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Effect of Planting Density on Agronomical Characteristics of Rice (*Oryza sativa* L.) Varieties in North of Iran

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Abstract: In order to study the effects of plant density on agronomical characteristics of rice varieties a field experiment was carried out in field of Ghaemshahr Azad University in 2006. This experiment was laid out in split plot in basis of Randomized Completely Block Design with three replications. Main factor was rice variety in three levels (Hashemi Tarom, Fajr, Neda) and minor factor was planting density (Including 10×8.3, 10×10, 12.5×10, 16.6×10, 16.6×15 and 25×20 cm or 120, 100, 80, 60, 40 and 20 plant m^{-2}, respectively). Results showed that planting density had significant effect on plant height, total spikelets, total tillers, fertile tillers, panicle per m^2, grain yield and harvest index. Days number till to 50% flowering stage and growth period length were maximum in Neda variety. Also these characteristics were not influenced by different planting densities. Maximum plant height and maximum panicle length were obtained in Hashemi Tarom variety and minimum of these characteristics were produced in Neda variety. Plant height was decreased significantly with increase of planting density.

Key words: Rice, plant density, morphology, yield

INTRODUCTION

Rice (*Oryza sativa*) is one of the most important crops in Iran. It is the largest crop in terms of area and production in north of Iran (Hatami, 2002). Rice is the dominant staple food for many countries in Asia and the Pacific, south and north America as well as Africa. In Asia more than 2 billion people obtain 60 to 70% of their calories from rice (Dowling *et al*., 1998). World rice production must increase by approximately 1% annually to meet the growing demand for food that will result from population growth and economic development (Horie *et al*., 2004). The crop plants growing depends largely on temperature, solar radiation, moisture and soil fertility for their growth and nutritional requirements. An unsuitable population crop may have limitation in the maximum availability of these factors. It is, therefore necessary to determine the optimum density of plant population per unit area for obtaining maximum yield. There have been extensive studies on the relationship between yield and plant density in rice under nonstressed conditions. The relationships varied with different planting systems in rice production. In transplanted culture systems, maximum grain yield can be reached at a plant density of about 200 plant m^{-2} (Nguu and De Datta, 1970; Akita, 1982). In drill-seeded 161 and 215 plant m^{-2}, which can be achieved with seeding densities between 90 and 112 kg ha^{-1} (Huey, 1984). In continuosly flooded, direct water flooded cultural systems that are common in some countries, a broad range of plant densities between 221 and 451 plant m^{-2} (Miller *et al*., 1991). A compensatory relationship between yield components and plant density has been observed. It was shown that panicle density significantly increased with increase of seeding densities, while filled spikelets per panicle were reduced significantly (Wells and Faw, 1978; Gravois and Helms, 1992). Tiller per plant and spikelets per panicle increased with decreases of plant density in direct-seeded rice (Wu *et al*., 1998). A number of workers have reported that maintenance of a critical level of rice plant population in field was necessary to maximize grain yield. The effect of plant density on kernel dimension were also identified during different panicle development stages. The reason for such low yield mainly associated with cultural technologies. Among cultural technology application of best planting space is the important ones (Barari, 2007).

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Almost all yield contributing characters were influenced significantly by planting density (Islam and Hossain, 2002). They also showed that total tiller and fertile tiller number in 25×15 cm planting space were more than 15×10 cm planting space. Wider spacing had linearly increasing effect on the performance of individual plants. The plants grown with wider spacing had more solar radiation to absorb for better photosynthetic process and hence performed better as individual (Baloch *et al.*, 2002). Appointing the best planting space related to rice variety. Determine best planting density for native and modern rice varieties in north of Iran were purposes of this experiment.

MATERIALS AND METHODS

The experiment was conducted at field of Gaemshahr Islamic Azad university in North of Iran. This experiment was laid out in split plot in basis of Randomized Completely Block Design (RCBD) with three replications. The plot size was 15 m^2. Main factor was rice variety in three levels (Hashemi Tarom, Fajr, Neda) and minor factor was planting density (Including 10×8.3, 10×10, 12.5×10, 16.6×10, 16.6×15, 25×20 cm or 120, 100, 80, 60, 40 and 20 plant m^{-2}, respectively). All plots received 100 kg P_2O_5 ha^{-1} and 100 kg k_2O ha^{-1} before transplanting. The nitrogen fertilizer in the form of urea was applied at the rate of 132 Kg N ha^{-1} in two split doeses. Half of nitrogen fertilizer was applied as top dressing in the maximum tillering stage. Standards cultural practices were carried out until the plant was matured. Five hills (excluding border hills) were randomly selected from each plot for measuring total tiller number. Six hills (excluding border hills) were randomly selected from each plot prior to harvest for measure yield components. Days numbers after transplanting till to 50% flowering stage and vegetative growth period length were measured in this experiment. Grain yield was determined from harvest area of 5 m^2 adjusting to 14% moisture content. All statistical tests were done using the statistically analysis system (SAS Institute, 1996) and mean values were compared by Duncan Multiple Range Test (DMRT).

RESULTS

Days numbers till to 50% flowering stage: Results showed that variety had significant effect on days numbers till to 50% flowering stage in this experiment (Table 1). In a way that the highest and the least days numbers till to 50% flowering stage were obtained in Neda variety (68.1 days) and Hashemi Tarom Variety (54.4 days), respectively (Table 2). This duration was 59.4 days for Fajr variety (Table 2). According to results planting density had not significant effect on days number till 50% flowering stage (Table 1). But maximum and minimum of this characteristic were obtained in density of 20 and 60 plant m^{-2}, respectively (Table 2).

Vegetative period length: Variety had significant effect on vegetative period length (Table 1). The least vegetative period length was obtained in Hashemi Tarom (48.3 days) and maximum vegetative period length was produced in Neda (54.6 days) variety (Table 2). Vegetative period length for Fajr variety was 52.7 days (Table 2). According to results planting density had not significant effect on vegetative period length (Table 1).

Plant height: Planting density and variety had significant effect on plant height at 0.01 and 0.05 probability levels, respectively (Table 1). Highest plant height was obtained in Hashemi Tarom variety (157.8) while minimum plant height was produced in Neda variety (90.3 cm). Plant height for Fajr variety was 106.7 cm. The highest (124.5 cm) and the least (113.5 cm) plant height were obtained in planting density of 20 and 120 hills m^{-2}, respectively (Table 2).

Panicle length: Results showed that variety had significant effect on panicle length at 0.01 probability level (Table 1). The highest panicle length was obtained in Hashemi Tarom variety (30.9 cm) and the least panicle length was produced in Neda variety (23.4 cm) while panicle length for Fajr variety was 28.5 cm (Table 2). Plant density had not significant effect on panicle length in this experiment (Table 1).

Total spikelets per panicle: Planting density and variety had a significant effect on total spikelets per panicle at 0.01 probability level (Table 1). The highest and the least total spikelets per panicle were obtained in Fajr variety and Hashemi Tarom variety, respectively. Total spikelets per panicle were 96 and 101.9 for Hashemi Tarom and Neda variety respectively (Table 2). Total spikelets per panicle for 20 plant m^{-2} planting density were 130.8 while for 120 plant m^{-2} planting density were 101.4 (Table 2). Intraction effects mean showed that highest spikelets per panicle (132.8) were obtained in Fajr variety in case of 20 per m^{-2} planting density (Table 3).

Filled spikelet percentage: Results showed that variety had significant effect on filled spikelets percentage at 0.01 probability level (Table 1). Highest and the least filled spikelets percentage were obtained in Hashemi Tarom variety (94.06%) and Neda variety (86.9%), respectively

Table 1: Mean squares of morphological characteristics of rice varieties in different treatments

SOV	df	Day till 50% flowering	Vegetative period	Plant height (cm)	Panicle length (cm)	Total spikelet	Filled spikelet	1000 grain weight	Total tiller	Fertile tiller	Panicle m^{-2}	Grain yield	Harvest index
Rep	2	36.88*	27.55ns	355.96ns	4.09ns	648.37ns	5.47ns	3.03ns	4.77ns	4.99ns	10078.9ns	145984.39ns	20.81ns
G	2	667.46**	186.72**	22285.26**	258.8**	7855.44**	374.66**	95.09**	13.45ns	13.78ns	60234.9ns	725099.90**	118.42ns
E(a)	4	3.574	2.27	107.48	6.59	127.79	2.696	7.58	8.06	7.89	18216.79	16690.67	97.98
Pd	5	1.274ns	3.28ns	126.02*	1.36ns	968.30**	2.00ns	1.55ns	118.48**	116.44**	51973.08**	36417.90**	9.91**
G×Pd	10	0.596ns	0.67ns	8.77ns	0.90ns	188.28ns	7.40ns	2.52ns	0.72ns	0.76ns	3773.6ns	1571.25ns	1.95ns
E(a)	30	0.611	1.01	11.61	0.67	143.61	11.45	1.53	0.93	0.96	3588.2	3638.70	2.73
CV%		1.28	1.94	2.88	2.96	10.81	3.80	4.97	16.65	16.98	15.70	7.60	3.82

ns,*, ** = non significant, significant at 0.05 and 0.01 probability level, Pd = Planting density, G = Genotype

Table 2: Mean comparision of morphological characteristics of rice varieties in different treatments

Variety	Day till 50% flowering	Vegetative period (day)	Plant height (cm)	Panicle length (cm)	Total spikelet (No.)	Filled spikelet (No.)	1000 grain weight (g)	Total tiller (No.)	Fertile tiller (No.)	Panicle (No.)	Grain yield ($g\ m^{-1}$)	Harvest index (%)
Hashemi Tarom	56.4b	48.3c	157.8a	30.9a	96b	94.06a	24.03b	6.36a	6.33a	430.3a	566b	40.87a
Fajr	59.4b	52.7b	106.7b	28.5ab	134.8a	86.07b	23.23b	4.8a	4.76a	317.6b	870.1a	45.99a
Neda	68.1a	54.6a	90.3b	23.4b	101.9b	86.9b	27.55a	6.21a	6.20a	396.7a	945a	43.11a
Plant density												
20 plant per m^2	61.9a	52.9a	124.5a	28.1a	130.8a	88.69a	25.14a	12.60	12.51a	270.9c	719.4b	270.9c
40 plant per m^2	61.3a	52.2a	119.9ab	27.3a	111.4ab	89.56a	24.73a	6.98b	6.95b	320bc	771.5b	320bc
60 plant per m^2	60.9a	51.3a	117.1bc	27.2a	104.7b	89.13a	25.01a	4.85c	4.85c	385.8ab	760.8b	385.8ab
80 plant per m^2	61.5a	54.4a	118.5abc	27.6a	109.4b	89.48a	24.23a	3.97cd	3.94cd	392.2ab	790.1b	392.2ab
100 plant per m^2	61.1a	52a	116.1bc	27.3a	107.6b	88.87a	25.03a	3.44cd	3.43cd	447a	813.9ab	447a
120 plant per m^2	61a	51.4a	113.5c	28.1a	101.4b	88.33a	25.46a	2.9d	2.9d	473.3a	906.5a	473.3a

Mean with similar letter(s) in each column are not significantly different at the 0.05 probability level according to DMRT

Table 3: Interaction effect of variety and planting density on yield and yield traits of rice varieties

Treatments		Total tiller (No.)	Fertile tiller (No.)	Panicle m^{-2}	Total spikelets	Filled spikeletes (%)	1000 grains weight (g)	Grainyield ($g\ m^{-2}$)
	20	9.48a	9.42a	350.6cde	113.4ab	91.37a	24.58ab	642.7d
	40	6.67b	6.64bc	375.15bcd	103.7b	91.81a	24.38ab	668.7d
Hashemi Tarom	60	5.60bc	5.59cd	408.05abcd	100.3b	91.59a	24.52ab	663.4d
	80	5.16bc	5.13cd	411.2abc	102.7b	91.77a	24.13ab	678.0d
	100	4.90bc	4.88cd	438.6ab	101.8b	91.46a	24.53ab	689.9d
	120	4.63c	4.61cd	451.8a	98.7b	91.19a	24.74ab	736.2cd
	20	8.70a	8.63ab	294.2d	132.8a	87.38a	24.18ab	794.7bc
	40	5.89bc	5.85cd	318.8cde	123.1ab	87.81a	23.98b	820.8bc
Fajr	60	4.82bc	4.80cd	351.7cde	119.7ab	87.60a	24.12ab	815.4bc
	80	4.38c	4.35d	354.9cde	122.1ab	87.77a	23.73b	830.1abc
	100	4.12c	4.09d	382.3bcd	121.2ab	87.47a	24.13ab	842ab
	120	3.85c	3.83d	395.4abcd	118.1ab	87.20a	24.34ab	888.3ab
	20	9.40a	9.35a	333.8cde	116.3ab	87.79a	26.34ab	832.2abc
	40	6.59b	6.57c	358.3cd	106.6ab	88.23a	26.14ab	858.25ab
Neda	60	5.53bc	5.52cd	391.2abcd	103.3b	88.01a	26.28ab	852.9ab
	80	5.09bc	5.07cd	394.4abcd	105.6b	88.19a	25.89ab	867.5ab
	100	4.82bc	4.81cd	421.8ab	104.7b	87.88a	26.29ab	879.4ab
	120	4.55c	4.55d	435ab	101.6b	87.61a	26.5a	925.7a

Mean with similar letter(s) in each column are not significantly different at the 0.05 probability level according to DMRT

(Table 2). Results showed that filled spikelets percentage in 120 plant m^{-2} was 88.33% and in 40 plant m^{-2} was 89.56% (Table 2). Interaction effects mean showed that highest spikelets per panicle (91.37%) were produced in Hshemi Tarom variety in case of 20 plant m^{-2} (Table 3).

1000 grains weight: Variety had a significant effect on 1000 grains weight at 0.01 probability level (Table 1). The most 1000 grains weight were obtained in Neda variety (27.55 g) and for Hashemi Tarom and Fajr variety were 24.03 and 23.23 g, respectively (Table 2). Planting density had not significant effect on 1000 grains weight (Table 1). Interaction effects mean showed that highest 1000 grains weight (26.5 g) were produced in Neda variety in case of 120 plant m^{-2} (Table 3).

Total tiller: Results showed that planting density had significant effect on total tillers numbers at 0.01 probability level (Table 1). Highest tillers numbers (12.6) were obtained in 20 plant m^{-2} planting density while minimum tillers number (2.9) were produced in 120 plant m^{-2} planting density (Table 2). Variety and planting density had not significant effect on total tillers numbers (Table 1). In Intraction effect of variety and planting density, highest tillers numbers (9.48) was observed in Hashemi Tarom variety in case of 20 plant m^{-2} planting density (Table 3).

Fertile tiller: Results showed that planting density had significant effect on total tillers number at 0.01 probability level (Table 1). Highest fertile tiller (12.51) and least fertile tiller (2.9) were produced in 20 and 120 plant m^{-2}, respectively. Variety had not significant effect on fertile tillers numbers (Table 1). Fertile tillers numbers for Hashemi Tarom, Fajr and Neda varieties were 7.33, 4.76 and 6.20, respectively (Table 2). Highest fertile tillers numbers (9.42) were produced in Hashemi Tarom variety in case of 20 plant m^{-2} planting density in intraction effect of variety and planting density (Table 3).

Panicle per m^2: Results showed that planting density had significant effect on panicle m^{-2} at 0.01 probability level (Table 1). Highest panicles m^{-2} (473.3) and the least panicles m^{-2} (270.9) were produced in 120 plant m^{-2} and 20 plant m^{-2} planting densities, respectively (Table 2). Variety had not significant effect on panicle m^{-2} (Table 1). Panicles numbers m^{-2} for Hashemi Tarom, Fajr and Neda varieties were 430.3, 317.6 and 396.7 (Table 2). In intraction effect of variety and planting density, highest panicle m^{-2} (451.8) were produced in Hashemi Tarom in case of 120 plant m^{-2} (Table 3).

Grain yield: Results showed that variety and planting density had significant effect on grain yield at 0.01 probability level. Highest grain yield was obtained in Neda Variety (945 g m^{-2}) and the least grain yield was produced in Hashemi Tarom variety (566 g m^{-2}) while grain yield for fajr variety was 870.1 g m^{-2} (Table 2). The least grain yield was obtained in 20 plant m^{-2} plant density (719.4 g m^{-2}). Increase in plant density can improve grain yield in this experiment. Grain yield was increased in 120 plant m^{-2} plant density for 20.6% compared to grain yield in 20 plant m^{-2} (Table 2). Interaction effects mean showed that highest grain yield (925.7 g m^{-2}) were produced in Neda variety in case of 120 plant m^{-2} (Table 3).

Harvest index: Result showed that plant density had significant effect on harvest index at 0.01 probability level (Table 1). Highest harvest index (44.86%) was obtained in 60 plant m^{-2} plant density and the least harvest index (42.18%) were produced in 100 plant m^{-2} plant density (Table 2). Highest and least harvest index were obtained in Hashemi Tarom and Fajr varieties, respectively while harvest index for Neda variety was 43.11% (Table 2).

DISCUSSION

Results of this experiment showed that vegetative period length was in maximum at low planting density (Table 2). Mobasser (2007) got almost similar result. In this experiment highest plant height was obtained in 20 plant m^{-2} planting density (Table 2). Barari (2007) showed that panicle length can influenced significantly by agronomical treatments but Mobasser (2007) indicated that panicle length is genetical characteristics that is not influenced significantly by planting density. Increase in planting density can decrease spikeletes numbers per panicle (Baloch *et al*., 2002). Counce (1987) showed that panicle density significantly increased with increase of seeding densities, while filled spikelets per panicle were reduced significantly. In this experiment in highest plant density total spikelets per panicle were decreased significantly (Table 2). Tiller per plant and spikeletes per panicle increased with decrease of plant density in direct-seeded rice (Wu *et al*., 1998). Under nonstressed conditions, the responses of yield to the changes of plant densities were determined by a compensatory relationship between plant density and yield components. Increase of plant stand and panicle density were offset by the reduction in seed weight per plant and fertility with the increases of seeding densities. With increase in plant density grain yield was increased because of increase in panicle m^{-2} (Table 2). Miller *et al*. (1991) showed that panicle density was the most important component of yield in rice. According to results panicle m^{-2} had significant correlation with grain yield also fertile spikelets had significant correlation with 1000 grains weight (Table 4).

Table 4: Correlation between yield and yield components of rice varieties

Variety	Grain yield	Total tiller	Panicle m^{-2}	Total spikelets per panicle	Fertile spikelets (%)	1000 grains weight	Harvest index
Grain yield	1						
Total tiller	-0.77 **	1					
Panicle per m^2	0.65*	-0.77 **	1				
Total spikelets per panicle	-0.45 ns	0.39 ns	-0.76*	1			
Fertile spikeletes(%)	-0.22 ns	0.56 ns	0.38 ns	-0.25 ns	1		
1000 grains weight	0.30 ns	-0.29 ns	0.55 ns	-0.55 ns	0.65*	1	
Harvest index	-0.21 ns	-0.06 ns	-0.38	0.14 ns	0.26 ns	0.31	1

ns,*, ** = non significant, significant at 0.05 and 0.01 probability level

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