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A Survey on the Morphological Effects of Rice Promising Lines (*Oryza sativa L.*) In Response to the Changes in Planting Density and Nitrogen Content

[1]*Mehdi Rajabi Shahrestani,* [1]*Mohammad Ali Esmaeili,*
[1]*Hematollah Pirdashti and* [2]*Sha pur Abdollahi*

[1]Sari Agricultural Sciences and Natural Resources University,
[3]Rice Research Institute of Iran, Rasht, Iran

Abstract: In order to study physiological indices and different nitrogen fertilizer and plant density effect on yield and yield components in promising lines of rice an experiment was conducted during 2009 at Rice Research Institute of Iran (Rasht). Experiment was arranged as factorial based randomized complete block design with three replications. Nitrogen fertilizer at four levels (0, 100, 200 and 300 kg net nitrogen ha-1), planting density (30×15 and 25×25 cm) and promising lines of rice (416, 203 and line 2 Hybrid) were the treatments. Results showed that different nitrogen fertilizer had significant effect on different traits such as grain yield, grain number per panicle, panicle number per unit area, harvest index, fertile tiller number and fertility number. Interaction effect of fertilizer and density showed that highest grain yield was recorded when rice genotypes were transplanted as 25×25 or 30×15 cm with 200 kg net nitrogen ha-1. Maximum grain number per panicle, also, was belonged line 2 Hybrid. In terms of harvest index, fertility percentage and fertile tiller number, the highest amounts were obtained when line 416 planted with 30×15 cm plus 200 or 300 kg N ha-1application. Results showed that most treatments had significant effect on physiological indices. Accordingly, crop growth rate and leaf area index showed highest significant probability in terms of different factors interaction. Adversely, relative growth rate did not show significant response. Results showed that maximum LAI was belonged to line 203 with 100 kg net nitrogen ha-1. Crop growth rate, however, was highest in line 2 hybrid with 300 kg N ha-1 and net assimilation rate for line 416 with 200 kg N ha-1. Generally, planting density of 25×25 in all studied lines had the higher CGR. Furthermore, grain yield had a significant and positive correlation with panicle number per unit area (r=0.59**), fertile tiller (r=0.53**) and harvest index (r=0.47**), however, grain number per panicle showed negative and significant (r=-0.39**) correlation. Among traits LAD and CGR had a positive and significant correlation (r=0.63** and r=0.3**, respectively) with total dry weight (TDW) but RGR had negative and significant (r=-0.25*) correlation.

Key words: Rice · Planting density · Growth indices · Nitrogen fertilizer · Promising lines

INTRODUCTION

Rice is the main food for about a half of world's people and for the most people who live in the developing countries [1]. Rice is the major product of most Asian countries and more than half of lands under cultivation in this continent are allocated to rice agriculture [2]. Overpopulation, increasing need of humanity to food and limitation of manufacturing resources all illustrate this fact that the only way to get to more productivity is increasing performance in unit level and this is possible through producing and using new and high yield numbers of rice along with applying proper methods in cultivation [3]. Today, people are forced to use chemical fertilizer to provide Nitrogen for different types of rice, because taking use of these fertilizers increases productivity [11]. Access to nitrogen for crop plants is one of the important limiting factors of agricultural production [5]. Nitrogen nutrition is important because it has a significant effect on growth parameters and physiological traits of rice plant.

Corresponding Author: Mehdi Rajabi Shahrestani, Sari Agricultural Sciences and Natural Resources University,

In terms of quantity, the amount of necessary nitrogen for vegetative growth is much more than necessary amount for reproductive growth [6]. The physiological and morphological characteristics of plants often change in response to the amount of access to the resources (such as fertilizer) [7]. Mostafavi Rad and Tahmasebi Sarvestani [8] through surveying 3 levels of nitrogen fertilizer on rice genotypes concluded there is meaningful difference in grain yield between genotypes and different levels of nitrogen fertilizer and increased performance can be attributed to factors such as the length of panicle, number of grains in a panicle and higher harvest index. In this examination, maximum performance obtained by using 300 kg urea ha $^{-1}$. In a survey to select the most suitable plant density, for DORFAC and KADOUS rice types, a density of 25×25 cm and the best content of 135 kg net nitrogen ha^{-1} are reported [9]. In densities higher than optimal level, plants weight loss is so much that counteracts performance increase which is expected to be resulted from increasing the number of plants per unit area [2]. The greater the distance between plants cause each plant to receive more light due to having more space around itself and to perform its photosynthetic activity better than before [10]. Applying proper agricultural management will help us getting to optimal performance in rice promising lines, as we can see about introducing different types in past, applying agricultural management in consumption of nitrogen fertilizer and plant density managed to enhance performance efficiency [4]. We can be hopeful to modify types with high quality and quantity by recognizing physiological process [11]. Recognition and evaluation of growth indices is very important in analyzing its factors and elements and the total produced dry material is a criterion for performance potential. Methods that are used to determine product growth elements are introduced as Growth Indices (7). Pirdashti (1377) quoting from Skoo Gorou expressed that performance in rice is dependent on attributes such as crop growth rate, relative growth rate, leaf area, leaf area duration, net assimilation rate, specific leaf area (2). Nourbakhshian and Rezaiee (1378) reported that crop growth rate (CGR) and relative growth rate (RGR) in rice had positive and meaningful correlation with grain yield in flowering stage (13). There is a direct relation between increase in amount of photosynthesis and increase in leaf area duration (LAD) during the grain filling (26). Murchie *et al*. (1999) expressed that in rice high-yielding varieties, NAR with RGR, specific leaf weight (SLW) had positive correlation (23). The purpose of this examination is to survey different plant densities and different levels of nitrogen fertilizer on different attributes including yield and yield component of rice promising lines and determining relations between these attributes and also evaluating Growth Indices in rice promising lines and comparing and selecting appropriate line are considered by the help of these indicators.

MATERIALS AND METHODS

This examination is conducted in crop year 2009, in the Rice Research Institute of Iran (Rasht) located at km 10 road Rasht - Qazvin. Latitude and longitude of project location are 49 degree and 36 eastern minutes and 37 degree and 16 northern minutes respectively. Height above sea level was 7 meters. Above research is arranged as factorial based in form of completely randomized block design in three repetitions. Nitrogen fertilizer in four levels (0, 100, 200, 300 kg net nitrogen ha $^{-1}$) as the first factor and planting densities of 30×15 and 25×25 cm as the second factor and three promising rice lines (416,203 and line 2 Hybrid) as third factor were considered. During this period all the agricultural operations are done based on technical instructions of the Rice Research Institute of Iran. A month after grain planting, 30-day-old seedlings are translated to the main land and are planted as single seedlings in plots size 4×4 meters. In the stage of traits maturity the number of tiller, total number of grains and the percentage of hollow grains are measured by selecting 10 plants from per plot. At harvest time, after removing the margin, about 4 square meters from middle of every plot was harvested and after thrashing, they were cleaning and weighted. The plots function was calculated based on 14% humidity. In order to evaluate physiological indicators, sampling for determining dry weight and leaf area began 20 days after transplanting and in 15-day intervals till the flowering stage from 4 random plants from the treatments. The obtained data were analyzed by using statistical software SAS and averages were compared by using LSD tests in probability level of 5 percent.

RESULTS AND DISCUSSION

Analyzing Growth Indices: Citing the analysis of variance table (Table 1), in most treatments, Growth Indices showed meaningful difference in probability level of 1 percent. Based on this fact all the interactions became meaningful in the level of 1 %.

Table 1: Analyzing variance (Mean-square) fertilizer interaction, density and genotype on physiological indicators

Sources of variation	Freedom degree	LAI	LAD	CGR	RGR	NAR	SLW	TDW
Repetition	2	1.77	1.16	16.70	41×10^{-7}	0.13	83.74	75.09
Genotype	2	0.22^{ns}	1.76^{ns}	30.98*	16×10^{-6ns}	1.56**	2074.05**	600.85**
Fertilizer	3	76.24**	26.48**	65.20**	50×10^{-7ns}	1.92**	2126.08**	1318.94**
Genotype ×Fertilizer	6	8.08**	2.25^{ns}	91.71**	92×10^{-7ns}	2.34**	197.68^{ns}	166.21**
Density	1	52.92**	21.34**	116.05**	34×10^{-6}*	2.94**	550.95^{ns}	3662.96**
Fertilizer ×Density	3	17.82**	1.05^{ns}	39.11**	50×10^{-7ns}	0.39^{ns}	330.98^{ns}	101.29**
Genotype × Density	2	39.66**	6.50**	23.69*	92×10^{-7ns}	1.50**	430.18^{ns}	504.77**
Genotype×Fertilizer×Density	6	29.05**	9.36**	30.20**	20×10^{-6}*	0.95**	1320.72**	429.77**
Test Error	46	0.88	1.02	6.56	70×10^{-7}	0.20	167.42	7.41
Coefficient Variation(percentage)	of	12.84	18.36	28.88	25.51	29.56	10.61	4.66

* &** are respectively meaningful in probability level of 1 & 5 percent. ns: Lack of meaningful differences

Table 2: Mutual effect of fertilizer and variety on studied Growth Indices

Factor		LAI	CGR	NAR	TDW
Genotype	Fertilizer (kg ha-1)				
	Testifier	6.22^{d}	3.77^{fg}	1.87^{bc}	43.05^{e}
	100	7.57^{bcd}	13.12^{ab}	1.77^{bc}	52.37^{d}
Line 416	200	6.02^{d}	9.92^{bcde}	2.87^{a}	56.23^{cd}
	300	9.54^{a}	8.41^{bcdef}	0.82^{e}	70.57^{a}
	Testifier	4.47^{e}	9.81^{bcde}	2.19^{ab}	43.17^{e}
	100	10.32^{a}	11.77^{bc}	1.30^{cde}	64.13^{b}
Line 203	200	6.17^{d}	0.52^{g}	1.04^{cde}	56.13^{cd}
	300	7.91^{ec}	5.96^{efg}	0.89^{de}	57.91^{c}
	Testifier	4.31^{e}	10.81^{bcd}	1.62^{bcde}	52.65^{d}
	100	9.93^{a}	8.23^{cdef}	1.26^{cde}	64.07^{b}
Line 2 hybrid	200	6.39^{cd}	6.48^{defg}	1.20^{cde}	68.55^{ab}
	300	9.01^{ab}	16.61^{a}	1.70^{bcd}	71.16^{a}

* Averages having similar words in one column, according to LSD test in probability level of 5%, have no meaningful difference with each other.

Table 3: Mutual effect of density and variety on studied Growth indices

Factor		LAI	CGR	RGR	NAR	TDW
Genotype	Density					
Line 416	25×25	5.49^{c}	11.20^{a}	0.010^{b}	2.14^{a}	57.39^{c}
	15×30	9.18^{ab}	6.41^{ab}	0.010^{b}	1.52^{b}	53.72^{c}
Line 203	25×25	7.82^{c}	8.29^{ab}	0.010^{b}	1.27^{ab}	65.22^{b}
	15×30	6.62^{a}	7.24^{b}	0.009^{b}	1.44^{ab}	45.45^{d}
Line 2 hybrid	25×25	6.08^{bc}	10.92^{ab}	0.009^{b}	1.82^{ab}	73.79^{a}
	15×30	8.74^{a}	9.15^{ab}	0.013^{a}	1.06^{b}	54.43^{c}

* Averages having similar words in one column, according to LSD test in probability level of 5%, have no meaningful difference with each other.

In surveying interaction between fertilizer and varieties, on the attributes studied (Table 2) the highest LAI is related to the line 203 with Fertilizer level of 100 kg N ha $^{-1}$ and in interaction between density and varieties (Table 3) line 416 and line 2 hybrid in density of 30×15 and line 203 in planting density of 25×25, has a higher LAI and in general the highest LAI was belonged to line 2 hybrid with planting density of 30×15 cm. Associated with the attribute CGR, line 2 hybrid in fertilizer level of 300 and for NAR, line 416 in fertilizer level of 200 with 16.61 and 2.87 respectively showed the best average (Table 2). Also, planting density of 25×25, in all the lines, had a higher CGR (Table 3). About RGR, only line 2 hybrid with planting density of 30×15 showed meaningful difference with other treatments and had the highest RGR in comparison with other treatments. Also, line 416 with density of 25×25 and line 2 hybrid with planting density of 30×15 with 2.14 and 1.06 respectively showed the most and the least NAR (Table 3).

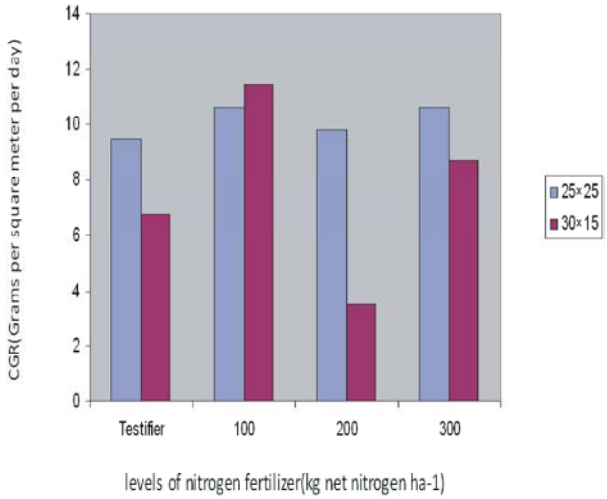

Fig. 1: Mutual effect of fertillizer and density on CGR

According to the Figure 1, CGR related to the density of 25×25 was more than planting density of 30×15 in every fertilizer levels except for fertilizer level of 100. In this regard, 25×25 density in fertilizer level of 300 and planting density of 30×15 in the fertilizer level of 100, showed the most LAI. In another words, in low density, more fertilizer level, a higher LAI is shown, the reverse in high density is also true. This result showed no meaningful effect about other attributes. In studying mutual effect for TDW (Total Dry Weight), all the mutual effects became meaningful in probability level of 1% (Table 1). In studying interaction between variety and fertilizer, the highest dry weight for lines 203 and 416 were respectively observed in fertilizer level of 100 and 300 kg and in general, line 2 hybrid with average of 71.16 had the highest dry weight which it was gained in the fertilizer level of 300 kg (Table 2). Results from table 1 for SLW (Special Leaf Weight) showed that the effect of two factors, fertilizer and variety, on this attribute became meaningful in the probability level of 1% and had no meaningful effect on the other factor. Also for mutual effects, the mutual effect of fertilizer, variety and density became meaningful ($p<0.01$) so that the highest special leaf weight with average of 155.30 for line 2 hybrid with planting density of 15×30 and fertilizer level of 200 kg was obtained (Table 4). Results of table 1 for LAD showed that the effect of variety on this attribute didn't become meaningful, but the effect of fertilizer and density on this attribute in probability level of 1% became meaningful.

Table 4: Mutual effect of Genotype¡ density and Fertilizer on One Thousand Grain Weight¡ Harvest Index and Special Leaf Weight

	Factor				
Genotype	Density	Fertilizer	One Thousand Grain Weight	Harvest Index	Special Leaf Weight
		Testifier	27.83^{efg}	47.33^{fgh}	141.18^{abc}
	25×25	100	27.96^{c-g}	47.00^{gh}	119.62^{b-g}
		200	28.46^{ab}	50.66^{b-e}	138.52^{abc}
		300	28.33^{a-d}	53.66^{a}	97.69^{fgh}
Line 416					
		Testifier	28.30^{a-e}	46.33^{h}	123.07^{b-f}
	15×30	100	28.16^{a-f}	48.33^{e-h}	117.26^{c-h}
		200	28.10^{b-f}	49.66^{c-g}	97.03^{gh}
		300	28.10^{b-f}	51.33^{a-d}	111.77^{d-h}
		Testifier	28.26^{a-e}	47.00^{gh}	119.68^{b-g}
	25×25	100	28.03^{b-g}	49.66^{c-g}	102.00^{e-h}
		200	28.43^{abc}	50.66^{b-e}	121.24^{b-g}
		300	27.60^{g}	50.00^{b-f}	108.82^{d-h}
Line 203					
		Testifier	28.26^{a-e}	46.33^{h}	144.67^{ab}
	15×30	100	27.86^{d-g}	48.66^{d-h}	102.80^{e-h}
		200	28.30^{a-e}	49.66^{c-g}	111.77^{d-h}
		300	28.10^{b-f}	49.66^{c-g}	108.74^{d-h}
		Testifier	28.43^{abc}	48.33^{e-h}	149.77^{a}
	25×25	100	28.43^{abc}	50.00^{b-f}	144.30^{ab}
		200	28.26^{a-e}	51.66^{abc}	121.23^{b-g}
		300	28.23^{a-e}	51.00^{b-e}	131.93^{a-d}
Line 2 hybrid					
		Testifier	28.16^{a-f}	41.33^{i}	139.75^{abc}
	15×30	100	28.43^{abc}	49.00^{c-h}	93.36^{h}
		200	27.70^{fg}	52.66^{ab}	155.30^{a}
		300	28.63^{a}	51.66^{abc}	124.06^{b-e}

* Averages having similar words in one column, according to LSD test in probability level of 5%, have no meaningful difference with each other.

Table 5: Variance Analysis (Mean-square) mutual effect of fertilizer, density and genotype on yield and yield component

Source of Changes	Freedom Degree	Grain yield	Panicle Number in Per Unit Area	Hollow Grain Percent	Total Number of Grains in Panicle	One Thousand Grain Weight	Fertility Percent	Fertile tiller Number	Harvest Index
Repetition	2	0.21	2539.05	2.37	606.12	0.004	2.37	6.51	9.72
Genotype	2	2.37*	2617.05^{ns}	43.87**	594.66*	0.20*	43.87**	4.38^{ns}	1.55^{ns}
Fertilizer	3	9.79**	170214.37**	52.34**	3129.05**	0.017^{ns}	52.34**	459.27**	98.82**
Genotype×Fertilizer	6	0.61^{ns}	630.31^{ns}	11.37**	196.14^{ns}	0.34**	11.37**	1.09^{ns}	10.09**
Density	1	4.76**	237590.22**	23.34**	66.12^{ns}	0.003^{ns}	23.34**	11.68^{ns}	19.01**
Fertilizer×Density	3	2.16**	9780.59**	2.23^{ns}	51.45^{ns}	0.26**	2.23^{ns}	3.49^{ns}	7.08*
Genotype×Density	2	0.16^{ns}	6782.38*	1.84^{ns}	528.50*	0.041^{ns}	1.84^{ns}	16.22*	1.38^{ns}
Genotype×Fertilizer×Density	6	0.10^{ns}	2370.75^{ns}	4.56^{ns}	245.38^{ns}	0.17*	4.56^{ns}	6.03^{ns}	8.62**
Test Error	46	0.47	1582.93	2.86	148.13	0.059	2.86	4.13	2.01
Coefficient Variation (Percentage)	of	13.50	12.56	14.88	11.35	0.86	1.91	12.25	2.88

* &** are respectively meaningful in probability level of 1 & 5 percent. ns: Lack of meaningful differences

Table 6: Mutual effect of fertilizer and density on yield and yield component

Factor		Grain yield	Panicle Number in Unit Area	One Thousand Grain Weight	Harvest Index
Density	Fertilizer				
25×25	Testifier	4.22^{c}	177.77^{d}	28.17^{a}	47.55^{c}
	100	4.98^{bc}	215.11^{d}	28.14^{a}	48.88^{bc}
	200	5.26^{bc}	316.44^{b}	28.38^{a}	51.00^{ab}
	300	4.82^{bc}	327.11^{b}	28.05^{a}	51.55^{a}
30×15	Testifier	4.04^{c}	242^{cd}	28.24^{a}	44.66^{d}
	100	5.04^{bc}	303.11^{bc}	28.15^{a}	48.66^{bc}
	200	6.58^{a}	459.55^{a}	28.03^{a}	50.66^{ab}
	300	5.67^{ab}	491.33^{a}	28.27^{a}	50.88^{ab}

* Averages having similar words in one column, according to LSD test in probability level of 5%, have no meaningful difference with each other.

Analysis of Yield and Yield Component: The table of analysis of test data variance for grain yield (Table 5) implies that factor F (different levels of Nitrogen) and factor D (plant density) became meaningful in probability level of 1% which represents the impact of different levels of each factor on promising lines. In studying mutual effects of factors, the mutual effect of genotype and fertilizer and also the mutual effect of density and fertilizer in probability level of 1% and mutual effect of genotype and density in probability level of 5%, became meaningful. By studying the mutual effect of fertilizer and density it was revealed that the highest grain yield in two planting densities of 25×25 and 15×30 is related to fertilizer level of 200 kg N ha^{-1} (Table 6). One thousand grain weight is one of the important components of performance in rice which is a genetic trait and differs in different types of rice and its amount is dependent on the conditions in maturity period. Since grain size inside the rice is controlled by its crust, these changes of this trait are not so much (27). Mutual effect of rice type in different contents of nitrogen fertilizer for this attribute became meaningful ($p<0.01$) which represents different responses from rice types in different amounts of fertilizer (Table 5). These results are consistent with the founding of Mostafavi Rad and Tahmasbi Sarvestani (19). The highest one thousand grain weight 28.43 was belonged to line 2 hybrid; this line also had the most grain number in each panicle (Tables 5&7). In this study it was revealed that the mutual effect of fertilizer, variety and density in probability level of 5% became meaningful and its highest average obtained in line 2 hybrid with density of 15×30 and fertilizer level of 300 kg N ha^{-1}(Table 4). Result showed (Table 5) that different rice types, in term of hollow grain numbers, has meaningful difference in the level of 1% and two other factors also had different impact on this attribute ($p<0.01$). Line 2 hybrid also had the most percent of hollow grain (Table 8). It seems like the produced photosynthetic materials were not enough to be allocated to the grains, in the other words, because of source limitation in these rice types all tanks were not filled. This result was in consistent with results gained from Yamamoto et al. (1991) and Peng *et al*. (1999) (30&24). In the same field, Ashraf *et al*. (1994) showed that reducing the capacity of allocating photosynthetic materials from source to tank can be another factor for fertility restriction (15). On the other hand, Honarnejad (14) stated that the number of hollow grains increases in the late rice types, this survey is in consistent with the results of our test, that is because line hybrid by having longer growth period than two other lines, has more

Table 7: Mutual effect of fertilizer and variety on yield and yield component

Factor		Hollow Grain Percent	One Thousand Grain Weight	Fertility Percent	Harvest Index
Genotype	Fertilizer				
Line 416	Testifier	11.16^{bcd}	28.06^{abc}	88.83^{abc}	46.83^{ef}
	100	8.83^{cd}	28.06^{abc}	91.16^{ab}	47.66^{de}
	200	8.50^{d}	28.28^{abc}	91.50^{a}	50.16^{abcd}
	300	12.50^{b}	28.21^{abc}	87.50^{c}	52.50^{a}
Line 203	Testifier	12.00^{bc}	28.26^{abc}	88.00^{c}	46.66^{ef}
	100	9.83^{bcd}	27.95^{bc}	90.16^{abc}	49.16^{cde}
	200	9.83^{bcd}	28.36^{ab}	90.16^{abc}	50.16^{abcd}
	300	12.33^{b}	27.85^{c}	87.66^{abc}	49.83^{bcd}
Line 2 hybrid	Testifier	10.50^{bcd}	28.30^{abc}	89.50^{abc}	44.83^{f}
	100	12.00^{bc}	28.43^{a}	88.00^{bc}	49.50^{cd}
	200	12.33^{b}	27.98^{abc}	87.66^{c}	52.16^{ab}
	300	16.66^{a}	28.43^{a}	83.33^{d}	51.33^{abc}

* Averages having similar words in one column, according to LSD test in probability level of 5%, have no meaningful difference with each other.

Table 8: Simple effect of variety and density on yield and yield component

Factor	Performance	One Thousand Grain Weight	Percent of Hollowness	Fertility Percent	Harvest Index
Genotype					
Line 416	5.43^{a}	28.15^{ab}	10.25^{b}	89.75^{a}	49.29^{a}
Line 203	4.84^{b}	28.10 ^{b}	11.00^{b}	89.00^{a}	48.95^{a}
Line 2 Hybrid	4.96^{b}	28.28 ^{a}	12.87^{a}	87.12^{b}	49.45^{a}
Density					
25×25	4.82 ^{b}	28.19^{a}	10.80^{b}	89.19^{a}	49.75^{a}
30×15	5.33^{a}	28.17 ^{a}	11.94^{a}	88.05^{b}	48.72^{b}

* Averages having similar words in one column, according to LSD test in probability level of 5%, have no meaningful difference with each other.

Table 9: Mutual effect of variety and density on yield and yield component

Factor		Panicle Number in Unit Area	Total Number of Grains	Fertile Tiller Number
Genotype	Density			
Line 416	25×25	258.66^{b}	105.16^{a}	16.16^{a}
	30×15	390.50^{a}	101.91^{a}	17.75^{a}
Line 203	25×25	252.00^{b}	107.08^{a}	15.75^{a}
	30×15	388.66^{a}	103.33^{a}	17.66^{a}
Line 2 Hybrid	25×25	266.66^{b}	106.50^{a}	16.66^{a}
	30×15	342.83^{a}	119.25^{a}	15.58^{a}

* Averages having similar words in one column, according to LSD test in probability level of 5%, have no meaningful difference with each other.

Table 10: Simple effect of fertilizer and variety on yield and yield component

Factor	Performance	Total Number of Grain in Panicle	Number of Panicles in Unit Area	Fertile Tiller Number
Genotype				
Line 416	5.43^{a}	103.54^{b}	324.58^{a}	16.95^{a}
Line 203	4.84^{b}	105.20^{b}	320.33^{a}	16.70^{a}
Line2 Hybrid	4.96^{b}	112.87^{a}	304.75^{a}	16.12^{a}
Fertilizer				
Testifier	4.13^{c}	122.05^{a}	209.89^{c}	11.05^{c}
100	5.01^{b}	114.33^{a}	259.11^{b}	13.61^{b}
200	5.92^{a}	94.11^{b}	388.00^{a}	20.33^{a}
300	5.24^{b}	98.11^{b}	409.22^{a}	21.38^{a}

* Averages having similar words in one column, according to LSD test in probability level of 5%, have no meaningful difference with each other.

hollow grains. The highest percent of fertility and consequently the least percent of hollow grains belong to line 416 with fertilizer level of 200 kg (Table 7). Many of the researchers connect the percentage of hollow grains and fertility to other factors such as climate factors during pollination and stated their role between 60 to 97% (32, 28). By increasing harvest index, we can increase performance potential of new rice types (22). The maximum harvest index (HI) was related to the line 416, this result obtained in fertilizer level of 300 kg and in the planting density of 25×25 (Tables 6 &7). According to the table 7, the least harvest index was related to the line 2 hybrid, this survey was in consistent with results of Yamauchi *et al*. (31). They expressed that harvest index of hybrid rice types in comparison with pure lines was either lower or similar which is representative of producing dry material towards the grain yield. Also, in this research it was revealed that the mutual effect of fertilizer, variety and density became meaningful in probability level of 1% (Table 5) and its highest average was belonged to line 416 with density of 25×25 and fertilizer level of 300 kg N ha $^{-1}$. The results of table 5 show that the amounts of fertilizer had meaningful effect on the number of fertile tiller in each square meter ($p<0.01$) and for mutual effects, only the mutual effect of genotype and density became meaningful in the level of 5%. According to the obtained results (Table 9) the highest number of fertile tiller is related to the line 416 and in density of 30×15 which consequently the highest number of panicle in per unit area was related to this line. The table of average comparison (Table 10) for amounts of fertilizer about the attribute of fertile tiller number indicates that testifier treatment, with average of 11.00 in class c and fertilizer level of 100 kg N ha $^{-1}$, with average of 13.61 in class b and fertilizer levels of 200 & 300 respectively with averages of 21.38 & 20.33 were placed in class a. The obtained results were in consistent with results of Mostafavi Rad *et al*. (10) and Fageria and Baligar (19) in different contents of nitrogen fertilizer. Results gained from variance analysis (Table 5) indicates that in term of grain number in each panicle, different lines are meaningful with each other in level of 5%. Moreover, the impact of nitrogen fertilizer contents on this attribute became meaningful in level of 1%, but density had no effect on this attribute. Regarding these results Mostafavi Rad and Tahmasebi Sarvestani (10) reported that the grain number in per panicle is under impression of genotype and different contents of nitrogen fertilizer. Hassini Imani (3) and Fageria and Baligar (18&19) and Singh *et al*. (29) also approve this fact. In studying mutual effects, only mutual effect of genotype and density in level of 5% became meaningful (Table 5). The comparison of averages showed that (Table 10) the highest number of grain in per panicle was related to line 2 hybrid. The final performance of paddy rice in rice product is somewhat predictable by using performance components like; panicle number in per unit area, grain number in per panicle, one thousand grain weight and other attributes (5). The obtained results from variance analysis (Table 5) showed that the effect of different contents of nitrogen fertilizer and different planting densities were meaningful on performance ($P<0.01$) and the effect of genotype on this attribute became meaningful in the level of 5% so that planting density of 15×30 with average of 5.33 was better than planting density of 25×25 and fertilizer level of 200 kg N ha^{-1} had the highest average in comparison with other fertilizer levels and also among lines, line 416 with average of 5.43 was better than two other lines and lines 203 and 2 hybrid statistically didn't have meaningful difference and were placed in class b (Tables 8&10). This survey is not consistent with results of Babapour (1), Erfani and Salehi (6) which state that the most appropriate plant density for promising lines is 25 cm on the rows × 25 cm between the rows. In surveying mutual effects, only mutual effect of fertilizer and density became meaningful in the level of 1% which is related to fertilizer level of 200 and planting density of 15×30 (Table 5). Fageria and Baligar (19) also reported that rice yield and its yield components have meaningful relation with the contents of nitrogen fertilizer. Singh *et al*. (29) described this amount as 150 to 200 kg N ha $^{-1}$ in the Philippines.

CORRELATIONS

According to the results (Figure 2) the total dry weight is highly correlated to the leaf area duration (LAD) which is because of longer leaf duration and getting solar energy for a longer time (12). LAD and CGR respectively with (r=0.63**) and (r=0.3**) had the highest positive correlation with total dry weight (TDW) and RGR showed meaningful negative correlation with TDW. The correlation between grain yield and studied physiological indices showed that total dry weight has a meaningful and positive correlation (r=0.24*) with grain yield and special leaf weight (SLW) had a meaningful and negative correlation(r= -0.24*) with grain yield. According to the results (Figure 3) grain yield had positive meaningful correlation with panicle number per unit (r=0.59**), fertile tiller number (r=0.53**) and harvest index (r=0.47**).

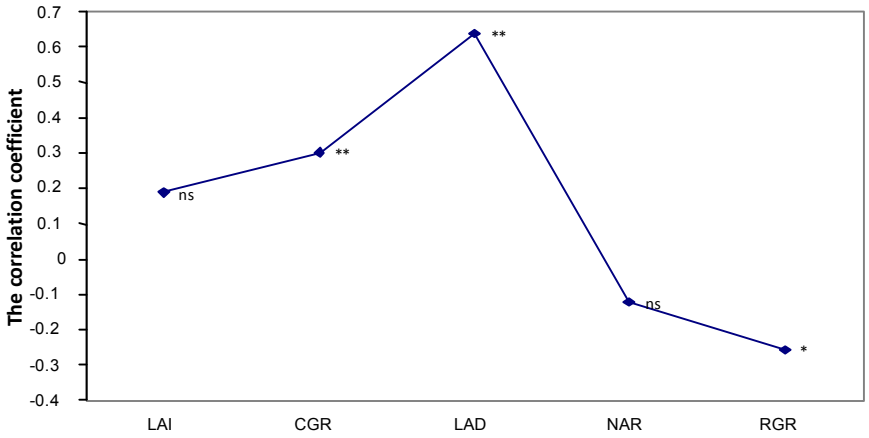

Fig. 2: Correlation between TDM and studied attributes

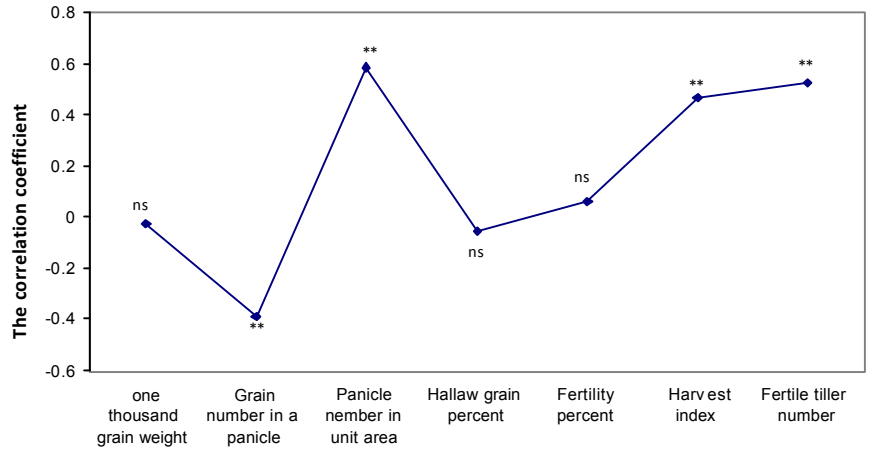

Fig. 3: Correlation between grain yield and studied attributes

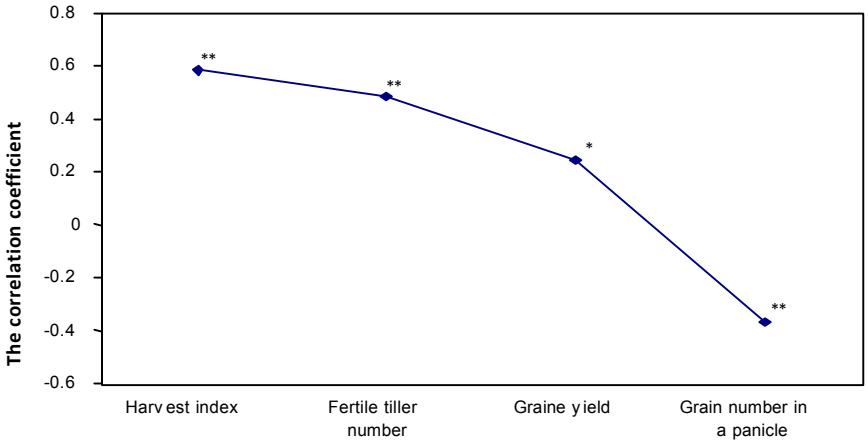

Fig. 4: Correlation between TDM and studied attributes

Yamauchi *et al*. (31) stated that harvest index of hybrid rice types was lower or similar to the other rice types which is representative of dry material production response towards grain yield, on the other hand, grain yield in grains largely depends on the fertile tiller in each plant and there is a positive correlation between the tiller number and performance (19). Thus, it is expected that by having an increase in number of panicles in unit area,

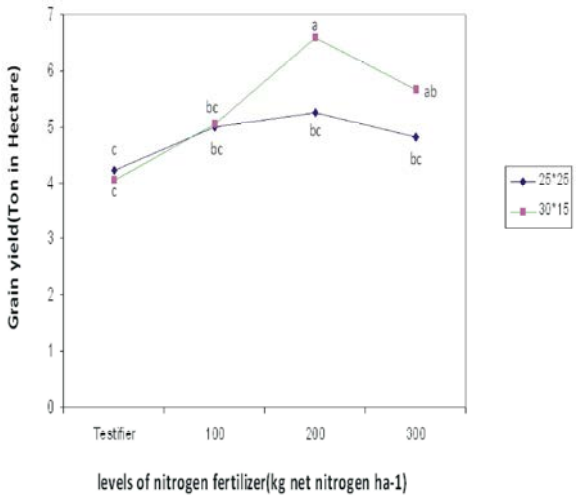

Fig. 5: Mutual effect of fertillizer and density on grain yield

the fertile tiller number, harvest index and grain yield increase as well. However; grain number in per panicle showed meaningful and negative correlation (r= -0.39**) with grain yield. According to the results (Figure 4), TDW had meaningful and positive correlation with harvest index (r=0.58**), fertile tiller number (r= 0.48**) and grain yield (r=0.24*). But total dry weight had negative meaningful correlation (r= -0.37**) with grain number in per panicle.

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