World Applied Sciences Journal 12 (10): 1754-1759, 2011
ISSN 1818-4952

Effect of Plant Spacing and Number of Seedlings per Hill of Yield and Yield Components Rice (Rezajo Variety)

Naser Mohammadian Roshan, Abdolkarim Keshavarz, Ebrahim Azarpour and Maral Moradi

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

Astract: To investigate the effects of plant density (plant spacing and number of seedling per hill) for select the best planting pattern in Rezajo variety, an experiment as split-plat in RCBD with four replications was conducted during 2008 year in Rudsar, East of Guilan, Iran. This experiment was carried out with three plant spacing (a_1=15cm×15cm, a_2=20cm×20cm, a_3=25cm×25cm) as horizontal factor and four different seedling Numbers (b_1=1 seedling hill^{-1}, b_2=3 seedling hill^{-1}, b_3=5 seedling hill^{-1}, b_4=7 seedling hill^{-1}) as vertical factor. The studied traits include yield of grains, yield of straw, harvest index, number of bearer and non-bearer tillers, number of grain per panicle, length of panicle and 1000-grain weight. Analysis of obtained results showed that the effect of plant spacings and number of seedlings hill- and their interaction effects in more measured characteristics have a significant difference in level of 1% probability. The highest grain yield with 4073.38 kg ha^{-1} was obtained of plant spacing 15×15 cm. the number of 5 seedling hill^{-1} with 3921.67 kg ha^{-1} was recorded highest grain yield. The interaction effect plant spacing of 15cm×15cm with number of 5 seedling hill^{-1}, the level of a1 b3 with the average of 4299.25 kg ha^{-1} of paddy yield, recorded the highest yield and then the level of a_1b_2 with 4175.50 kg ha^{-1} paddy yield. If we can't use the planting pattern level of a_1b_3 as the cropping planting; we can use of a_1b_2, since not only it has a yield close to a1 b3 but it seems that with creating of a favorable balance, the intra plant competition was reduced and with a good reparative power, increase tillers and we see increase of number of grain panicle^{-1} in this level. On the other hand in this level plants lodging is less and monotony during ripening is further, also because of the less number of seedling hill^{-1} beside thrift in produce expense and performance on planter tends up and also the risk of fungal diseases is decreased.

Key words: Rice · Plant Spacing · Number of seedling per hill · Yield · Yield compensates

INTRODUCTION

Rice is one of the most important cereal crops of the world. About 146.5 million hectares of farming lands in the world are under rice planting which over of 90% is in Asia [1]. This plant has the first grade from aspect of production and energy supply in the world and it is food supplier for over of 50% worlds people and over of 90% people in Asia [2]. Improved cultural practices can play an important role in augmenting yield of rice crop. For successful rice production, timely planting, appropriate control of vegetative growth throughout the duration of the crop, suitable transplanting densities for optimum tillering and control of leaf growth by controlling water, Fertilizer and chemical inputs are essential for improving the growth variables responsible for high yield [3]. Number of seedling hill^{-1} 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 the plants is high in which sometimes results in gradual shading and lodging and thus favor increased production of straw instead of grain. It is, therefore, necessary to determine the optimum plant spacing and number of seedling hill^{-1} for high yield [4-7]. The maximum benefit to rice can be obtained from a field if it is properly spaced between the

Corresponding Author: Naser Mohamadian Roshan, Department of Agriculture, Lahijan Branch, Islamic Azad University, Iran, P.O. Box 616, E-mail: nasermroshan@gmail.com.

plants. Optimum plant spacing ensures the plants to grow properly both in their aerial and underground parts through different utilization of solar radiation and nutrients. When the plant density exceeds an optimum level, competition among plants for light above ground or for nutrients below the ground become severe, consequently the plant growth slows down and the grain yield decreases [6]. Salemv [8] Indicated that the narrowest spacing of 20×15cm recorded the highest values of days to heading, leaf area index, plant height, number of panicles/m^2 and grain and straw yields compared with wider spacing of 20×20 and 20×25cm while, both wider spacing recorded the highest values of panicle length, panicle weight, number of filled grains/panicle and 1000-grain weight. Similar results also were obtained by Zayed *et al.* [9]. Omina EL-Shayieb, [10] 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. [11] stated that the heading date wasn't affected by planting space of rice. Mobasser *et al.* [12] Realized that the growing period, length of panicle, percentage of filled spikelets and 1000-grain weight, statistically have not ever been affected by planting density, also with increase density in different rice genotypes, despite reducing the total number of tillers and effective tillers per plant due to increase the number of stalk in unit area (m^2), number of panicle per square meter was added, Zahran, [13] indicated that space of 15 cm between hills gave the tallest plants, highest number of panicles/m^2 as well as grain and straw yields, while 25cm space among hills gave the highest values of number of filled grains/panicle and 1000-grain weight. Hamidul Islam *et al.* [5] reported that plant spacing of 25×12 cm is the best pattern of planting rice compared with 15×10 cm or 20×12 cm. [14]. Found that all the yield parameters but 1000-grain weight and panicle length was influenced by number of seedling hill^{-1}. They reported that the lowest number of bearing tillers hill^{-1}, the highest number of non-bearing tillers hill^{-1}, the lowest number of grains panicle^{-1}, the lowest grain yield and the lowest straw yield was recorded from single seedling hill^{-1}. Again, the tallest plant height, the highest number of bearing tillers hill^{-1}, the lowest number of non-bearing tillers hill^{-1}, the highest number of grains panicle^{-1}, the highest grain yield and the highest straw yield was recorded from two seedling hill^{-1}. also the shortest plant height was recorded from three seedling hill^{-1}. moreover, the maximum number of sterile spikelets was recorded from three seedling and the lowest number of sterile spikelets was recorded from two seedling hill^{-1}. which was statistically similar to single seedling hill^{-1}.

MATERIALS AND METHODS

The experiment was conducted at Farming year 2008 in a field of Roshan Absar village that is one of the village of Roodsar township situated in north of Iran with 37°7' N latitude and 49°35' E longitude and it's level is as the same as Caspian sea. By continental dividing it is the part of mild and Mediterranean zone, the soil texture was loam with PH 6.8. The experiment was conducted in split block format based on randomized complete block design (RCBD) with four replication for determining the best plant spacing and the number of seedlings hill^{-1} and at last pattern of planting. In this research horizontal factor (A) includes 3 plant spacing level (a_1=15cm×15cm, a_2=20cm×20cm and a_3=25cm×25cm) and vertical factor (B) with 4 different density of the number of seedling hill^{-1} (b_1=1 seedling hill^{-1}, b_2=3 seedling hill^{-1}, b_3=5 seedling hill^{-1}, b_4=7 seedling hill^{-1}) have been chooses. The used variety in this experiment (Rezajo) is one of the local rice varieties of north of Iran that it's cooking quality and yield is high. The operations of preparing land includes first plough in winter and secondary plough along with giving phosphorus and potash and secondary plough was one week before transplant of seeding with giving 3/4 of N fertilizer along with leveling ground base of soil analysis (Table 1). mean value of precipitation, temperature and rainfall in Roudsar were showed in table 2. After the nursery building and sowing seeds, transition of seeding in the stage of 3 to 4 leaves took form in mid-spring. All options consist of Irrigation, weeding, fighting with pests and diseases up to harvest stage have been done. The last harvest was carried in the mid-summer and the characteristics such as yield of grain yield of straw, harvest index, number of bearer and non-bearer tillers, number of grain per panicle, length of panicle and 1000-grain weight, had been examined. The data was analyzed using SAS program.

Table 1: Some chemical and physical properties of soil of the experimental location.

Potassium (ppm)	Phosphorus (ppm)	Nitrogen (%)	pH	EC (ds m^{-1})	Soil texture
230	9.5	0.052	6.5	1.9	Loamy sand

Table 2: Mean value of precipitation, temperature and rainfall in Roudsar

	Precipitation (%)		Temperature (°C)	
	Max	Min	Max	Min
Mar-Apr	99	71	15	8
Apr-May	99	64	21	12
May-Jun	97	54	30	19
Jun- Jul	96	62	28	20
Jul-Aug	97	57	32	22
Aug-Sep	98	57	30	20

RESULTS AND DISCUSSION

Results of variation analysis show that (Table 3), plant spacing and the number of seedling hill^{-1} in more studied Traits have a significant difference in 1% probability level. comparison of Mean between plant spacing show that (Table 4), The highest grain yield with 4073.38 kg ha^{-1}, straw yield with 5758 kg ha^{-1}, harvest index with 41.43% and number of bearer tillers with 388.94 per square meter was obtained of plant spacing 15×15 cm (a1). The maximum number of grains per panicle with 126.44 and the maximum length of panicle with 26.50 cm, was found from plant pacing of 25×25 cm (a3). Plant spacing of 20×20 cm (a2), with 25.52 g was recorded the highest 1000-grain weight. Comparison of mean between number of seedling hill^{-1} show that (Table 4), the highest grain yield and harvest index respectively with 3921.67 kg ha^{-1} and 41.76% was obtained of 5 seedling hill^{-1}. The maximum amounts of straw yield and Weight of 1000 grain recorded by 3 seedling hill^{-1} with 5577.50 kg ha^{-1} and 24.86 g respectively. The highest number of grains per panicle and length of panicle obtained of 1 seedling hill^{-1} respectively with 131.42 and 26.63 cm. The 7 seedling hill^{-1} with 354.08 bearer tillers per square meter recorded the highest number of bearer tillers (m^2). The interaction effect of plant spacing and the number of seedling hill^{-1} in traits grain yield, straw yield, harvest index, number of bearer tillers per square meter, number of grains per panicle and panicle length showed a significant difference in 1% probability level and on 1000-grain weight showed a significant difference in 5% probability level (Table 3).

Comparison of mean between interaction show that effects (Table 4), By increasing plant density in area unit (m^2), up to defined limit, the yield of grain increased, as the highest grain yield in area unit (m^2) was obtained of plant spacing of 15×15cm and 5 seedling hill^{-1} (a_1b_3) with 4299.2 kg ha^{-1} and the lowest grain yield was recorded from plant spacing of 25×25cm and 1 seedling hill^{-1} (a_3b_1) with 3167 kg ha^{-1}. It seems that the maximum plants in area unit (m^2) exists in level of a_1b_3 (with minimum competition) As a result, the yield is in the highest level but in the a_3b_1 treatment, because of minimum plant in area unit (m^2) the Lowest yield was showed. The reasons are modern high yielding varieties require higher prices for seeds, fertilizer, irrigation and pesticides. Our farmers are poor, so they can not always afford their costs. Hence, special attention should be given for increasing the yield per unit area through effective management practices. Among different management practices, use of appropriate number of seedlings hill^{-1} and optimum nitrogen fertilizer application are important. number of seedlings hill^{-1} is an important factor as it influences the plant population unit^{-1} area, availability of sunlight, competition for nutrients, photosynthesis and respiration which ultimately influence the yield and yield contributing characters of rice. The crop plants depends largely on temperature, solar radiation, moisture and soil fertility for their growth and nutritional requirements. A thick population crop may have 1 imitations in the maximum availability of these factors. It is, therefore, necessary to

Table 3: Variance Analysis of studied grain yield and yield components

Source of variability	DF	Yield of grains (kg/ha)	Yield of straw (kg/ha)	Harvest index (%)	Number of bearer tiller(m^2)	Number of non bearer tiller(m^2)	Number of grains per panicle	Length of panicle(cm)	Weight of 1000 grain(g)
MS									
Replication	3	56.137	2806.389	0.160	286.576	8.410	254.750	1.325	1.033
Main factor A	2	1987472.333**	1827593.063**	9.344**	77154.250**	3762.333**	3369.813**	16.349**	18.505**
Error a	6	60.139	2795.368	0.083	701.306	8.389	226.896	1.002	0.345
Factor B	3	552900.583**	335066.056**	9.411**	21043.354**	1667.243**	2662.472**	12.311**	3.559
Error B	9	109.972	6154.815	0.216	213.447	6.650	129.287	0.774	1.413
Interaction AB	6	116364.833**	409032.188**	3.511**	6218.667**	373.889**	729.868**	2.592**	1.393*
Error c	18	67.306	5217.905	0.143	949.648	6.796	256.877	0.719	0.556

** and * respectively significant in 1% and 5% area; ns: none significant

Table 4: Comparison of Mean Effect of plant spacing and number of seedling hill^{-1}

Treatment	Yield of grains (kg/ha)	Yield of straw (kg/ha)	Harvest index	Number of bearer tiller(m^2)	Number of non bearer tiller(m^2)	Number of grains per panicle	Length of panicle (cm)	Weight of 1000 grain(g)
Plant spacing								
15×15(a_1)	4073.38a	5758.00a	41.43a	388.94a	47.19a	100.88b	24.56ab	23.39b
20×20(a_2)	3577.38b	5291.31b	40.33b	318.19b	27.69b	125.56a	26.03a	25.52a
25×25(a_3)	3391.63b	5101.19c	39.97c	250.06c	16.94c	126.44a	26.50a	24.19a
Number of seedling hill^{-1}								
1	3458.75c	5308.75b	39.61b	260.33c	19.17d	131.42a	26.63a	23.62b
3	3801.25a	5577.50a	40.50a	318.58b	22.08c	128.08a	26.42a	24.86a
5	3921.67a	5453.17a	41.76a	343.25a	37.92b	111.50ab	25.29a	24.66a
7	3514.50b	5194.58c	40.43a	354.08a	43.25a	99.50b	24.46a	24.31ab

Means followed by the same letter in the same column are not significantly different at the 5% probability level by Duncan test.

Table 5: The interaction effect of plant spacing and number of seedling hill^{-1} on yield and yield components

Treatment	Yield of grains (kg/ha)	Yield of straw (kg/ha)	Harvest index	Number of bearer tiller(m^2)	Number of non bearer tiller(m^2)	Number of grains per panicle	Length of panicle (cm)	Weight of 1000 grain(g)
a_1b_1	4077.750a	6051.200a	40.260ab	326.00c	26.00e	115.25ab	25.625ab	23.173b
a_1b_2	4175.500a	6089.500a	40.677ab	365.250b	31.50d	108.25b	25ab	23.553b
a_1b_3	4299.250a	5787.750a	42.492a	410.5a	57.00b	89.75c	24.5b	24.182ab
a_1b_4	3741.000b	5103.750b	42.300a	454.00a	74.25a	90.25bc	23.125bc	22.633c
a_2b_1	3212.501cd	4959.000b	39.400b	216.75d	21.25f	126.25ab	26.625a	24.780ab
a_2b_2	3824.500b	5373.500b	41.850ab	361.75b	24.00e	154.5a	28.00a	25.963a
a_2b_3	3711.250b	5357.250b	40.925ab	335.25b	35.00c	123.00ab	25.25ab	24.458ab
a_2b_4	3561.250c	5475.500b	39.410b	359.00b	30.50d	98.5b	24.25b	25.977a
a_3b_1	3167.000d	4916.250b	39.182b	238.25d	10.25g	152.75a	27.625a	22.913c
a_3b_2	3403.750c	5269.500b	39.245b	228.75d	10.75g	121.50ab	26.25a	25.70a
a_3b_3	3754.500b	5214.500b	41.860a	284.00c	21.75f	121.75ab	26.125a	25.340a
a_3b_4	3241.250cd	5004.500b	39.573b	249.25d	25.00e	109.75b	26a	24.325ab

Means followed by the same letter in the same column are not significantly different at the 5% probability level by Duncan test.

determine the optimum density of plant population per unit area for obtaining maximum yields. A number of workers have reported that maintenance of a critical level of rice plant population in field was necessary to maximize grain yields.

Similar results were obtained by Venkateswarlu *et al.* 1987 [15]. Also [16] found that increasing grain yield under high density is due to increase the number of panicle in area unit (m^2). The highest number of bearer tillers and maximum number of non-bearer tillers in area unit (m^2) recorded from a1b4 with plant spacing of 15×15cm and the 7 number of seedling hill^{-1} with 454 and 74 tillers/(m^2) respectively. The agent of having the highest bearer tillers/(m^2) depend on further number of plant and high number of seeding hill^{-1}, but the maximum number of non-bearer tillers/m^2 in this level was because of increasing of intra plant and inter plant competition. On the contrary, in a_3b_1 treatment, because of the minimum density/m2 and minimum competition, 216 bearer tillers/m2 and 10 non-bearer tillers/m^2 were obtained respectively. The highest number of grains in panicle was obtained of a_2b_2 treatment with 154 grains in panicle. This shows that in this treatment, plants spaces each other and suitable number of seeding hill^{-1} creates a balance between vegetative and generative growth. As a result, because of suitable food atmosphere, plant has the best situation to fill grains. As a result the highest number of grains in panicle created in this level, whereas in a1b3 treatment because of high competition in light reception and absorb water and nutrient the amount of plant sap decreased and as a result the number of grains per panicle decreased to 89 grain per panicle. Nakano and Mizushima, [17] obtained similar results in their research. The highest 1000-grain weight recorded from a_2b_2 treatment with 2.59 g. The

lowest 1000-grain weight obtained of a_1b_4 treatment with 22.6 g. This shows that in a_2b_2 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 and as a result it shows the highest 1000-grain weight, whereas in a1b4 treatment, because of high density and shadow and shortage of light for photosynthesis, the weight of 1000-grain decreased. [18, 8] come to this conclusion that by increase of density up to defined limit because of increase competition, the 1000-grain weight decrease. Decrease tiller and 1000-grain weight has negative impact on paddy yield [19]. The highest yield of straw obtained of a1b2 treatment with 6089.5 kg ha^{-1} and lowest yield of straw obtained of a3b1 with 4916.25 kg ha^{-1}. It seems that with increasing density up to a1b2 treatment the straw yield increased, but then, due to increasing density, severe competition in the nutrient, especially light occurred and cause to decrease sufficient light reception to plant communities and reduced yield. The low yield in a3b1 probably due to a minimum density of number of plant per hill and number of stalk per hill Hasanuzzaman *et al.* [6] obtained of similar results. With attention to obtained results the level of a_1b_3 with the average of 4299.25 kg ha^{-1} of paddy? recorded the highest yield and then the level of a_1b_2 with 4175.50 kg ha^{-1} paddy yield. If we can't use the cropping pattern level of a_1b_3 as the pattern of planting; we can use of a_1b_2, since not only it has a yield close to a_1b_3 but it seems that with creating of a favorable balance, the intra plant competition was reduced and with a good reparative power, increase tillers and we see increase of number of grain $panicle^{-1}$ in this level. On the other hand in this level plants lodging is less and monotony during ripening is further, also because of the less number of seedling $hill^{-1}$ beside thrift in produce expense and performance on planter tends up and also the risk of fungal diseases is decreased.

REFERENCES

1. IRRI (International Rice Research Institute). 1999. Feeding the world, Facts and Figures.
2. Tanji, K.K., 1990. In: Agricultural salinity assessment and Management. ed.: KK. Tanji, Amer. SOC. Civil. Engineers, N.Y.,
3. Anonymous. The Monthly Current Memory" April, 2008. Glorious pub. Dhaka. pp: 5.
4. Ghosh, D.C. and B.P. Singh, 1998. Crop growth modeling for wetland rice management. Environ. and Ecol., 16(2): 446-449.
5. Hamidul Islam, M. and S.M. Altafhossain, 2002. Effect of fertilization and planting density on the yield of two varieties of fine rice. Pakistan J. Biological Sci., 5(5): 513-516.
6. Hasanuzzaman, M., M.L. Rahman, T.S. Roy, J.U. Ahmed and A.S.M. Zobaer, 2009. Pant characters, yield components and yield of late transplanted Aman Rice as Affected by plant spacing and number of seedling per hill. Advances in Biological Res., 3(5-6): 201-207.
7. Hossain, M.S., A.A. Mamun, M.N. Rikta Basak and M.K. Anam, 2003. Effect of cultivar and spacing on weed infestation and performance of transplanted aman rice in Bangladesh. Pakistan J. Agron., 2(3): 169-178.
8. Salem, A.K.M., 2006. Effect of Nitrogen Levels, Plant Spacing and Time of Farmyard Manure Application on the Productivity of Rice. J. Applied Sciences Res., 2(11): 980-987.
9. Zayed, B.A., I.S. EL-Refaee, R.N. Gorgy and A.A.M. Abd El-Rahman, 2005. Effect of sowing dates, plant spacing and nitrogen levels on growth and yield of rice under saline soil. The 11th Conference of Agronomy, Dept. Fac. Agric. Assiut. Univ., pp: 265-283.
10. Omina, El-Shayieb, M.A., 2003. Agronomic studyon rice crop. M. Sc. Thesis, Agron. Dept. Fac. Of Agric. Mansoura Univ. Egypt,
11. Shin, H.R., S.W. Kim, O.D. Kwon, H.G. Park, X. Lee, T.D. Park and Y.J. Kim, 1998. Effect of transplanting date, nitrogen rate and plant density on growth and yield of purple rice. RDA-J. of Agric. Environment Sci., (C.F. CD-Room Computer system). 40:56-62.
12. Mobaser, H.R., M. Mohseni Delarestaghi, A. Khorgami, D. Bararitar and H. Pour Kalhor, 2007. Effect of planting density on agronomical characteristics of rice varieties in North of Iran. Pakistan J. Biological Sci., pp: 3208-3209.
13. Zahran, H.A.A., 2000. Response of some rice cultivars to different spaces among hills and rows under saline soil conditions. M.Sci. Thesis, Fac. Agric. Mansoura Univ. Egypt,
14. Faruk, M.O., M.A. Rahman and M.A. Hasan, 2009. effect of seedling age and number of seedling per hill on the yield and Yield contributing characters of BRRI Dhan 33. Int. J. Sustain. Crop Prod., 4(1): 58-61.
15. Venkateswarlu. B., B.S. Vergara and R.M. Visperas, 1987. Influence of photosynthetically active radiation on grain density of rice. Crop Sci., 27: 1210-1214.

16. Baloch, A.W., A.M. Soomro, M.A. Javed and M. Ahmed, 2002. Optimum plant density for high yield in rice (*Oriza sativa* L.) Asian J. Plant Sci., 1(1): 25-27.
17. Nakano, H and T. Mizushima, 1994. Effect of competition in a hill to seedling number per hill on yield components and yield in paddy rice. Japanese. J. Crop Sci., (Japan). 63(3): 452-459.
18. Muhammad, A.Y., M.S. Sharer, M.S. Nazir, 1987. The yield and yield components of fine rice as influenced by different spacing. Pakistan, journal, of. Scientific and Industrial Res., 30:7, 523-525;12 ref.
19. Amin, M., M. Ayyaz Khan, E. Ahmed Khan and M. Ramzan, 2004. Effect of increased plant density and fertilizer dose on the yield of rice variety IR-6. Journal of Research (Science), Bahauddin Zakariya University, Multan, Pakistan, 15(1): 09-16.