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Differential response of local and improved varieties of rice to cultural practices

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ABSTRACT

Cultural practices such as N-fertilizer and plant spacing for each rice variety may differ because of their different genetic background. For obtaining the optimum N-fertilizer and plant spacing requirement of two rice varieties (a local and a breeding variety) a field experiment was conducted in RCB design with four replications. Two varieties were treated with three nitrogen levels (45, 85 and 125 kg ha^{-1}) and three plant spacings (15x15, 22.5x22.5 and 30x30 cm). Effect of variety was significant for all of traits, except for thousand seed weight and biomass weight, totally indicating that varieties respond differentially to cultural practices. Results also showed that fertilizer effect was significant for thousand seed weight, plant height and yield, while spacing effect was significant for all of traits, except for thousand seed weight. Two varieties had different biomass production only at third level of nitrogen. Breeding variety produced more yield than local one with application of 85 kg ha^{-1} nitrogen, although local variety also produced its maximum yield with 85 kg ha^{-1} nitrogen. Local variety had an invariable response to different levels of nitrogen, while breeding variety had a variable response. Breeding variety had maximum biomass in 15 cm spacing and local variety did not differentially respond to spacing level. However, biomass of breeding variety was severely reduced with increasing space between hills. Altogether, breeding variety had more harvest index compared to local variety for most combinations of nitrogen and spacing levels, indicating that breeding variety allocated higher material to storage organs and transmitted more products from sources to its sinks (kernels). On the basis of these results, for production of maximum yield local variety must be cultivated with 85 kg ha^{-1} nitrogen and 22.5 cm transplanting space, while breeding variety must be cultivated with 85 kg ha^{-1} nitrogen and 15 cm transplanting space.

Key words: Rice, Nitrogen, Spacing.

INTRODUCTION

Rice is one of the most important food crops grown in Asia. Nitrogen is among the principal factors which limiting yield of lowland rice production around the world. Increasing amounts of mineral fertilizer constitutes a major reason of soil pollution so that minimizing the use of these chemicals is a way to reduce pollution [9].

Nitrogen fertilizer is applied to enhance crop production especially for non-legume plants such as rice. Most researches indicate the importance of N-fertilizer for rice crop but they differ in the optimum doses to be applied. For example, El-Rewainy [3] reported that applying 40 kg N/fed caused significant increase in plant height, number of panicles/m^2, panicle length, panicle weight, number of filled grains/panicle as well as grain and straw yields. Also, El-Batal *et al*. [2] showed that increasing nitrogen rate from 50 to 80 kg N/fed significantly increased plant height, panicle length, number of filled grains/panicle and grain and straw yields, while number of panicles/m^2, panicle weight and harvest index were not significant, but 1000-grain weight decreased. Hari *et al*. [4] showed that there was a significant increase in grain yield with increasing in nitrogen application and it attributed with each additional nitrogen application up to 150-200 kg/ha. Ibrahiem *et al*. [5] reported that number of grains/panicle, 1000-grain weight, panicle weight and grain and straw yields were not significantly affected by increasing nitrogen levels from 30 to 60 kg N/fed. Howevere, Zayed *et al*. [12] found that increasing nitrogen levels up to 165 kg N/ha significantly increased growth and yield and its components. Increasing nitrogen levels from 0 to 70 kg N/fed significantly increased all studied characters in both seasons except 1000-grain weight in 2005 season and grain protein content in 2004 season, which responded to N up to 35 kg N/fed only [9].

With respect to plant density, several studies reported that density is an important factor for limiting grain yield of rice and its components. For example, Maske *et al*. [7] reported that plant height, leaf area index and yield and its components were higher with 15x10 cm than that of 15x15 or 15x20 cm. Zahran [11] indicated that space of 15x15 cm gave the tallest plants, highest number of panicles/m^2 as well as grain and straw yields, while 25 x 25 cm spacing gave the highest number of filled grains/panicle and the highest 1000-grain weight. Shin *et al*. [10] reported that the heading date wasn't affected by plant density of rice. Omina El-Shayieb [8] showed that 10x20 cm spacing gave the highest yield and yield components of Giza 177 rice variety compared with 20x20 or 30x20 cm. Also, Zayed *et al*. [12] reported that the 15x10 cm spacing caused the highest days to heading, leaf area index, number of panicles/m^2 and grain and straw yields compared with wider spacing 15x15 or 15x20 cm; These two spacings caused the highest panicle length, panicle weight, number of filled grains/panicle and 1000-grain weight.

Salem [9] stated that the narrowest spacing of 20x15 cm recorded the highest values of days to heading, leaf area index, plant height, number of panicles/m^2 and grain and straw yields in both seasons compared with wider spacing of 20x20 and 20x25 cm; while both wider spacing recorded the highest values of panicle length, panicle weight, number of filled grains/panicle and 1000-grain weight in both seasons as well as grain protein content in 2005 season.

A narrow spacing may have limitations in the maximum availability of important factors needed for crop production. It is, therefore, necessary to determine the optimum density of plant population per unit area for obtaining maximum yields [1]. The grain yield per unit area depends evidently on the performance of individual plants, panicle density as well as the total number of plants grown on the area. In most studies the performance of individual plants grown with wider spacing was better as compared to the plants with narrower spacing. Hence, a balance has to be brought between the performance of individual plants and the plants density per unit area for obtaining optimum crop yields. Baloch [1] reported that in the case of 20 x 20 cm spacing, 22.5 x 22.5 cm spacing and 25 x 25 cm spacing, corresponding grain yields were 2.30 kg, 2.95 kg and 2.19 kg per plot, respectively. The grain yield of 2.95 kg per plot in case of 22.5 x 22.5 cm spacing was significantly higher (P<0.01) than that of the other two spacings. It was concluded that the spacing of 22.5 x 22.5 cm between hills and rows was most suitable for obtaining optimum grain yield in the rice crop [1].

The objectives of this research were to obtain (1) the optimum N-fertilizer requirement and (2) the optimum level of spacing between hills for two rice varieties, Champa (a local, scented tall variety) and Choram (a breeding, non-scented semi-dwarf variety), cultivated in southern Iran.

MATERIAL AND METHODS

Plant materials consisted two varieties namely Champa, local scented tall rice, and Choram, breeding non-scented semi-dwarf rice. Field experiment was conducted in a factorial randomized complete block design with four replications. Three factors were the two above-mentioned varieties, N-fertilizer applied after tillering (at three levels: 45, 85 and 125 kg ha^{-1}) and spacing between hills (at three levels: 15 x 15, 22.5 x 22.5 and 30 x 30 cm). Thirty days-old seedlings were transplanted in plots of 2 x 2 m area. Following traits were recorded at desirable times: plant height (PLH, cm) spikelet number (SPN), grain number/panicle (GNP), thousand seed weight (TSW; g), fresh biomass (FB; g/m^2), grain yield (GY; g/m^2) and harvest index (HI; %). Collected data was analyzed using spss.11 software and graphs were drawn in excel environment.

RESULTS AND DISCUSSION

Analysis of variance (ANOVA)

Results of ANOVA for different traits showed that fertilizer effect was significant for thousand seed weight, plant height and yield (at 1%, 1% and 5%, respectively), while spacing effect was significant for all of traits, except for thousand seed weight (Table 1). Variety effect was significant for all of traits, except for thousand seed weight and biomass weight, indicating that varieties respond differentially to cultural practices. Fertilizer * spacing interaction effect was significant only for biomass weight and harvest index, while fertilizer * variety interaction was not significant for all of traits, except for plant height, indicating that varieties did respond differentially to fertilizer level for this trait. Spacing * variety interaction was significant for grain number, biomass weight and yield, indicating that varieties did differentially respond to spacing level. Tertiary interaction effect of fertilizer * spacing * variety was significant only for grain number (table 1).

Comparison of varieties

Two varieties were compared in different traits as showed in table 2. As seen in the table, the two varieties differ in all of studied traits, except thousand-seed weight. Breeding variety, Choram, showed superiority over local variety, Champa, in spikelet number (350 vs. 293), grain number (98 vs. 89), yield (556 g/m^2 vs. 523 g/ m^2) and harvest index (46% vs. 41%), while local variety produced higher plant height and higher fresh biomass than improved variety (136 cm vs. 87 cm and 1269 g/m^2 vs. 1219 g/m^2, respectively). On the basis of these results, it seems that despite of producing higher biomass, local variety could not allocate more material to economic part of plant; that is could not transmit more carbohydrate from sources toward sinks (kernels).

Fertilizer effect on varieties

Two varieties were compared in three selected traits under three levels of nitrogen as shown in Figure 1. It can be seen that two varieties did not produce different biomass at two first levels of nitrogen; while they produced different biomass at third level of nitrogen. However, breeding variety produced less biomass than local one with application of 125 kg ha^{-1} nitrogen.

Breeding variety produced more yield than local one with application of 85 kg ha^{-1} nitrogen, although they had not difference at first and third level of nitrogen. However, as seen in figure 1, local variety also produced its maximum yield with 85 kg ha^{-1} nitrogen.

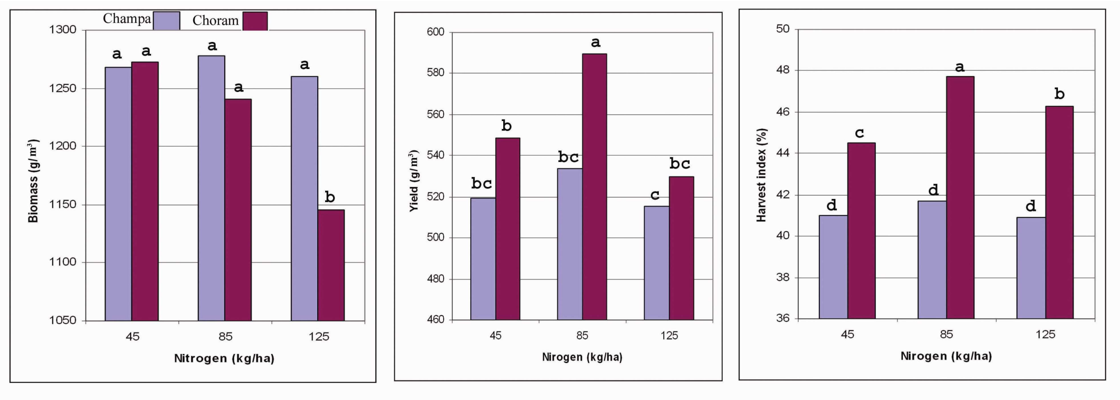

Figure 1. Comparison between two varieties in different traits as affected by three nitrogen levels
Means with a common letter have not significant difference at 5% level of probability

Both varieties obtained highest harvest index with 85 kg ha^{-1} nitrogen. It is interesting that in three selected traits local variety had an invariable response to different levels of nitrogen (Figure 1), while breeding variety had a variable response. These results indicate that local varieties have more stability than breeding varieties, although they allocate less biomass to yield; that is, they can not efficiently transmit synthesized material from sources toward sinks (kernels) [2, 3].

Spacing effect on varieties

Two varieties were compared in three selected traits at three levels of transplanting space as shown in Figure 2. As seen, breeding variety had maximum biomass in 15 cm spacing and local variety did not differentially respond to spacing. However, biomass of breeding variety was severely reduced with increasing space between hills.

Breeding variety produced more yield than local one with 15 cm spacing, while local variety did not respond differentially to spacing. Breeding variety obtained highest harvest index with 22.5 cm spacing. The two varieties produced lowest grain yield at 30 cm spacing. Jayawardena and Abeysekera [6] also reported that tested hybrid rice varieties produced lowest grain yield at 30 cm spacing. It is interesting that again in three selected traits local variety had an invariable response to different levels of spacing (Figure 2), while breeding variety had a variable response. These results indicate that local varieties have more stability than breeding varieties, although they can not efficiently transmit synthesized material from sources toward sinks (kernels).

Local variety had an invariable harvest index at three levels of spacing. However, breeding variety had higher harvest index at three spacing levels, although it had significantly higher harvest index at 22.5 cm. In the case of this variety, it seems that at closer spacing mutual shading may reduce the maximum utilization of available sunlight for accumulating maximum dry matter [6], and at wider of an optimum spacing (22.5 cm) plant does not adequately spread its canopy to utilize the maximum sunlight.

Table 1. Result of ANOVA for different traits.

Source of variation	Spikelet number	Grain number/panicle	TSW (g)	PLH (cm)	Fresh biomass (g/m^2)	Grain yield (g/m^2)	Harvest index (%)
Fertilizer	5256.51	478.47	23.013**	172.167**	31954.167	9751.952*	34144.04
Spacing	160077.26**	922.43**	2.667	214.292**	245054.167**	85694.767**	14.46*
Variety	58938.89**	1358.94**	7.094	42973.347**	44005.556	19658.140*	30.48**
Fertilizer x Spacing	944.31	128.19	5.292	5.083	109677.083*	5868.052	396.75*
Fertilizer x Variety	4483.01	129.67	2.035	26.389*	21943.056	2618.462	24.71
Spacing x Variety	33559.26**	814.64**	1.553	0.514	310043.056**	85268.794**	6.13
Fertilizer x Spacing x Variety	910.64	670.37**	3.510	11.181	26386.806	1755.418	17.93
Error	1993.31	155.85	3.129	8.935	37738.235	3032.098	15.32
Mean	321.81	93.511	23.57	111.79	1244.17	539.35	43.55
C.V. (%)	3.33	2.07	1.02	2.63	2.22	1.99	1.05

* and ** indicate significant differences at 5% and 1% levels of probability.

Table 2. Comparison between two studied varieties in different traits.

Variety	Spikelet number	Grain number	TSW (g)	PLH (cm)	Biomass (g/hole)	Yield (g/hole)	Harv. index (%)
Champa	293.19^{b}	89.17^{b}	23.88^{a}	136.22^{a}	1268.89^{a}	522.83^{b}	41.20^{b}
Choram	350.42^{a}	97.86^{a}	23.26^{a}	87.36^{b}	1219.44^{b}	555.87^{a}	45.89^{a}
S.E.	7.44	2.08	0.29	0.50	32.38	9.18	0.45

S.E: standard error; Means with a common letter have not significant differences at 5% level of probability.

Table 3. Comparison of mean yield of two varieties under different spacing and nitrogen levels.

Spacing (cm)	15 cm			22.5 cm			30 cm			
Nitrogen application (kg/ha)	45	85	125	45	85	125	45	85	125	Grand mean
Cahmpa	516.6^{c}	534.5^{c}	486.4^{c}	500.6^{c}	586.6^{ab}	534.9^{bc}	540.6^{a}	480.6^{bc}	524.6^{ab}	522.83^{b}
Choram	646.1^{b}	710.2^{a}	644.8^{b}	553.7^{bc}	612.7^{a}	541.1^{bc}	446.1^{cd}	445.4^{cd}	402.8^{d}	555.87^{a}
S.E.		27.53			27.53			27.53		9.18

S.E: standard error; Means with a common letter have not significant differences at 5% level of probability.

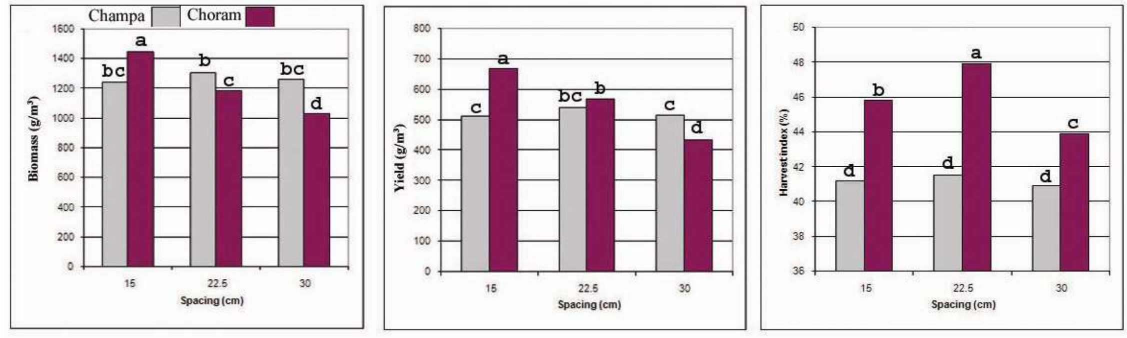

Figure 2. Differential response of two varieties to transplanting space

Means with a common letter have not significant difference at 5% level of probability

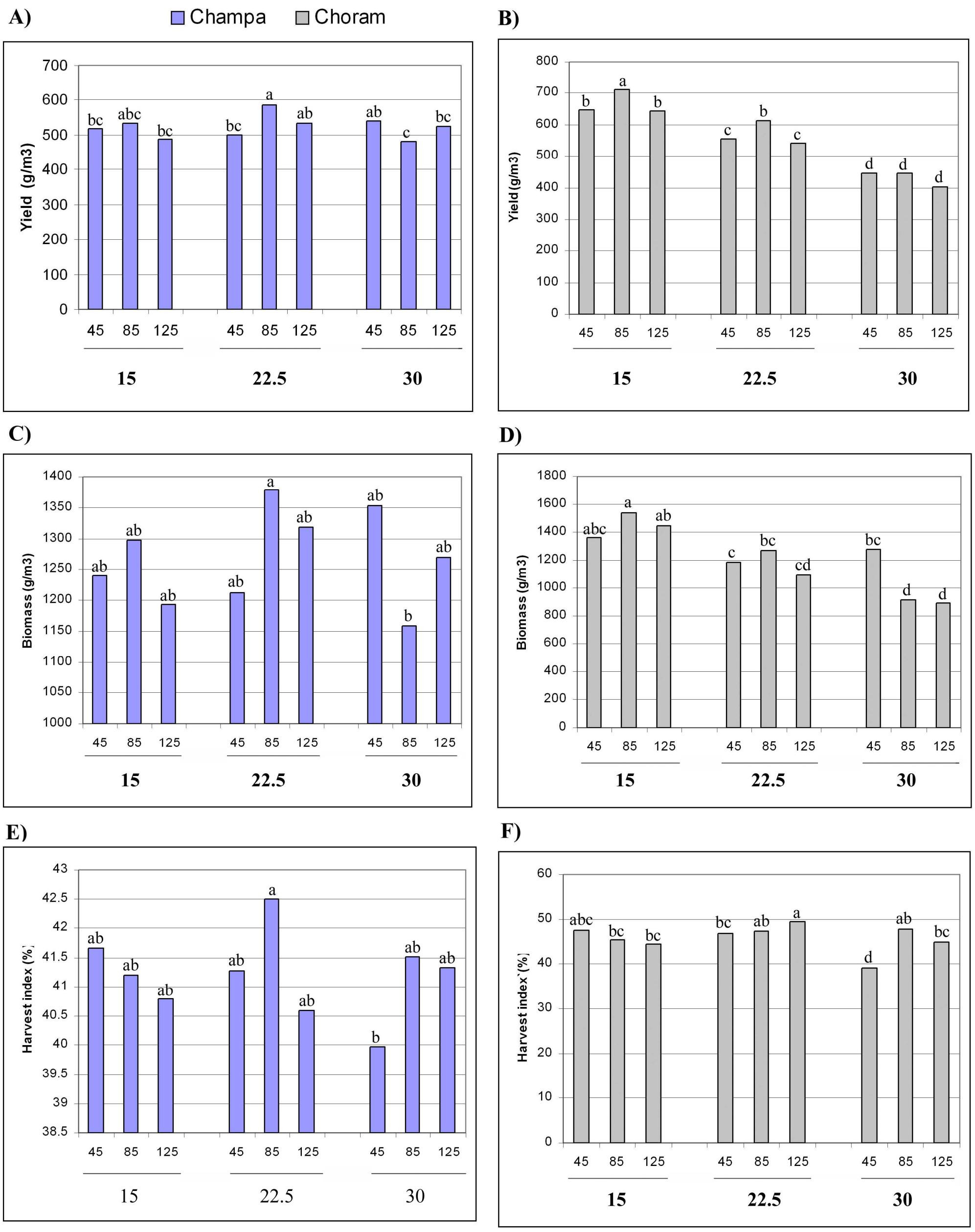

Figure 3. Response of two varieties to simultaneous effect of nitrogen and transplanting space

Means with a common letter have not significant difference at 5% level of probability.

Simultaneous effect of nitrogen and spacing on varieties

Comparison between two varieties in yield at different levels of nitrogen and spacing is shown in Table 3. Local variety, Champa, showed maximum yield with 85 kg ha^{-1} nitrogen and 22.5 cm transplanting space, while breeding variety, Choram, showed maximum yield with 85 kg ha^{-1} nitrogen and 15 cm transplanting space.

As shown in figure 3, local variety had more stability with different levels of nitrogen and spacing for three selected traits (e. g. fresh biomass, grain yield and harvest index). As seen in the figure, breeding variety had highest biomass with 85 kg ha^{-1} nitrogen and 15 cm transplanting space, while local variety had highest biomass with 85 kg ha^{-1} nitrogen and 22.5 cm transplanting space. This did affect harvest index of two varieties. Altogether, breeding variety had more harvest index compared to local variety for most combinations of nitrogen and spacing levels, indicating that breeding variety allocated higher material to storage organs and transmitted more products from sources to its sinks (kernels).

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