Study on the physiological and morphological indices among the modern and old rice (*Oriza sativa* L.) genotypes

Freshteh Mahdavi[1], Mohammad Ali Esmaili[1], Hemmatollah Pirdashti[1,2] and Allahyar Fallah[3]

[1]Agricultural College, University of Mazandaran, Sari, Iran. E-mail: fereshteh_m6194@yahoo.com
[2]Tarbiat Modarres University, Tehran, Iran.
[3]Iran Rice Research Institute, Amol, Iran.

Abstract

In order to study on the morphological and physiological indices of rice genotypes, a field experiment was carried out in the Rice Research Institute of Iran, Deputy of Mazandaran (Amol) in 2003. Design arranged in completely randomized block with three replications was used, in which 10 genotypes [including Tarom, Ramazanali Tarom (traditional genotypes), Fajr, Shafagh, Neda, Onda, Jahesh, Fuji Minori, Dasht and Khzar (improved genotypes)] were the treatments. In this experiment, the traits such as plant height, tillering capacity and physiological indices such as CGR, RGR, and LAI were evaluated every ten days once. Because of the differences in developmental pattern and maturity among the genotypes used in this study, we have used growing degree-days (GDD). Morphological indices (leaf angle and flag leaf area) were evaluated in the flowering stage. Results showed that physiological indices of improved genotypes were greater than traditional genotypes. LAI of all genotypes was greater in the flowering than other stages. CGR and RGR had a positive and negative significant correlation respectively. Morphological indices of modern genotypes were greater than old genotypes. Old genotypes had higher plant height and less tillering capacity than modern genotypes. Plant height and tillering capacity had negative and positive correlation with yield, respectively. Generally, traditional genotypes reached physiological maturity earlier than improved genotypes. In the other hands, flag leaf area had no correlation with grain yield and flag leaf angle had positive correlation with grain yield.

Media summery

The best parents for new genotypes breeding Programs are the genotypes that have higher CGR, LAI and lower flag leaf angle.

Key words

Rice, GDD, Genotype, Physiological indices, Yield

Introduction

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 (Murty *et al*. 1986). 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). Yousefian (2000) showed that tillering capacity had negative and significantly correlation with flag leaf length and plant height. In rice flag leaf area had positive correlation with grain yield and yield components (Rao 1992).

Material and Methods

A field experiment was carried out in Rice Research Institute of Iran –Deputy of Mazandaran (Amol) located in north of Iran (52? 22′ N, 36? 28′ E, altitude 28m) in 2003. This experiment was laid out in randomized complete block design and three replication the treatments were ten improved and traditional genotypes. The traditional genotypes including Tarom and Ramazan Ali Tarom. The improved genotypes including Fajr, Neda, Shafagh, Fuji Minori, Onda, Jahesh, Khazar and Dasht. All plots received 100 kg P2O5 ha^{-1}, 100 kg K2O ha^{-1} , 50 and 100 kg N ha^{-1}(for traditional and improved genotypes, respectively) before transplanting. Topdressing of 50 and 100 kg N ha^{-1} for traditional and improved genotypes respectively. 30-35 days old seedlings were transplanted on 10 June 2003 at a hill spacing of 0.2?0.2 m^2 with four plants per hill. Plots were sampled at 10-days intervals from transplanting to final harvest. Dry matter determination (measurement) based on 0.04 m^2 quadrates harvested at ground level. The sample were dried in the oven at 70?C and weighted. Before drying the samples, for determining of leaf area, the leaves were detached and were measured by a Leaf Area Meter. Plant height and number of tiller also were measured every 10-days. Plant height was determined on 4 hills by measuring the distance from the soil surface to the tip of the height panicle within each hill. At flowering stage, 5 hills from every plot were selected at random for measuring the following treats: Flag leaf area and Flag leaf angle. Because of the differences in developmental pattern maturity among genotypes used in this study, was used growing degree days (GDD) instead of calendar days in computing the growth indices. GDD is a temperature index and calculated by summing the following equation for each day from the date of sowing to the date of each sampling: $GDD=\Sigma_1^n$ [(Tmax+Tmin)/2]-Tb, Where Tmax is the maximum daily air temperature with an upper limit of 30?C, Tmin is the minimum daily air temperature with a lower limit of 10?C and Tb is set equal 10?C, the base temperature below which no growth occurs. At physiological maturity, 12 hills were harvested and were dried at 70?C for harvest index determination. 10 hills from each plot were harvested at maturity to measure yield components. Grain yield was determined from a harvest area of 5 m^2 (125 hills) adjusting to 14% moisture content. The data were analyzed based on the randomized complete blocks. The all statically tests were done using the Statically Analysis System (SAS).

Results and Discussion

According to data, the traditional genotypes and japonica improved genotypes reached flowering stage earlier than improved genotypes (1100-1160 GDD). Among indica improved genotypes, Fajr reached flowering stage earlier (1180 GDD). The improved genotypes reached physiological maturity and final harvest later than traditional genotypes. The means compared according to Duncan's Multiple Range Test (p=0.05, Table4 and Table5 for morphological and physiological traits respectively). In this study, Onda had greater Total Dry Matter (TDM) among other genotypes (this genotype also had highest grain yield). The maximum TDM gotten earlier for improved genotypes than traditional genotypes (1445 and 1625 GDD respectively). At flowering the dry matter was greater for Jahesh and was lower for Ramazan Ali Tarom (923.93 gr.m^{-2} and 429 gr.m^{-2} respectively). So the photosynthetic potentials of improved genotypes were greater as reflected by their TDM production. TDM had positive correlation with grain yield (r^2=0.28, Table1). All genotypes reached maximum LAI at pre-flowering except Dasht and Tarom, which reached maximum LAI at flowering. At pre-flowering Neda (high-yielding genotype) had greatest LAI comparing to other genotypes (LAI=5.70). Neda was a late-maturity genotype and due to longer vegetative phase had greatest LAI. A large LAI and large sink capacity, determined by grain number and grain weight, witch might be cause by the increasing nitrogen absorption before anthesis (Yun *et al.* 2002). The results of the experiment showed that for old genotypes, the photosynthetic surface as indicated by lower LAI is a limiting factor. For the genotypes, which had high LAI and low grain yield, the partitioning of assimilate from stem and leaf to grains may be a problem (Dutta *et al*.2002). Maximum LAI was correlated positively and strongly with grain yield (r^2=0.58, table 1). Maximum CGR occurred at flowering stage for all genotypes. Generally, CGR was greater in modern genotypes than old genotypes (Onda and Ramazan Ali Tarom had greater and lower CGR respectively, table 2). The genotypes, which had greatest and lowest dry matter production, had highest and lowest CGR. It represented high dry matter at flowering influenced grain yield. It may be that modern genotypes with higher CGR at flowering translocated more carbohydrate to the grains than old genotypes (Pheloung and Siddique, 1991). RGR and NAR were higher for traditional genotypes than improved genotypes. So, by rice inbreeding, not only RGR did not increase, but also decreased. RGR had negative and significantly correlation with grain yield that was similar to that reported by Pirdashti (1998), and Kulmi (1992). In this experiment, Ramazan Ali Tarom had highest plant height. This trait was correlated negatively with grain yield (Table1).

Table1. Correlations (r) among the maximum growth indices and total dry matter, biological yield, grain yield and harvest index (HI) at final harvest for 10 rice genotypes

	TDM	**Biological yield**	**Grain yield**	**HI**
TDM	1.00	0.68	0.77	0.27
CGR	0.57	0.41	0.45	0.52
RGR	-0.48	-0.41	-0.41	-0.10
NAR	-0.25	-0.43	-0.33	-0.02
LAI	0.41	0.56	0.57	0.12
Flag Leaf Angle	0.13	0.04	0.16	0.25
Flag Leaf Area	0.05	0.29	0.085	-0.28
Plant Height	-0.56	-0.44	-0.64	-0.07
Tillering Capacity	0.30	0.43	0.42	-0.03

Table2. The morphological and physiological indices for 10 rice genotypes, Means followed by the same letters in each column are not significantly different according to Duncan's Multiple Ranges Test (p=0.05)

Genotypes	FlagLeafAngle (degree)	FlagLeafArea (cm^2)	LAI	CGR ($gr/m^2.GDD$)	RGR (gr/gr.GDD)	NAR ($gr/m^2.GDD$)	TDM (gr/m^2)
Shafagh	23.33^{e}	34.22^{c}	4.87^{abc}	2.28^{bc}	0.022^{abc}	1.21^{abcd}	1291.08^{ab}
Neda	11.25^{g}	32.11^{c}	5.70^{a}	2.73^{ab}	0.017^{bcd}	0.74^{e}	1279.36^{abc}

Onda	43.54[a]	22.59[de]	4.17[cde]	3.29[a]	0.013[d]	1.37[abc]	1347.22[a]
Dasht	35.00[b]	38.23[b]	5.42[ab]	2.09[c]	0.023[ab]	1.12[bcde]	1210.77[bcd]
Jahesh	27.92[d]	30.88[c]	5.06[abc]	2.37[bc]	0.016[cd]	1.08[bcde]	1190.96[bcd]
Khazar	26.67[d]	50.82[a]	3.59[e]	2.38[be]	0.013[d]	0.88[de]	1144.31[de]
Fajr	16.42[f]	31.96[c]	5.46[ab]	2.03[c]	0.014[d]	0.96[cde]	1225.40[bcd]
Fuji Minori	31.42[c]	26.02[d]	4.59[bcd]	2.73[ab]	0.017[bcd]	0.97[cde]	1163.98[cde]
Tarom	21.25[e]	25.88[d]	3.84[de]	2.15[bc]	0.028[a]	1.44[ab]	1053.78[e]
Rmazan Ali Tarom	27.08[d]	19.76[e]	3.83[de]	1.98[c]	0.028[a]	1.59[a]	1046.63[e]

Thus, in improved genotypes, plant height was not a limiting factor for grain yield because reduced lodging and conduced better translocation of assimilates. Recent studies indicated that plant height of semi dwarf rice and wheat may limit canopy photosynthesis and biomass production (Gent, 1995). The maximum tillering occurred at 738 GDD in all genotypes expect Neda and Dasht that occurred at 920 GDD. Neda (improved genotype) and Ramazan Ali Tarom (traditional genotypes) had greatest and lowest tillering capacity respectively. Onda (Japonica improved genotype) and Neda (Indica improved genotype) had greatest and lowest flag leaf angle respectively. In the rice crop several factors influence the response of leaf photosynthesis to light, one of them is leaf angle that has been identified as influencing the degree of light saturation of upper leaves (Murchie et al. 1999). Both steeper leaf angles and increased self-shading are thought to reduce potential carbon gain by decreasing total light interception (D.S.Falster and M.Westoby 2003). In this experiment, flag leaf angle had positive correlation with grain yield and biological yield (Table1). But, Mohtashami (1998) obtained a significant negative correlation between leaf angle and grain yield in rice. D.S.Falster and M.Westoby (2003) showed that steeper leaf angle function to reduce exposure to excess light levels during the middle of the day more than to maximize carbon gain. In this study Flag leaf area was greater for improved genotypes than traditional genotypes. But Neda and Onda that had higher grain yield compared to other modern genotypes had lower flag leaf area. In these genotypes, erect and thin leaves caused better light diffusion in canopy. Cultivars with greater flag leaf area generally have high grain weight (N. Mahmood and M.A. Chowdhry, 2000). Although genetic studies pertaining to flag leaf parameters (flag leaf and specific flag leaf area and weight) have been occasionally conducted by few scientists. In this study flag leaf area had positive and poor correlation with grain yield (r^2=0.085). Monyo and Whittington (1971) obtained a significant positive correlation coefficient of 0.41 for the association between grain yield per tiller and flag leaf area in wheat. Similarly Briggs and Aytenfisu (1980) recorded a positive and significant association of flag leaf area with grain yield per plant and 1000-grain weight.

Acknowledgment

Financial support by the Mazandaran University and Rice Research Institute of Iran-Deputy of Mazandaran (Amol) highly appreciated.

References

Briggs, K.G. and A. Aylenfisu. 1980. Relationships between morphological characters above the flag leaf node and grain yield in spring wheat. *Crop Sci* 20: 350-354

Dutta, R.K., Mia, M.A.B. and S. Khanam. 2002. Plant architecture and growth characteristics of fine grain and aromatic rices and their relation with grain yield.
http://www.fao.org/DOCREP/005/Y6159T/y6159t06.htm

Erfani, A. and M.Nasiri. 2000. Study of morphological and physiological indices in rice cultivars. Rice Research Institute of Iran. Pp: 24

Falster, D.S. and M.Westoby. 2003. Leaf size and angle vary widely across species: what consequences for light interception? http://www.bio.mq.edu.au/ecology/reprints/fw03newphytol.pdf

Gent, M.P.N. 1995. Canopy light interception, gas exchange and biomass in reduced height lines of winter wheat. *Crop Sci*. 35:1636-1642.

James, R. and L. Fowler. 2003. Growth analysis of lesqurella in response to moisture stress.
http://www.hort.purdue.edu/newcrop/procceedings/pdf.

Karimi, M.M., and K.H. Seddique. 1991. Crop growth and relative growth rates of old and modern wheat cultivars. *Aust.J.Agric.Res*.42:13-20.

Kulmi, G.S. 1992. Analysis of growth and productivity of transplanted rice in relation to methods of weeding. *Indian J. Agron*.37:312-316.

Mahmood, N. and M.A. Chowdhry. 2000. Inheritance of flag leaf in bread wheat genotypes.
http://www.grs.nig.ac.jp/wheat/wis/No90/p7/1.html.

Mohtashami, R. 1998. Study of genotypic and phonotypical correlation between quantitative and qualitative traits and grain yield in rice (Orysa sativa) using path analysis. MS thesis. Sari Agriculture College, Mazandaran University. Pp: 217

Monyo, J.H. and W.J. Whittington. 1971. Inheritance of plant growth characters and their relation to yield in wheat substitution lines*. J Agric Sci Camb* 76: 167-172.

Murchie, E.H., Y.Z. Chen, S. Hubbart, S. Peng, and P. Horton., 1999. Interaction between senescence and leaf orientation determine in situ patterns of photosynthesis and photoinhibition in field-grown rice. *Plant physiol*.119:553-564.

Noorbakhshian, J. and A. Rezai. 1999. Study of correlation between some traits and grain yield in rice cultivars using path analysis. *Iranian Journal of Crop Science.* 1(4):55-65.

Pirdashti, H.1998. Study of dry matter and nitrogen remobilization and determining of rice (Orysa sativa) cultivars growth indices in different sowing dates. MS thesis. Agriculture College. Tarbiat Modarres University. Pp: 158

Pheloung, P.C., and Siddique, K.H.M. 1991. Contribution of stem dry matter to grain yield in wheat cultivars. *Aust. J. Plant Physiol*. 18(1) in press.

Rao, S.D. 1992. Flag leaf: a selection criterion for exploiting potential yields in rice. *Indian J. Plant Physio*.35 (3):265-268.

Yun, W.Y., Sasak, S., Maeda, H., Miura, T. and K. Watanabe. 2002. Dry matter production and nitrogen absorption of Japonica-Indica hybrid rice cultivars growth under upland conditions- a comparing with Japonica cultivars. *Japanese J. of Crop Sci.* 71(1):28-35.