American-Eurasian J. Agric. & Environ. Sci., 5 (3): 403-408, 2009
ISSN 1818-6769
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Flag leaf Morphophysiological Response to Different Agronomical Treatments in a Promising Line of Rice (*Oryza sativa L.*)

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Abstract: In order to study of different agronomical treatments like transplanting date, planting spaces and nitrogen fertilization on rice flag leaf morphophysiological characteristics, a field experiment was conducted at the Rice Research Institute of Iran in 2005. Results showed that with increasing the applications of nitrogen fertilization the flag leaf area was significantly increased and flag leaf angle was decreased (P<0.01). The flag leaf was improved by early transplanting date due to more extends flag leaf area and decline of flag leaf angle. Also, the highest plant density resulted in a reduction in both flag leaf area and flag leaf angle. None of responsive the flag leaf chlorophyll was detected to different agronomical treatments. Flag leaf morphophysiological characteristics were influenced by nitrogen fertilization levels, transplanting date and plant density,respectively. The flag leaf angle was greatly affected by the interaction effects of transplanting date×nitrogen fertilizer (P<0.01). In this experiment, transplanting date on 12 May, planting space at 20×20 cm and 138 kg N ha^{-1} for the best performance of flag leaf and yield attributes were recommended.

Key words: Rice · Flag leaf · Transplanting date · Planting space · Nitrogen · Yield

Introduction

Rice (*Oryza sativa L.*) is being one of principal food crops and utilized by one third of world population. It provides some 700 calories per person, mostly residing in developing countries. Rice production can be increased either by increasing its yield per unit area or bringing more area under its cultivation. It is held that any significant increase in rice growing area is not possible and to produce an extra 200 million tones from same area, per unit rice productivity has to be increased. So the development of biologically superior and physiologically efficient genotypes with high yield potential is essentially required [1].

The top three leaves espicially flag leaf contributes most to grain yield [2, 3]. Greater carbohydrate translocation from vegetative plant parts to the spikelets [3-5] and larger leaf area index (LAI) during the grain filling period. Flag leaf has an important role in rice yield by increasing grain weight in amount of 41 to 43 percent. For this case flag leaf is activist leaf at grain filling period. Flag leaf area could be choosing as a factor for increasing rice grain yield [6]. Grain yield increased in federroz 50 varieties due to increase in both flag leaf area and grain maturity duration [7]. Flag leaf angle could be affected rice physiological activity. There was a positive correlation between flag leaf angle and photosynthesis material translocation and spikelets fertility increases also for increasing grain yield in rice, flag leaf must be wide and vertical [8].

In rice, 60-90% of total carbon in the panicles at harvest is derived from photosynthesis after heading, while 80% or more of nitrogen (N) in the panicles at harvest is absorbed before heading and remobilized from vegetative organs [9]. Leaf senescence during reproductive and maturity stages is directly related to biomass production and grain yield of rice crop [2, 10]. Also, during leaf senescence, chlorophyll content also decline but the rate of the decline is much slower than Rubisco content [11-13]. Chlorophyll meter, which

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measures leaf greenness, can predict the need for N top- dressing at prepanicle initiation and panicle differentiation for rice in Texas [14]. The chlorophyll meter has been used successfully by soil scientists in Nebraska for corn by applying in- season N fertilizer doses when sufficiency indices of chlorophyll meter readings of the plot in question divided by awell- fertilized reference plot fall below 0.95 [15, 16]. Correlation between cholorphyll meter readings and N concentration of rice leaves was improved by adjusting for specific leaf weight [17]. Rice scientists in each region determine the appropriate critical values for their rice cultivars and seasons (wet or dry) [18]. Flag leaf contributes most to grain yield so we hypothesized that improvement of flag leaf morphophysiological characters for increasing grain yield may be occur by optimizing some agronomical treatments in rice. Therefore, the objective of this study was to evaluate the response of flag leaf characteristics such as flag leaf area, flag leaf angle and flag leaf chlorophyll to some agronomical factors like different levels of transplanting date, planting spaces and nitrogen fertilization in a promising line of rice

MATERIALS AND METHODS

In order to investigation flag leaf morphophysiological characteristics in different agronomical treatments in rice a field experiment was conducted at the Rice Research Institute of Iran- Deputy of Mazandaran (Amol) where located in north of Iran (52° 22'N, 36° 28'E altitude 28m). The experiment design was laid out in split plot factorial as randomized completely block design with three replications. The plot size was $12m^2$ (3×4 m). A promising line (IR6874-3-2) was used in this experiment. Main plot was transplanting date in three levels (May 2, May 12, May 22) and sub plots were combination of planting spaces and amount of nitrogen fertilizer including (16×30, 20×20, 25×25cm and 92, 115, 138 kg N ha^{-1}),respectively. All plots were 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 92 kg, 115 kg and 138 kg N ha^{-1} in two split doses. Half of nitrogen fertilizer was applied before transplanting,while the remaining amount applied as a top dressing in the maximum tillering stage. Standards cultural practices were carried out until the crop was mature. Five hills (excluding border hills) were randomly selected from each plot at flowering stage for measuring flag leaf angle and area. Leaf area meter (LI-31000, LI-COR, Lincoln, NE) was used for determine of flag leaf area. For measuring chlorophyll of flag leaf, Chlorophyll Meter (SPAD) was used [19]. The grain yield was determined from harvest area of $5m^2$ after adjusting for 14% moisture content. All variables were analyzed using analysis system [20] and means were separated by Duncan Multiple Rang Test (DMRT) at $P<0.05$.

RESULTS

Flag Leaf Angle: Results showed that among treatments, nitrogen fertilization amount had significant effect on flag leaf angle at $P<0.01$,also the interaction effect of transplanting date×nitrogen fertilization had significant effect on flag leaf angle at $P<0.05$ (Table 1). Interaction effect of transplanting date×planting space×nitrogen fertilization had significant effect on flag leaf angle at $P<0.01$ (Table1). Results showed that in different levels of nitrogen fertilizer, the highest flag leaf angle from stem (33.89) was measured in use of 92 kg N ha^{-1} and the least flag leaf angle from stem (26.38) was obtained in use of 138 kg N ha^{-1} (Table 2). Interaction effect of transplanting date×planting space showed that the most flag leaf angle (33.49) were obtained on 22 May transplanting date in case of 25×25cm planting space,while the least flag leaf angle (23.72) were produced on 12 May transplanting date and 25×25cm planting space (Table 3). Results of interaction effect of transplanting date×nitrogen fertilization showed that the most flag leaf angle from stem (34.39) was produced on 2 May transplanting date in 92 kg N ha^{-1} nitrogen fertilization and the least flag leaf angle (25.83) from stem was obtained on 22 May transplanting date in case of 138 kg N ha^{-1} nitrogen fertilization (Table 4). Interaction effect of planting space×nitrogen fertilization showed that the most flag leaf angle from stem (36.78) were obtained in 25×25cm planting space in 92 kg N ha^{-1} and the least flag leaf angle from stem (24.93) were produced in 25×25cm planting space in use of 138 kg N ha^{-1} nitrogen fertilization (Table 5). Interaction effect of transplanting date×planting space×nitrogen fertilization showed that the most flag leaf angle from stem (47.5) was obtained on 22 May transplanting date, in 25×25cm planting space in case of 92 kg N ha^{-1} nitrogen fertilization and the least flag leaf angle from stem (20.66) was obtained on 12 May transplanting date in 20×20cm planting space in case of 138 kg N ha^{-1} nitrogen fertilization (Table 6).

Table 1: Mean squares of flag leaf morphophysiological characteristics in rice (IR6874-3-2 promising line)

Source of Variation	df	Flag leaf area(m^2)	Flag leaf angle (°)	Flag leaf chlorophyll(SPAD)	Grain yield (t ha^{-1})
Rep	2	0.069 ns	187.19 ns	51.85 ns	1.36 ns
‡TD	2	0.028 ns	199.82 ns	484.52 ns	4.03 ns
Error (a)	4	0.012	45.22	110.06	0.62
‡PS	2	0.013 ns	24.06 ns	9.23 ns	3.22 ns
‡N	2	0.093**	394.93**	13.9 ns	3.65*
PS×N	4	0.007 ns	49.82 ns	6.11 ns	1.05 ns
TD×PS	4	0.012 ns	48.25 ns	6.82 ns	0.39 ns
TD×N	4	0.023 ns	77.47*	4.84 ns	0.34 ns
TD×PS×N	8	0.008 ns	84.04**	11.36 ns	0.63 ns
Total Error	48	0.018	23.5	8.32	1.01
CV (%)		22.58	16.32	8.79	12.12

‡. TD, PS, N= transplanting date, planting spaces and nitrogen fertilizer respectively

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

Table 2: Mean comparision of flag leaf morphophysiological characteristics of rice promising line under different treatments

Treatment		Flag leaf area (m^2)	Flag leaf angle(°)	Flag leaf chlorophyll(SPAD)	Grain yield(t ha^{-1})
Transplanting	2	0.63 a	29.7 ab	27.96 a	8.44 ab
date	12	0.57 a	27.00 b	34.78 a	8.56 a
(May)	22	0.58 a	32.44 a	35.72 a	7.84 b
Planting	16×30	0.62 a	30.74 a	32.48 a	8.23 ab
spaces	20×20	0.60 a	28.89 a	32.49 a	8.65 a
(cm)	25×25	0.57 a	29.50 a	33.5 a	7.97 b
Nitrogen	92	0.54 b	33.89 a	32.29a	7.86 b
fertilizer	115	0.59 ab	28.85 b	33.64a	8.44 a
(kg ha^{-1})	138	0.65 a	26.38 b	32.54 a	8.55 a

Mean with similar letters in each column are not significantly different at the 0.05 probability level according to DMRT

Table 3: Interaction effect of transplanting date and planting space on flag leaf morphophysiological parameters of rice promising line (IR6874-3-2)

Transplanting date	Planting Space	Flag leaf area (m^2)	Flag leaf angle (°)	Flag leaf chlorophyll(SPAD)	Grain yieldt ha^{-1}
May 2	16×30	0.64 ab	29.78 ab	27.78 b	8.35 abc
	20×20	0.66 a	28bc	27.67 b	8.95 a
	25×25	00.58 ab	31.28 ab	28.43 ab	8.03 cd
May 12	16×30	0.63 ab	29.72 ab	34.87 ab	8.4 abc
	20×20	0.55 b	27.55 bc	33.43 ab	8.79 ab
	25×25	0.55 b	23.72 c	36.05 a	8.51 abc
May 22	16×30	0.56 b	32.72 ab	34.81 ab	7.94 cd
	20×20	0.61 ab	31.11 ab	36.34 a	8.22 bc
	25×25	0.58 ab	33.49	36 a	7.38 d

Means with similar letters in each column are not significantly different at the 0.05 probability level according to DMRT

Table 4: Interction effect of transplanting date and nitrogen on morphological parameters of rice promising line (IR6874-3-2)

Transplanting date	Nitrogen (kg ha^{-1})	Flag leaf area (m^2)	Flag leaf angle (°)	Flag leaf chlorophyll(SPAD)	Grainyield(tha^{-1})
May 2	92	0.53 bc	34.39 ab	26.59 c	8.08 bc
	115	0.61 bc	28.5 cd	28.92 abc	8.78 a
	138	0.76 a	26.17 d	28.37 bc	8.48 abc
May 12	92	0.52 c	28.28 cd	34.87 ab	8.10 bc
	115	0.58 bc	26.1 d	35.19 ab	8.57 ab
	138	0.62 b	26.89 d	36.8 a	9.03 a
May 22	92	0.56 bc	39.00 a	34.3 abc	7.42 d
	115	0.59 bc	32.22 bc	35.41 ab	7.96 cd
	138	0.59 bc	25.83 d	34.94 ab	8.15 bc

Means with similar letters in each column are not significantly different at the 0.05 probability level according to DMRT

Table 5: Interction effect of planting space and nitrogen on flag leaf morphophysiological parameters of rice promising line (IR6874-3-2)

Planting spaces (cm)	Nitrogen (kg ha^{-1})	Flag leaf area (m^2)	Flag leaf angle (°)	Flag leaf chlorophyll (SPAD)	Grain yield (t ha^{-1})
16×30	92	0.55 bc	33.11 ab	32.91 a	7.63 bc
	115	0.60 b	30.9 bcd	33.13 a	8.59 a
	138	0.70 a	28.22 bcde	31.41 a	8.48 a
20×20	92	0.57 bc	31.78 abc	31.4 a	8.67 a
	115	0.60 b	28.89 bcde	33.71 a	8.55 a
	138	0.63 ab	26.00 de	32.33 a	8.75 a
25×25	92	0.50 c	36.78 a	32.55 a	7.3 c
	115	0.58 bc	26.78 cde	33.87 a	8.18 ab
	138	0.64 ab	24.93 e	34.07 a	8.44 a

Means with similar letters in each column are not significantly different at the 0.05 probability level according to DMRT

Table 6: Interction effect of transplanting date and planting space and nitrogen on flag leaf morphophysiological parameters of rice promising line (IR6874-3-2)

Transplanting date (May)	Planting space (cm)	Nitrogen Fertilizer (kg ha^{-1})	Flag Leaf Area (m^2)	Flag leaf angle (°)	Flag leaf chlorophyll (SPAD)	Grain yield (t ha^{-1})
2	16×30	92	0.58 ef	30 efghi	29.70 abcde	7.96 efg
		115	0.58 ef	30.5 defghi	26.66 de	8.54 cdef
		138	0.83 a	28.83 fghij	26.96 cde	8.55 cdef
	20×20	92	0.55 fg	33 defgh	24 e	9.12 abc
		115	0.67 bcde	25.33 ij	29.16 abcde	9.31 ab
		138	0.72 b	25.66 ij	29.83 abcde	8.42 cdefg
	25×25	92	0.47 gh	40.16 bc	26.06 de	7.14 ij
		115	0.57 efg	29.66 efghij	30.93 abcde	8.48 cdef
		138	0.71 bc	24 ij	28.30 bcde	8.48 cdef
12	16×30	92	0.59 ef	35 cdef	34.46 abcd	7.95 efgh
		115	0.60 def	25.83 hij	36.13 ab	8.61 bcdef
		138	0.69 bcd	28.33 ghij	34 abcd	8.64 bcde
	20×20	92	0.54 fgh	27.16 hij	33.93 abcd	8.28 defgh
		115	0.54 fgh	31 defghi	34.1 abcd	8.62 bcdef
		138	0.56 fg	20.66 j	32.26 abcde	9.48 a
	25×25	92	0.44 h	22.66 j	36.2 ab	8.07 efgh
		115	0.58 ef	24.5 ij	35.33 abcd	8.49 cdef
		138	0.62 cdef	27.83 hij	36.63 ab	8.96 abcd
22	16×30	92	0.48 gh	34.33 cdefg	34.56 abcd	6.98 ij
		115	0.62 cdef	36.33 cd	36.6 ab	8.6 bcdef
		138	0.58 ef	27.50 hij	32.26 abcd	8.23 defgh
	20×20	92	0.63 bcdef	35.16 cde	36.26 ab	8.61 bcdef
		115	0.57 efg	30.33 defghi	37.86 a	7.71 gh
		138	0.62 cdef	27.83 hij	34.90 abcd	8.35 defg
	25×25	92	0.58 ef	47.5 a	35.40 abcd	6.68 j
		115	0.59 ef	30 efghi	35.93 abc	7.58 hi
		138	0.58 ef	22.96 ij	36.66 ab	7.86 fgh

Means with similar letters in each column are not significantly different at the 0.05 probability level according to DMRT

Flag Leaf Area: Results showed that nitrogen fertilization had significant effect on flag leaf area at 1% probability level (Table 1). Results of flag leaf morphophysiological characters showed that the most ($0.65m^2$) and the least ($0.54m^2$) flag leaf area were produced in use of 138 and 92 kg N ha^{-1} respectively (Table 2). In interaction effect of transplanting date×nitrogen fertilization levels, the most flag leaf area (0.76 m^2) was obtained on 2 May transplanting date in case of 138 kg N ha^{-1} nitrogen fertilizer level. The least flag leaf area ($0.52m^2$) was produced on 12 May transplanting date in 92 kg N ha^{-1} nitrogen fertilization level (Table 4). Results of interaction effect of planting space×nitrogen fertilization amount showed that the most flag leaf area (0.7 m^2) was obtained in 16×30cm planting space in 138 kg N ha^{-1} nitrogen fertilization level,while the least flag leaf area (0.5 m^2)

was obtained in 25×25cm planting space in case of 92 kg N ha^{-1} nitrogen fertilizer level (Table 5). Results of interaction effect of transplanting date×planting spaces×nitrogen fertilization on flag leaf area showed that the most flag leaf area (0.83m^2) was obtained on 2 May transplanting date in case of 16×30cm planting spaces in 138 kg N ha^{-1} nitrogen fertilization,while the least flag leaf area (0.44 m^2) was produced on 12 May transplanting date in case of 25×25cm planting space in 92 kg N ha^{-1} nitrogen fertilization level (Table 6).

Flag Leaf Chlorophyll Content: Results showed that all the treatments in this experiment had not significant effect on flag leaf chlorophyll content (Table 1). Interaction effect of transplanting date × planting space showed that, flag leaf chlorophyll content in amount of 36.34 was obtained in May 22 transplanting date in case of 20 ×20cm planting spaces (Table 3). In interaction effect of transplanting date × nitrogen fertilization on flag leaf chlorophyll content showed that, the lowest chlorophyll content was obtained in first transplanting date in use of 92 kg N ha^{-1} nitrogen fertilization level and flag leaf chlorophyll content in the other treatments had not difference significantly (Table 4). Interaction effect of transplanting date × planting space × nitrogen fertilization showed that flag leaf chlorophyll content in amount of 36.66 was obtained on 22 May transplanting date in 25×25cm planting space and in use of 138 kg N ha^{-1} nitrogen fertilization level and flag leaf chlorophyll content in amount of 24 was obtained on 2 May tansplanting date in 20× 20cm planting space and in use of 92 kg N ha^{-1} (Table 6).

Grain Yield: Results showed that grain yield was influenced significantly by nitrogen fertilization (Table 1). These results indicate that among different nitrogen fertilizer levels, the highest grain yield (8.55 t ha^{-1}) and the least grain yield (7.86 t ha^{-1}) were obtained in 138 and 92 kg N ha^{-1} respectively (Table 2). Interaction effect of transplanting date×planting space showed that the most grain yield (8.95) was produced in May 2 transplanting date in 20×20 cm planting space,while the least grain yield (7.38 t ha^{-1}) was obtained on 22 May transplanting date in 25×25cm planting space (Table 3). In interaction effect of transplanting date and nitrogen fertilization amount, the highest grain yield (9.03) was produced on 12 May transplanting date in case of 138 kg N ha^{-1} nitrogen fertilization level and the least grain yield (7.42 t ha^{-1}) was produced on 22 May transplanting date in case of 92 kg N ha^{-1} nitrogen fertilization level (Table 4). Results of planting space×nitrogen fertilizer showed that the most grain yield (8.75 t ha^{-1}) was obtained in 20×20cm planting space in 138 kg N ha^{-1} nitrogen fertilizer level,while the least grain yield (7.3 t ha^{-1}) was produced in 25×25cm planting space in case of 92 kg N ha^{-1} nitrogen fertilizer level (Table 5). Interaction effect of transplanting date×planting spaces×nitrogen fertilization on grain yield showed that the most grain yield (9.48 t ha^{-1}) was produced on 12 May transplanting date in 20×20cm planting space in case of 138 kg N ha^{-1} nitrogen fertilization level (Table 6).

DISCUSSION

In this experiment flag leaf area, flag leaf angle and grain yield were influenced significantly by treatments especially nitrogen fertilization levels. Among treatments in this experiment nitrogen fertilization amount had an important role in improving morphophysiological characteristics of rice flag leaf that was subsequently influenced grain yield. Nitrogen could be increase rice leaves and roots growth to prepared appropriate LAI for obtained most grain yield in this experiment. Most flag leaf area and grain yield were produced in use of 138 kg N ha^{-1}. Also the lowest flag leaf angle from stem was obtained in use of 138 kg N ha^{-1}. This case showed that for increasing rice grain yield, flag leaf must be wide and vertical [6].

Flag leaf angle had an important effect for increasing rice grain yield. Grain yield is a function of photosynthesis products and an optimum distribution and arrangement of leaves may increase the efficiency of biomass production in crop cultures. A greater penetration of light in to the structure of crop plant, combined with morphophysiological traits that contribute to increase productivity appears to be an appropriate goal. Modifications of leaf angle and flag leaf angle have been emphasized by investigators as a means of obtaining better light utilization, with more upright leaves permitting the penetration of solar energy in to the lower levels of the aerial structure of plants [7, 21].

Rice for reaching to maximum grain yield need sufficient LAI for best photosynthesis activity while in rice 60-90% of total carbon in the panicles at harvest is derived from photosynthesis after heading that 80% or more of nitrogen (N) in the panicles at harvest is absorbed before heading and remobilized from vegetative organs [20]. Leaf Area increase contributes for canopy development. As the leaf area increases; a greater photosynthetically active surface area becomes available and it would therefore be expected that production rate would be greater the highest the leaf area index (LAI) [22]. So flag leaf photosynthesis activity had important effect on rice grain yield [6]. In this study flag leaf morphophysiological characteristics were influenced significantly by nitrogen fertilization levels and in use of 138 kg N ha^{-1} flag leaf's characteristics had better activity and also grain yield would be increased. According to results, transplanting date on 12 May, planting space at 20×20 cm and 138 kg N ha^{-1} for the best performance of flag leaf and yield attributes of this promising line were recommended.

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