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Evaluation of some growth indices on vegetative and reproductive stage of rice cultivars under nitrogen fertilizer management

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Abstract

In order to study the effects of nitrogen fertilizer on some growth indices of rice cultivars (*Oryza sativa* L.), an experiment as factorial in RCBD with three replications was conducted during 2009 year in the Rice Research Institute, Iran, Rasht, central of Guilan and Rudsar, East of Guilan. Factors were cultivar (V1= Hashemi, V2= Ali Kazemi and V3= Khazar), and nitrogen fertilizer levels (N1= 0, N2= 30, N3=60, and N4= 90 Kg N/ha). Characters measured were: leaf area index (LAI), leaf dry weight (LDW), Total of dry weight (TDW), Crop growth rate (CGR), net assimilation rate (NAR) and grain yield. Growth parameters were calculated during two growth stages tillering and flowering by harvesting samples in all treatments. Results of growth analysis indicated that, nitrogen increasing rates of fertilizer caused the increment of growth indexes in comparison with don't application fertilizer, highest these growth indexes were obtained in N4 treatment. Among of rice cultivars, Khazar showed higher growth indices rather than Ali Kazemi and Hashemi.

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Introduction

Rice (*Oryza sativa* L.) is the foremost staple food for more than 50% of the world's population. It is estimated that by the year 2025, farmers in the world should produce about 60% more rice than at present to meet the food demands of the expected world population at that time (Thakur *et al.,* 2011). Nitrogen, a plant nutrient is required by plants in comparatively larger amounts than other elements. Nitrogen is essential component of many compounds of plant, such as chlorophyll, nucleotides, proteins, alkaloids, enzymes, hormones and vitamins (Marschner, 1995). For an optimal yield, the N supply must be available according to the needs of the plant. Nitrogen deficiency generally results in stunted growth, chlorotic leaves because lack of N limits the synthesis of proteins and chlorophyll. This leads to poor assimilate formation and results in premature flowering and shortening of the growth cycle. The presence of N in excess promotes development of the above ground organs with relatively poor root growth. Synthesis of proteins and formation of new tissues are stimulated, resulting in abundant dark green (high chlorophyll) tissues of soft consistency. This increases the risk of lodging and reduces the plants resistance to harsh climatic conditions and to foliar diseases (Lincoln, 2006). There are two types of plant growth analysis, attitude, classical and functional approach to separating these two approaches, for use in analyzing the growth took place in 1960. This title was first used by Keaston other words, the scientists used a functional approach to the dynamics with respect to the terms of the return that contains a view of the fitted curve and the other not. In the classical view, the events of the relatively small number of samples but with a large volume (high number of measurements) will follow the basic concepts in the books, Evans and Keaston and Venus, in view of the statistical function to fit curves of various samples, but low volume (less the number of measurements) will result in a lack of time and space, both views can be merged (the number of large samples and large size), but both of Perspective directions of growth parameters and determine the impact of the paths are different treatments (Rawsthorne *et al.,* 1985). Among the growth parameters leaf area index (LAI) is a dimensionless variable and was first defined as the total one-sided area of photosynthetic tissue per unit ground surface area (Inge *et al.,* 2004). LAI is the component of crop growth analysis that accounts for the ability of the crop to capture light energy and is critical to understand the function of many crop management practices. Leaf area index can have importance in many areas of agronomy and crop production through its influence: light interception, crop growth, weed control, crop-weed competition, crop water use and soil erosion (Welles, 1190; Sonnentag *et al.,* 2007). NAR measures the mean photosynthetic efficiency of leaves in a crop community. The integration of weight and leaf area measurement over time provides value that is highly useful for studying the growth of crops (Shipley, 2006). Patterson (1982) stated that relative growth rate (RGR), net assimilation rate (NAR) and leaf area ratio (LAR) are good measures of solar radiation capture during growth with NAR and LAR for an individual plant and LAI for population helping to explain differences in RGR. Samba *et al.* (1982) found that interception of PAR (photosynthetically active radiation) is closely followed by LAI. Reduced NAR interception causes reduction of the RGR, NAR and LAR. Mansab *et al.* (2003) reported that for maximum crop growth, enough leaves must be present in the canopy to intercept most of the incident NAR. Therefore, growth is often expressed on a leaf-area basis. The present study was undertaken to analyze the different growth parameters: leaf area index (LAI), leaf dry weight (LDW), Total of dry weight (TDW), Crop growth rate (CGR), net assimilation rate (NAR) and grain yield on vegetative and reproductive stage of rice cultivars under nitrogen fertilizer management. The objectives of this study was to evaluation of some growth indices on vegetative and reproductive stage of rice cultivars under nitrogen fertilizer management in north of Iran.

Materials and methods

Materials

Agricultural research in 2009 at Rice Research Institute in Rasht, Iran, township in Guilan province Center (latitude 37 degrees 16 minutes North and longitude 41 degrees 36 minutes East) and located in East Guilan, Rudsar city (latitude 37 degrees 7 minutes north and longitude 49 degrees 35 minutes East) was performed. Factors tested, including cultivars in three levels (the Khazar, Ali Kazemi and Hashemi) and nitrogen fertilizer at four levels (0, 30 kg ha^{-1} pure nitrogen: one part at the time of transfer seedlings from the nursery to the main field, 60 and 90 kg ha^{-1} of nitrogen: in two part at the time of transfer seedlings from the nursery to the main field and in the tillering stage) was the source of urea. In late February the first plowing was done in the second half of May main field after secondary plowing, drawing trowel and after leveling, the scheme was implemented. Sowing in nursery in the first half of May was done and seedlings after 4-3 leaf were transferred to the main field in early Jun. The number of seedlings per hill 3-4 and plant spacing between two seedlings for Hashemi and Ali kazemi cultivars 20×20 cm and for Khazar cultivar 25×25 cm in plots with 12 m^2 spaces was determination. The result of soil analysis in two locations was illustrated in table 1. For chemical combat with stem borer worm of rice diazinon 5% was used and for weeds chemical combating satrin herbicide (3-3.5 lit/ha) one week after transplantation was used. Also handy weeding in twice (25 and 50 day after transplantation) was performed. Among the cultivars, improved and late maturity cultivars of Khazar later than the other two cultivars were harvested. Ali-Kazemi and Hashemi cultivars were the native cultivars of Guilan province but Khazar cultivar was obtained through crossing between TNAU7456 cultivar and IR2071-625-1-52 line. Grain yield with harvest from 4 m^2 per plot was measured.

Table 1. Some physical and chemical properties of experimental filed soil.

Potassium of absorb able (ppm)	Phosphor of absorb able (ppm)	Total nitrogen *(%)*	PH	Electrical Conductivity (mmhos/cm)	Texture paddy	Location
280	17.8	0.189	7.4	1.12	Silty clay	Rasht
230	9.5	0.052	6.5	1.9	clay	Rudsar

Method to calculate growth indices

Growth parameters (leaf area index (LAI), leaf dry weight (LDW), Total of dry weight (TDW), Crop growth rate (CGR), net assimilation rate (NAR)) were calculated during two growth stages tillering and flowering by harvesting samples in all treatments. Leaf area was determined by Leaf area meter. In order to determine TDW and LDW, after cultivation to harvesting time, 10 plants were selected randomly in all plots and then weighed. Growth indices calculated by following standard formulae as shown below:

$LAI = L / P$

$NAR = 1 / L * dw / dt$

$CGR = 1 / P * dw / dt$

dw = Dry Weight Production in t Days

dt = Number of Days

P = Ground Area

L = Initial Leaf Area.

Grain yield with harvest from 4 m^2 per plot was measured.

Result and discussion

Leaf area index

With attention to variance analysis table (Table 2), location, the effect of nitrogen fertilizer levels and rice cultivars on LAI had a significant.

Table 2. Analysis of variance on growth indices for rice cultivars production under nitrogen fertilizer management.

SOV	*Df*	*GR*	*NAR_2*	*NAR_1*	*CGR_2*	*CGR_1*	*LDW_2*	*LDW_1*	*TDW_2*	*TDW_1*	*$LA1_2$*	*$LA1_1$*
L	1	14942951**	26.21**	1329**	114.98**	4.91**	85760**	421.94**	195357**	14284**	9.921**	0.00027*
R(L)	4	84023	0.021	34.329	4.564	0.041	1967	102.49	13553	222.51	0.128	0.00016
N	3	8766194**	0.842**	10.299	156.5**	0.712**	56074**	2895**	240085**	11363**	3.981**	0.00185**
L×N	3	49068	0.219**	25.441	3.194	0.092*	639.68	29.514	452.85	1598**	0.279**	0.00009
(V)	2	3243184*	5.733**	39.573	266.03**	1.713**	685999**	15034**	115183**	84971**	8.684**	0.0019**
L×V	2	183286	77.67**	18.135	105.68**	0.838**	2209	7364**	15368*	6869**	7.249**	0.0021**
V×N	6	959624	0.433**	19.024	13.461**	0.115**	3112*	311.55**	17454**	1510**	0.190**	0.0001**
L×V×N	6	359745*	0.277**	55.664**	15.629**	0.741*	2716*	264.85**	9171.15*	812**	0.119	0.0001
Error	44	132890	0.035	14.699	2.403	0.024	1000	52.61	3778.21	77.183	0.052	0.00006
CV		10.34	2.47	20	8.02	17.58	10.77	13.08	9.53	11.54	8.51	16.51

Ns, ** and * respectively: non-significant, significant in 1% and 5% area

Note1: Vegetative stage

Note2: Reproductive stage

L: Location, N: Nitrogen, C: Cultivar, R: Replication, leaf area index: LAI, leaf dry weight: LDW, Total of dry weight: TDW, Crop growth rate: CGR, net assimilation rate: NAR and grain yield: GR).

In vegetative stage the highest amount of LAI were recorded from Khazar cultivar (0.056); application 90 kg N/ha (0.060) (Table 3). On the other hand the lowest amount of LAI were recorded from Hashemi cultivar (0.039); application 0 kg N/ha (0.037) and 30 kg N/ha (0.031) (Table 3). The comparison of Mean of data (Table 4) showed that vegetative stage LAI in Rudsar site with mean of 0.049 respects to Rasht site with mean of 0.045 is significantly superior.

In reproductive stage the highest amount of LAI were recorded from Khazar cultivar (3.19); application 90 kg N/ha (3.24) (Table 3). On the other hand the lowest amount of LAI were recorded from Hashemi cultivar (2.01); application 0 kg N/ha (2.13) (Table 3). The comparison of Mean of data (Table 4) showed that reproductive stage LAI in Rudsar site with mean of 3.04 respects to Rasht site with mean of 2.30 is significantly superior.

Leaf dry weight

With attention to variance analysis table (Table 2), location, the effect of nitrogen fertilizer levels and rice cultivars on LDW had a significant difference at 1% probability level.

In vegetative stage the highest amount of LDW were recorded from Khazar cultivar (81.63 g/m^2); application 90 kg N/ha (70.03 g/m^2) (Table 3). On the other hand the lowest amount of LDW were recorded from Hashemi cultivar (31.77 g/m^2); application 0 kg N/ha (40.07 g/m^2) and 30 kg N/ha (51.73 g/m^2) (Table 3). The comparison of Mean of data (Table 4) showed that vegetative stage LDW in Rudsar site with mean of 57.85 g/m^2 respects to Rasht site with mean of 53.01 g/m^2 is significantly superior.

In reproductive stage the highest amount of LDW were recorded from Khazar cultivar (346.43 g/m^2); application 90 kg N/ha (232.73 g/m^2) (Table 3). On the other hand the lowest amount of LDW were recorded from Hashemi cultivar (233.51 g/m^2); application 0 kg N/ha (362.93 g/m^2) (Table 3). The comparison of Mean of data (Table 4) showed that reproductive stage LDW in Rudsar site with mean of 328.01 g/m^2 respects to Rasht site with mean of 259 g/m^2 is significantly superior.

Total dry weight

With attention to variance analysis table (Table 2), location, the effect of nitrogen fertilizer levels and rice cultivars on TDW had a significant difference at 1% probability level.

Table 3. Comparison of mean on growth indices for rice cultivars production under nitrogen fertilizer management.

Treatments	*GR*	*NAR_2*	*NAR_1*	*CGR_2*	*CGR_1*	*LDW_2*	*LDW_1*	*TDW_2*	*TDW_1*	*$LA1_2$*	*$LA1_1$*
Location											
Roudsar	3069B	6.98B	14.55B	18.06B	0.62B	259B	53.01B	592.51B	125.17B	2.30B	0.045B
Rasht	3980A	8.19A	23.15A	20.59A	1.14A	328.01A	57.85A	696.69A	153.34A	3.04B	0.049A
N											
0	2734D	7.43B	17.90A	16.17D	0.67C	362.93D	40.07C	512.82D	110.57C	2.13D	0.037C
30	3210C	7.48B	18.60A	18.03C	0.78C	309.10C	51.73C	604.41C	129.29C	2.50C	0.031C
60	3827B	7.52B	19.33A	20.03B	0.93B	269.24	59.89B	674.69B	147.95B	2.82B	0.049B
90	4328A	7.90A	19.57A	23.06A	1.13A	232.73A	70.03A	786.47A	169.19A	3.24A	0.060A
Cultivar											
Hashemi	3223B	8.08A	17.38A	15.77C	0.62C	233.51C	31.77C	582.76B	109.29C	2.01C	0.039C
Alikazemi	3417AB	7.58B	19.44A	19.82B	0.86B	294.56B	52.89B	631.57B	114.07B	2.81B	0.045B
Khazar	3943A	7.10C	19.73A	22.36A	1.15A	346.43A	81.63A	719.46A	194.45A	3.19A	0.056A

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

In vegetative stage the highest amount of TDW were recorded from Khazar cultivar (194.45 g/m²); application 90 kg N/ha (169.19 g/m²) (Table 3). On the other hand the lowest amount of TDW were recorded from Hashemi cultivar (109.29 g/m²); application 0 kg N/ha (110.57 g/m²) and 30 kg N/ha (129.29 g/m²) (Table 3). The comparison of Mean of data (Table 4) showed that vegetative stage TDW in Rudsar site with mean of 153.34 g/m² respects to Rasht site with mean of 125.17 g/m² is significantly superior.

Table 4. Correlation coefficients between studied traits.

Parameter	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
1- GR	1										
2- $LA1_1$	0.41**	1									
3- $LA1_2$	0.85**	0.75**	1								
4- TDW_1	0.34**	0.81**	0.80**	1							
5- TDW_2	0.59**	0.56**	0.62**	0.66**	1						
6- LDW_1	0.37**	0.84**	0.65**	0.88**	0.51**	1					
7- LDW_2	0.70**	0.64**	0.77**	0.76**	0.83**	0.51**	1				
8- CGR_1	0.41**	0.68**	0.70**	0.71**	0.58**	0.72**	0.59**	1			
9- CGR_2	0.62**	0.53**	0.69**	0.66**	0.75**	0.47**	0.90**	0.46**			
10- NAR_1	0.20	-0.81	0.16	0.19	0.26**	0.81	0.19	0.64**	0.11		
11- NAR_2	-0.36**	0.40**	-0.65**	-0.34**	-0.11	-0.28**	-0.20	-0.43**	0.43	-0.12	1

Ns, ** and * respectively: non-significant, significant in 1% and 5% area

In reproductive stage the highest amount of TDW were recorded from Khazar cultivar (719.46 g/m^2); application 90 kg N/ha (786.47 g/m^2) (Table 3). On the other hand the lowest amount of TDW were recorded from Hashemi cultivar (582.76 g/m^2) and Alikazemi cultivar (631.57 g/m^2); application 0 kg N/ha (512.82 g/m^2) (Table 3). The comparison of Mean of data (Table 4) showed that reproductive stage TDW in Rudsar site with mean of 696.69 g/m^2 respects to Rasht site with mean of 592.51 g/m^2 is significantly superior.

Crop growth rate

With attention to variance analysis table (Table 2), location, the effect of nitrogen fertilizer levels and rice cultivars on CGR had a significant difference at 1% probability level.

In vegetative stage the highest amount of CGR were recorded from Khazar cultivar (1.15 g/m^2.day); application 90 kg N/ha (1.13 g/m^2.day) (Table 3). On the other hand the lowest amount of CGR were recorded from Hashemi cultivar (0. 62 g/m^2.day); application 0 kg N/ha (0.67 g/m^2.day) and 30 kg N/ha (0.78 g/m^2.day) (Table 3). The comparison of Mean of data (Table 4) showed that vegetative stage CGR in Rudsar site with mean of 1.14 g/m^2.day respects to Rasht site with mean of 0.62 g/m^2.day is significantly superior.

In reproductive stage the highest amount of CGR were recorded from Khazar cultivar (22.36 g/m^2.day); application 90 kg N/ha (23.06 g/m^2.day) (Table 3). On the other hand the lowest amount of CGR were recorded from Hashemi cultivar (15.77 g/m^2.day); application 0 kg N/ha (16.17 g/m^2.day) (Table 3). The comparison of Mean of data (Table 4) showed that reproductive stage CGR in Rudsar site with mean of 20.59 g/m^2.day respects to Rasht site with mean of 18.06 g/m^2.day is significantly superior.

Net Assimilation Rate

With attention to variance analysis table (Table 2), location on vegetative stage NAR had a significant difference at 1% probability level. The effect of nitrogen fertilizer levels and rice cultivars on vegetative stage showed a non-significant. The comparison of Mean of data (Table 4) showed that vegetative stage NAR in Rudsar site with mean of 23.15 g/m^2.day respects to Rasht site with mean of 14.55 g/m^2.day is significantly superior.

With attention to variance analysis table (Table 2), location, the effect of nitrogen fertilizer levels and rice cultivars on NAR had a significant difference at 1% probability level.

In reproductive stage the highest amount of NAR were recorded from Hashemi cultivar (8.08 g/m^2.day); application 90 kg N/ha (7.9 g/m^2.day) (Table 3). On the other hand the lowest amount of CGR were recorded from Khazar cultivar (7.10 g/m^2.day); application 0, 30, 60 kg N/ha (Table 3). The comparison of Mean of data (Table 4) showed that reproductive stage NAR in Rudsar site with mean of 8.19 g/m^2.day respects to Rasht site with mean of 6.98 g/m^2.day is significantly superior.

Grain yield

With attention to variance analysis table (Table 2), location, the effect of nitrogen fertilizer levels and rice cultivars on grain yield had a significant. The highest amount of grain yield were recorded from Khazar cultivar (3943 kg/ha); application 90 kg N/ha (4328 kg/ha) (Table 3). On the other hand the lowest amount of grain yield were recorded from Hashemi cultivar (3223 kg/ha) and Alikazemi cultivar (3417 kg/ha); application 0 kg N/ha (2734 kg/ha) (Table 3). The comparison of Mean of data (Table 3) showed that grain yield in Rudsar site with mean of 3980 kg/ha respects to Rasht site with mean of 3069 kg/ha is significantly superior. Table 5 shows that among the Growth parameters in this experiment (LAI, LDW, TDW and CGR) with grain yield a positive and very significant correlation was showed. Also on the base of our expectance between NAR and grain yield a negative and significant correlation in probability level of 1% (-0.36) was recorded (Table 3). Nitrogen increasing rates of fertilizer caused the advantage of growth indexes (LAI, LDW, TDW and CGR) (Azarpour *et al.,* 2011; Mohaddesi *et al.,* 2011). Rice scientists are engaged in developing new high yielding varieties and management practices to increase the productivity per unit land area per unit time. One of the main practices for plant breeding and increasing grain yield is select of suitable parents. Traditional genotypes have high diversity hence the comparing old and modern genotypes are essential that was determined various characters (for example physiological, morphological indices) for selection and inbreeding of new genotypes. Karimi and Siddique (1991) expressed that CGR at anthesis was greater for modern than old cultivars. Norbakhshian and Rezai (1999) reported that ratio growth rate (RGR) and CGR had positive correlation with grain yield at flowering in rice. CGR, NAR and leaf area index (LAI) were higher throughout growth stages in improved genotypes than traditional genotypes (Erfani and Nasiri, 2000). Grain yield had not correlation with RGR in rice because grain yield is influenced by cultivar and sowing date (Pirdashti 1998, Erfani 1995, Kulmi 1992). LAI was correlated negatively with grain yield at flowering and was greater for late-maturity cultivars than early-maturity cultivars (Norbakhshian and Rezai 1999). High-yielding rice varieties had higher LAI and greater LAR and consequently produced more dry matter (Dutta *et al.,* 2002). In high-yielding varieties, NAR was correlated positively with RGR, SLW and dry matter accumulation. At the IRRI, new rice varieties have been developed that possess a series of ideal traits, including rigid, upright leaves. Upright leaves were introduced to these new varieties to increase the penetration of sunlight through to lower leaves, thus optimizing light distribution throughout the canopy (Murchie *et al.,* 1999). Mohtashami (1998) found that flag leaf angle had negative and significantly correlation with grain yield, 1000-grain weight and filled grain number in rice. Flag leaf area and flag leaf angle may be more related (r=0.88, 0.90) to recent photosynthate synthesis and translocation for grain filling and higher grain fertility in local rices (Dutta *et al.,* 2002).

Conclusion

Plant growth analysis is an explanatory, holistic and integrative approach to interpreting plant form and function. It uses simple primary data in the form of weights, areas, volumes and contents of plant components to investigate processes within and involving the whole plant. Based on the resukts of this research, nitrogen increasing rates of fertilizer caused the increment of growth indexes in comparison with don't application fertilizer, highest these growth indexes were obtained in N4 treatment. Among of rice cultivars, Khazar showed higher growth indices rather than Ali Kazemi and Hashemi. Results indicated that location, cultivar and N fertilizer significantly effected on grain yield. Khazar and Ali Kazemi have the highest grain yield among cultivars. Also, Results indicated with increasing N fertilizer application, grain yield increased significantly.

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