4417 B	124.7 A	32.10 AB	97.33 C	10.67 A	252.0 B	30.33 C	31.47 A
b_4	5188 A	127.5 A	32.13 AB	96.78 C	12.67 A	269.5 A	32.33 B	30.37 B

Within each column, means followed by the same letter do not differ significantly at $P<0.05$

plant spacing of 15×15 cm (a_1). The lowest number of bearer and non bearer tillers was obtained of plant spacing 25×25 cm (a_3) respectively with 138 and 30.5 tillers per square meter. The highest number of grains per panicle with 105.25 was recorded from plant spacing of 25×25 cm (a_3) and the lowest one with 89.17 was recorded from plant spacing of 15×15cm (a_1). similar results were obtained by Salem [15]. Although in this experiment the panicle length, percentage of unfilled grains and 1000 grain weight were not affected by the plant spacing but the maximum amounts of 1000 grain weight was recorded from plant spacing of 20×20 cm (a_2). the minimum percentage of unfilled grains per panicle and 1000 grain weight was recorded from plant spacing of 15×15 cm (a_1). The maximum amounts of panicle length with 32.02 cm was recorded from plant spacing of 15×15 cm (a_1) and The minimum value of panicle length with 31.9 cm was found from plant spacing of 20×20 cm (a_2).

Effect of Number of Seedling per Hill: All the studied traits except grain yield and plant height was influenced by number of seedling per hill (Table 1). The effect of number of seedling per hill on traits panicle length, number of grains per panicle, percentage of unfilled grains, number of bearer and non bearer tillers per square meter and 1000 grain weight had a significant difference in 1 % probability level (Table 1). Comparison of Mean between number of seedlings per hill show that (Table 2), The maximum amounts of percentage of unfilled grains and number of bearer tillers per square meter respectively with 12.67 % and 269.45 was obtained of 7 seedlings per hill (b_4) and the minimum amounts of mentioned traits was obtained of 1 seedling per hill (b_1) respectively with 6.67 % and 207.44 tillers. In b_4 treatment due to maximum number of plants in hill increased but in b_1 due to minimum plants in hill decreased. Also in b_4 due to high competition for light, water and nutrient, the photosynthesis decrease and less photosynthetic matters receive by grains. Faruk *et al*. Found that the lowest number of bearing tillers per hill and the highest number of non-bearing tillers per hill was recorded from 1 seedling per hill [8]. The highest 1000 grain weight with 31.47 g was found from 5 seedlings per hill (b_3) and the lowest one with 30.13 g was found from 1 seedling per hill. The longest panicle length with 32.33 cm was obtained of 3 seedlings per hill and the shortest panicle length with 31.33 cm was obtained of 1 seedling per hill. The maximum number of grains per panicle and number of non bearer tillers per square meter respectively with 107.67 and 36.67 was recorded from 1 seedling per hill. The lowest number of grains per panicle with 86.78

Table 3: the interaction effect of plant spacing and number of seedlings per hill on studied traits

Treatment	Grain yield (kg/ha)	Plant height (cm)	Panicle length (cm)	No. of Grains per panicle	unfilled Grains per panicle (%)	No. of bearer tillers	No. of non bearer tillers	1000grain weight (g)
a_1b_1	4831 AB	122.3 CD	30.4 A	106 C	6.5 D	296 D	28 E	31.7 B
a_1b_2	5193 A	126 ABC	32.7 A	91.67 E	6.48 D	326.67 C	33 D	29.6 CD
a_1b_3	5300 A	125.7 ABCD	32.1 A	82.33 G	10 BC	396 B	40 B	32.1 AB
a_1b_4	6020 A	130.8 A	32.9 A	76.67 H	10 BC	432 A	48 A	28.7 D
a_2b_1	5872 A	131.33 A	31.2 AB	110.33 B	8 CD	185 G	50 A	29.1 D
a_2b_2	5872 A	126.3 ABC	32.6 A	117.67 A	6.24 CD	205 F	36 C	29.1 D
a_2b_3	4594 AB	129.3 AB	32.3 A	97.33 D	12 AB	220 F	23 F	33.4 A
a_2b_4	5988 A	128 ABC	31.5 AB	86.67 H	14 A	241.67 E	25 F	31.5 B
a_3b_1	2988 B	125.63 ABCD	32.4 A	106.67 C	6.24 D	141.33 H	32 D	29.6 CD
a_3b_2	4743 AB	125.6 ABCD	31.7 AB	105 C	10 BC	136 I	38 BC	33.2 A
a_3b_3	4935 AB	119.2 D	31.9 AB	112.33 B	12 AB	140 H	28 E	28.9 D
a_3b_4	5227 AB	123.8 BCD	32 AB	97 D	14 A	134.67 HI	24 F	30.9 BC

Within each column, treatments that carry the same superscript letter are not significantly different at $P<0.05$

was found from 7 seedlings per hill. It seems that more competition and less photosynthesis in b_4 level casing to decreases number of grains per panicle. The minimum number of non bearer tillers per square meter was recorded from 5 seedlings per hill with 30.33 tillers per square meter. However; the grain yield and plant height were not significantly influenced by number of seedling per hill but the highest amounts of mentioned traits was found from 7 seedling per hill (b_4) respectively with 5188 kg/ha and 127.52 cm. the lowest grain yield with 4245 kg/ha was obtained by 1 seedling per hill (b_1) and the lowest plant height with 124.71 cm was obtained by 5 seedling per hill (b_3).

Interaction Effects: With attention to variance analysis table (Table 1), the interaction effects of plant spacing and number of seedlings per hill on traits grain yield, plant height, number of grains per panicle, percentage of unfilled grains per panicle, number of bearer and non bearer tillers per square meter, panicle length and 1000 grain weight had a significant difference in 1 % probability level. The mean comparison of interaction effects show that (Table 3), the highest amounts of grain yield, panicle length and number of bearer tillers was found from plant spacing of 15×15 cm and 7 seedlings per hill (a_1b_4) respectively with 6020.53 kg/ha, 32.9 cm and 432. The lowest grain yield with 2988 kg/ha was found from plant spacing of 25×25 cm and 1 seedling per hill (a_3b_1). The minimum number of bearer tillers per square meter with 136 tillers was recorded from plant spacing of 25×25 cm and 3 seedlings per hill (a_3b_2) and the lowest panicle length with 30.4 cm was recorded by (a_1b_1). It seems that in a_1b_4 treatment due to maximum plant in area unit the grain yield increased but in a_3b_1 treatment due to minimum plant in area unit the lowest grain yield was recorded. Similar results were obtained by Venkateswarlu *et al.* [16]. Baloch *et al.* found that increasing grain yield under high density is due to increase the number of panicle in area unit [6]. The highest plant height and number of non bearer tillers per square meter was recorded from plant spacing of 20×20 cm and 1 seedling per hill (a_2b_1) respectively with 131.33 cm and 50 tillers. The shortest plant height with 119.2 cm was found from (a_3b_3) and the minimum number of non bearer tillers was found from (a_2b_3) with 23 tillers. The highest number of grains per panicle with 117.67 was recorded from (a_2b_2) and the lowest one with 76.67 was recorded from (a_1b_4). It seems that in a_2b_2 due to suitable plant spacing and number of seedlings per hill an optimum balance between vegetative and generative growth create and As a result due to proper feeding atmosphere, plant has the best situation to fill grains. But in a_1b_4 treatment due to competition in light, water and nutrient number of grains per panicle decreased. Similar results was obtained by Nakano and Mizushima [17]. The maximum percentage of unfilled grains per panicle with 14 % was obtained by (a_2b_4) and the minimum of this trait with 6.24 % was obtained by (a_3b_1). The highest 1000 grain weight with 33.4 g was found from (a_2b_3) and the lowest one with 28.7 g was found from (a_1b_4). In a_2b_3 treatment with best use of nutrition and light and create better situation for photosynthesis, transition of photosynthesis materials occurred in long time and with more amount but in a_1b_4 treatment, due to high density and shadow and shortage of light for photosynthesis, the weight of 1000-grain decreased. With attention to results of this experiment due to higher grain yield in a_1b_4 treatment, this level suggest for planting pattern of Ali Kazemi variety.

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