World Applied Sciences Journal 6 (8): 1021-1027, 2009
ISSN 1818-4952

Investigation Some Agronomical Traits of Rice under Different Transplanting Dates, Planting Spaces and Nitrogen Fertilization Levels in North of Iran

[1]Davood Barari Tari, [2]Hemmat Allah Pirdashti and [3]Morteza Nasiri

[1]Young Researchers Club, Iran Islamic Azad University, Ghaemshahr Branch, Ghaemshahr, I.R. Iran
[2]Sari Agricultural and Natural Resources University, Sari, I.R. Iran
[3]Iran Rice Research Institute, Amol, I.R. Iran

Abstract: In order to investigating effects of transplanting date, planting space and nitrogen fertilization on some agronomical traits such as panicle length, flag leaf characters (flag leaf chlorophyll, flag leaf angle and flag leaf area) and grain yield of rice, a field experiment was carried out in split plot factorial in basis of Randomized Completely Block Design with three replications in 2008. Main factor was transplanting date in three levels (Including May 2, May 12, May 22) and sub factors were planting spaces and amount of nitrogen fertilizer (Including 16 × 30cm, 20 × 20cm, 25 × 25cm and 92, 115 and 138 kg N ha^{-1} respectively). Results showed that nitrogen fertilization levels had significant effect on flag leaf area, flag leaf angle, panicle length and grain yield. Interaction effect of planting space and nitrogen fertilization had significant effect on panicle length (P<0.01). interaction effect of transplanting date and nitrogen fertilization had significant on flag leaf angle. Flag leaf angle would be influenced significantly by interaction of transplanting date, planting spaces and nitrogen fertilization level. According to this research. transplanting date at May 12, 20×20cm planting space and use of 138 kg N ha^{-1} for the best performance of agronomical attributes were recommended.

Key words: Rice · Panicle length · Agronomic · Yield

INTRODUCTION

World rice production must increase by approximately 1% annually to meet the growing demand for food that will result from population growth and economic development [1]. Most of this increase has to come from greater yields on existing cropland to avoid existing cropland to avoid environmental degradation, destruction of natural ecosystems and loss of biodiversity [2,3]. Rice is vital to more than half of the world population. It is most important food grain in the diets of hundreds of millions of Asians, Africans and Latin Americans living in the tropics and subtropics [4]. Studies investigating the effect of seeding date on rice (*Oryza sativa L*) grain yields have been sporadically conducted since the 1930 [5-10]. Some reports showed that rice grain yields declined as seeding date was delayed and that very short-season cultivars did not always produce higher grain yields than midseason cultivars when seeded late [8]. Current seeding-date recommendations for rice use guidelines that were developed from seeding date studies conducted with tall Long-season cultivars that are no longer grown [7,10]. There have been extensive studies on the relationships between yield and plant density in rice under nonstressed conditions. The relationship varied with different planting systems in rice production. In transplanted cultural systems, maximum grain yield can be reached at a plant density of about 200 plant m^{-2} [11,12]. A compensatory relationship between yield components and plant density has been observed. It was shown that panicle density significantly increased with increases of seeding densities, while filled spikelets per panicle were reduced significantly [13-15]. Tillers per plant and spikelets per panicle increased with decreases of plant density in direct-seeded rice [16]. Proper amount and timing of nitrogen application reduces the loss of nitrogen in rice field from its efficient utilization point of view. Leaf Area Index and CGR are the growth attributes most closely related to the genotypic yield variation [17] and were affected by fertilizers sepecially nitrogenous fertilizers [18]. Seeding date primarily influences the length of the

Corresponding Author: Davood Barari Tari, Young Researchers Club, Iran Islamic Azad University, Ghaemshahr Branch, Ghaemshahr, I.R. Iran

vegetative growth period of rice and early seeded rice requiring a greater number of days to accumulate the same number of degree-day units compared with later seeded rice [19]. The time between seeding and seedling emergence decreases as seeding date is delayed and soil and air temperature increase [20]. Similarly, the time between seedling emergence and heading declines as seeding date is delayed, but the accumulated number of growing degree-day units remains relatively [19]. Leaf N content can be estimated non-destructively with a chlorophyll meter (SPAD) or leaf color chart (LCC) [21,22]. Most studies on improving fertilizer-N management were conducted using only one variety [23]. Some results suggested that flag leaf area could be choosed as a factor for increase rice grain yield [24]. Between flag leaf angle and photosynthesis material translocation and spikelets fertility increases had a positive correlation [25]. chlorophyll meter is a simple and fast method for determined rice flag leaf chlorophyll [22]. The objective of this study was to observe effectiveness of transplanting date, planting space and nitrogen fertilization levels on flag leaf area, flag leaf angle, flag leaf chlorophyll, panicle length and grain yield of rice.

MATERIALS AND METHODS

The experiment was conducted at Rice Research Institute of Iran Deputy of Mazandaran (Amol) located in North of Iran (52° 22' N, 36° 28' E, altitude 28 m) in 2008. Experiment was laid out in split plot factorial in basis of Randomized Completely Block Design with three replications. The plot size was 10 m^2 (2.5 × 4 cm). Main factor was transplanting date in three levels (Including May 2, May 12, May 22) and sub factors were planting spaces and amount of nitrogen fertilizer (Including 16 × 30cm, 20 × 20cm, 25 × 25cm and 92, 115 and 138 kg N ha^{-1} respectively). All plots 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 N ha^{-1}, 115 kg N ha^{-1} and 138kg N ha^{-1} in two split doeses. Half of nitrogen fertilizer was applied before transplanting while the remaining quantity applied as a top dressing in the maximum tillering stage. Standard cultural practices were carried out until the crop was mature. Some traits like flag leaf area; flag leaf angle; flag leaf chlorophyll; panicle length and grain yield were measured. Five hills (excluding border hills) were randomly selected from each plot in flowering stage for measuring the flag leafs angle, flag leafs area and chlorophyll. Leaf Area Meter was used for determine of flag leaves area. For measuring chlorophyll of flag leaves, Chlorophyll Meter (SDAD) were used. Ten panicles (excluding border panicles) were randomly selected from each plot prior to harvest for measure panicle length. Grain yield was determined from harvest area of 5 m^2 adjusting to 14% moisture content. All variable tests were done using the Statically Analysis System (SAS, Institute, 1996) [26] and mean values were compared by Duncan Multiple Rang Test (DMRT).

RESULTS

Flag Leaf Characters: Results showed that among treatments, nitrogen fertilization amount had significant effect on flag leaf angle at 1% probability level also interaction effect of transplanting date and nitrogen fertilization had significant effect on flag leaf angle at 5% probability level (Table 1). Interaction effect of transplanting date and planting space and nitrogen fertilization had significant effect on flag leaf angle at 1% probability level (Table1). Simple mean camparision results showed that in different levels of nitrogen fertilizer, the most flag leaf angle from stem (34.89) was produced in use of 92 kg N ha^{-1} and the least flag leaf angle from stem (27.38) was obtained in use of 138 kg N ha^{-1} (Figure 1). Interaction effect of transplanting date and planting space showed that the most flag leaf angle (34.49) were obtained in May 22 transplanting date in case of 25cm×25cm planting space while the least flag leaf angle (24.72) were produced in May 12 transplanting date and 25cm×25cm planting space (Table 2). Results of interaction effect of transplanting date and nitrogen fertilization showed that the most flag leaf angle from stem (35.39) was produced in May 2 transplanting date in 92 kg N ha^{-1} nitrogen fertilization and the least flag leaf angle (26.83) from stem was obtained in May 22 transplanting date in case of 138 kg N ha^{-1} nitrogen fertilization (Table 3). Interaction effect of planting space and nitrogen fertilization showed that the most flag leaf angle from stem (37.78) were obtained in 25cm×25cm planting space in 92 kg N ha^{-1} and the least flag leaf angle from stem (25.93) were produced in 25cm×25cm planting space in use of 138 kg N ha^{-1} nitrogen fertilization(Table 4). Interaction effect of transplanting date, planting space and nitrogen fertilization showed that the most flag leaf angle from stem (48.5) was obtained in May 22 transplanting date, in 25cm×25cm planting space in case of 92 kg N ha^{-1} nitrogen fertilization and the least flag leaf angle from stem (21.66) was obtained in May 12 transplanting date in 20cm×20cm planting space in case of 138 kg N ha^{-1}

Table 1: Mean squares of agronomical characteristics in rice

Source of Variation	df	Flag leaf area	Flag leaf angle	Flag leaf chlorophyll	Panicle length	Grain yield
Rep	2	ns	ns	ns	ns	ns
‡TD	2	ns	ns	ns	ns	ns
Error (a)	4	0.012	45.22	110.06	0.54	0.62
‡PS	2	ns	ns	ns	ns	ns
‡N	2	**	**	ns	**	*
PS×N	4	ns	ns	ns	**	ns
TD×PS	4	ns	ns	ns	ns	ns
TD×N	4	ns	*	ns	ns	ns
TD×PS×N	8	ns	**	ns	ns	ns
Total Error	48	0.018	23.5	8.32	37.07	1.01
CV (%)		22.58	16.32	8.79	3.03	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: Interaction effect of transplanting date and planting space on agronomical parameters of rice promising line (IR6874).

Transplanting date	Planting Space	Flag leaf area (m^2)	Flag leaf angle(°)	Flag leaf chlorophyll	Panicle length (cm)	Grain yield t ha^{-1}
May 2	16 × 30	0.59 ab	30.78 ab	28.78 b	28.98 b	8.05 abc
	20 × 20	0.61 a	29 bc	28.67 b	28.74 b	8.65 a
	25 × 25	00.53 ab	32.28 ab	29.43 ab	28.79 b	7.73 cd
May 12	16 × 30	0.58 ab	30.72 ab	35.87 ab	29.51 a	8.1 abc
	20 × 20	0.50 b	28.55 bc	34.43 ab	28.78 b	8.49 ab
	25 × 25	0.50 b	24.72 c	37.05 a	29.19 ab	8.21 abc
May 22	16 × 30	0.51b	33.72 ab	35.81 ab	29.58 a	7.64 cd
	20 × 20	0.56 ab	32.11 ab	37.34 a	28.72 b	7.92 bc
	25 × 25	0.53 ab	34.49	37 a	28.71 b	7.08 d

Table 3: Interction effect of transplanting date and nitrogen on agronomical parameters of rice promising line (IR6874)

Transplanting date	Nitrogen (kg ha^{-1})	Flag leaf area (m^2)	Flag leaf angle (°)	Flag leaf chlorophyll	Panicle length (cm)	Grainyield(tha^{-1})
May 2	92	0.48bc	35.39 ab	27.59 c	28.07 d	7.78 bc
	115	0.56 bc	29.5 cd	29.92 abc	29.33 ab	8.48 a
	138	0.71a	27.17 d	29.37 bc	29.06 b	8.38 abc
May 12	92	0.47 c	29.28 cd	35.87 ab	28.24 d	7.8 bc
	115	0.53 bc	27.1 d	36.19 ab	29.42 ab	8.37 ab
	138	0.57b	27.89 d	37.8 a	29.23 b	8.73 a
May 22	92	0.51 bc	40.00 a	35.3 abc	28.41 cd	7.12 d
	115	0.54 bc	33.22 bc	36.41 ab	28.97 bc	7.66 cd
	138	0.54 bc	33.22 bc	36.41 ab	29.82 a	7.66 cd

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 planting space and nitrogen on agronomical parameters of rice promising line (IR6874).

Planting spaces (cm)	Nitrogen (kg ha^{-1})	Flag leaf area	Flag leaf angle (°)	Flag leaf chlorophyll	Panicle length (cm)	Grain yield(tha^{-1})
16×30	92	0.50 bc	34.11 ab	33.91 a	28.79 c	7.33 bc
	115	0.55 b	31.9 bcd	34.13 a	29.01 c	8.29 a
	138	0.65 a	29.22 bcde	32.41 a	29.72 ab	8.18 a
20×20	92	0.52 bc	32.78 abc	32.4 a	27.07 d	8.37 a
	115	0.55 b	29.89 bcde	34.71 a	29.19 bc	8.25 a
	138	0.58 ab	27.00 de	33.33 a	29.98 a	8.25 a
25×25	92	0.45 c	37.78 a	33.55 a	28.86 c	6.8 c
	115	0.53 bc	27.78 cde	34.87 a	28.72 c	7.88 ab
	138	0.59 ab	25.93 e	35.07 a	29.21 bc	8.14 a

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 transplanting date and planting space and nitrogen on agronomical parameters of rice promising line (IR6874)

Transplanting date	Planting space	Nitrogen Fertilizer (kg ha^{-1})	Flag Leaf Area (m^2)	Flag leaf angle (°)	Flag leaf chlorophyll	Panicle length (cm)	Grain yield (t ha^{-1})
May 2	16cm×30cm	92	0.53 ef	31 efghi	30.70 abcde	28.74 efgh	7.66 efg
May 2	16cm×30cm	115	0.53 ef	31.5 defghi	27.66 de	28.62 efgh	8.24 cdef
May 2	16cm×30cm	138	0.78 a	29.83 fghij	27.96 cde	29.41 cdef	5.25 cdef
May 2	20cm×20cm	92	0.50 fg	34 defgh	25 e	26.96 i	8.82 abc
May 2	20cm×20cm	115	0.62 bcde	26.33 ij	30.16 abcde	30.46 b	9.01 ab
May 2	20cm×20cm	138	0.67 b	26.66 ij	30.83 abcde	28.77 defgh	8.12 cdefg
May 2	25cm×25cm	92	0.42 gh	41.16 bc	27.06 de	28.49 fgh	6.84 ij
May 2	25cm×25cm	115	0.52 efg	30.66 efghij	31.93 abcde	28.88 defgh	8.18 cdef
May 2	25cm×25cm	138	0.66 bc	25 ij	29.30 bcde	28.98 defg	8.18 cdef
May 12	16cm×30cm	92	0.54 ef	36 cdef	35.46 abcd	29.4 cdef	7.65 efgh
May 12	16cm×30cm	115	0.55 def	26.83 hij	37.13 ab	28.86 defgh	8.31 bcdef
May 12	16cm×30cm	138	0.64 bcd	29.33 ghij	35 abcd	30.27 abc	8.34 bcde
May 12	20cm×20cm	92	0.49 fgh	28.16 hij	34.93 abcd	26.28 i	7.98 defgh
May 12	20cm×20cm	115	0.49 fgh	32 defghi	35.1 abcd	29.42 cdef	8.32 bcdef
May 12	20cm×20cm	138	0.51 fg	21.66 j	33.26 abcde	30.63 a	9.18 a
May 12	25cm×25cm	92	0.39 h	23.66 j	37.2 ab	29.04 defg	7.77 efgh
May 12	25cm×25cm	115	0.53 ef	25.5 ij	36.33 abcd	28.76 efgh	8.19 cdef
May 12	25cm×25cm	138	0.57 cdef	28.83 hij	37.63 ab	29.78 abcd	8.66 abcd
May 22	16cm×30cm	92	0.43 gh	35.33 cdefg	35.56 abcd	28.22 ghi	6.68 ij
May 22	16cm×30cm	115	0.57 cdef	37.33 cd	37.6 ab	29.55 bcde	8.3 bcdef
May 22	16cm×30cm	138	0.53 ef	28.50 hij	33.26 abcd	29.47 bcdef	7.93 defgh
May 22	20cm×20cm	92	0.58 bcdef	36.16 cde	37.26 ab	27.96 hi	8.31 bcdef
May 22	20cm×20cm	115	0.52 efg	31.33 defghi	38.86 a	28.84 defgh	7.41 gh
May 22	20cm×20cm	138	0.57 cdef	28.83 hij	35.90 abcd	29.36 cdef	8.05defg
May 22	25cm×25cm	92	0.53 ef	48.5 a	36.40 abcd	29.04 defg	6.38 j
May 22	25cm×25cm	115	0.54 ef	31 efghi	36.93 abc	29.52 fgh	7.28 hi
May 22	25cm×25cm	138	0.53 ef	23.96 ij	37.66 ab	28.86 defgh	7.56 fgh

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

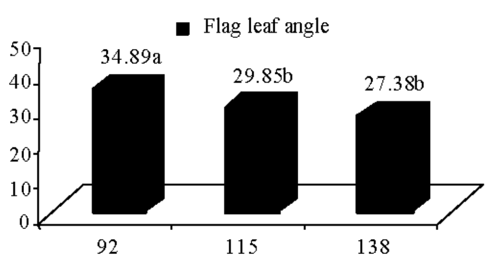

Fig. 1: Simple mean comparision of flag leaf angle in different nitrogen fertilizer Levels

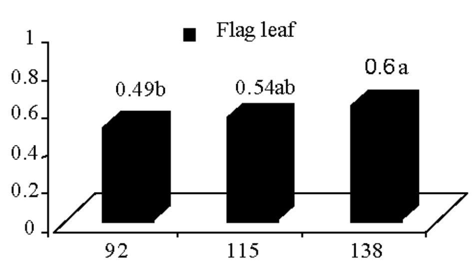

Fig. 2: Simple mean comparision of flag leaf area in different nitrogen fertilizer Levels

nitrogen fertilization (Table 5). Results showed that Nitrogen fertilization had significant effect on flag leaf area at 1% probability level (Table 1). Simple mean comparision of flag leaf morphophysiological characters showed that the most (0.60 m^2) and least (0.49 m^2) flag leaf area were produced in use of 138 and 92 kg N ha^{-1} respectively (Figure 2). Interaction effect of transplanting date and planting spaces showed that the most flag leaf area (0.61 m^2) was produced in May 2 transplanting date in 20cm×20cm planting space while the least flag leaf area (0.50 m^2) were obtained in May 12 transplanting date in case of 20 cm × 20 cm and 25 cm × 25 cm planting spaces (Table 2). In interaction effect of transplanting date and nitrogen fertilization levels, the most flag leaf area (0.71 m^2) was obtained in May 2 transplanting date in case of 138 kg N ha^{-1} nitrogen fertilizer level. The least flag leaf area (0.47m^2) was produced in May 12 transplanting date in 92 kg N ha^{-1} nitrogen fertilization level (Table 3). Results of interaction effect of planting space and nitrogen fertilization amount showed that the most flag

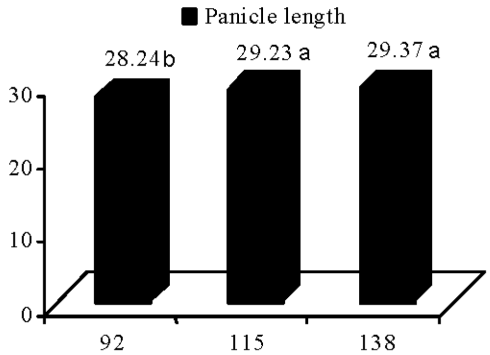

Fig. 3: Simple mean comparision of panicle length in different nitrogen fertilizer Levels

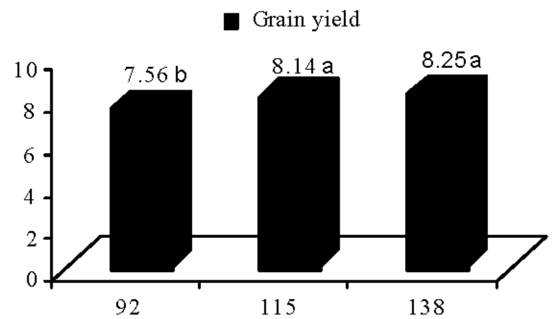

Fig. 4: Simple mean comparision of grain yield in different nitrogen fertilizer Levels

leaf area (0.65 m^2) was obtained in 16cm×30cm planting space in 138 kg N ha^{-1} nitrogen fertilization level while the least flag leaf area (0.45 m^2) was obtained in 25cm×25cm planting space in case of 92 kg N ha^{-1} nitrogen fertilizer level (Table 4). Results of interaction effect of transplanting date, planting spaces and nitrogen fertilization on flag leaf area showed that the most flag leaf area (0.78m^2) was obtained in May 2 transplanting date in case of 16cm×30cm planting spaces in 138 kg N ha^{-1} nitrogen fertilization while the least flag leaf area (0.39 m^2) were produced in May 12 transplanting date in case of 25cm×25cm planting space in 92 kg N ha^{-1} nitrogen fertilization level (Table 5). Results showed that none of the treatments in this experiment had not significant effect on flag leaf chlorophyll content (Table 1). But mean comparision of interaction effect of transplanting date and planting space showed that, most flag leaf chlorophyll content (37.34) was obtained in May 22 transplanting date in case of 20cm×20cm planting spaces (Table 2). In interaction effect of transplanting date and nitrogen fertilization on flag leaf chlorophyll content showed that, the most chlorophyll content (37.8) was produced in May 12 transplanting date in use of 138 kg N ha^{-1} nitrogen fertilization level (Table 3). Results of interaction effect of planting space and nitrogen fertilization on flag leaf chlorophyll content showed that the most chlorophyll content (35.07) was obtained in 20cm×20cm planting space in case of 138 kg N ha^{-1} nitrogen fertilizer level (Table 4). Interaction effect of transplanting date, planting space and nitrogen fertilization showed that the most flag leaf chlorophyll content (36.66) were obtained in May 22 transplanting date in 25cm×25cm planting space and in use of 138 kg N ha^{-1} nitrogen fertilization level (Table 5).

Panicle Length: Results showed that panicle length was influenced significantly by nitrogen fertilization level and interaction of planting space and nitrogen fertilization at 1% probability level (Table 1). Simple mean comparision results showed that in different nitrogen fertilization levels, the most panicle length (29.37) was produced in use of 138 kg N ha^{-1} and the least panicle length (28.24) was obtained in use of 92 kg N ha^{-1} (Figure 3). Interaction effect of transplanting date and planting space showed that the most panicle length (29.58) was produced in may 22 transplanting date in case of 16cm × 30cm planting space and least panicle length (28.71) was obtained in May 22 transplanting date in 25cm × 25cm planting space (Table 2). Results of interaction effect of transplanting date and nitrogen fertilization showed that the most panicle length (29.82) was obtained in May 12 transplanting date in case of 138 kg N ha^{-1} and the least panicle length was obtained in May 2 transplanting date in use of 92 kg N ha^{-1} (Table 3). In interaction effect of planting space and nitrogen fertilization level showed that most panicle length (29.98) was obtained in 20cm × 20cm planting space in case of 138 kg N ha^{-1} and the least panicle length was produced in 20cm × 20cm planting space in case of 92 kg N ha^{-1} (Table 4).In interaction effect of transplanting date, planting space and nitrogen fertilization on panicle length showed that most panicle length (30.63) was produced in 12 May transplanting date and 20cm × 20cm planting space in case of 138 kg N ha^{-1} (Table 5).

Grain Yield: Results showed that grain yield was influenced significantly by nitrogen fertilization (Table 1). Simple mean comparision results showed that among different nitrogen fertilizer levels, the most grain yield (8.25 t ha^{-1}) and least grain yield (7.56 t ha^{-1}) were produced in 138 and 92 kg N ha^{-1} respectively (Figure 4). Interaction effect of transplanting date and planting space showed that the most grain yield (8.65) was produced in May 2 transplanting date in 20cm×20cm planting space while the least grain yield (7.08 t ha^{-1}) was obtained in May 22 transplanting date in 25cm×25cm planting space (Table 2). In interaction effect of transplanting date and nitrogen fertilization amount, the highest grain yield (8.73) was produced in May 12 transplanting date in case of 138 kg N ha^{-1} nitrogen fertilization level and the least grain yield (7.12 t ha^{-1}) was produced in May 22 transplanting date in case of 92 kg N ha^{-1} nitrogen fertilization level (Table 3). Results of planting space and nitrogen fertilizer showed that the most grain yield (8.45 t ha^{-1}) was obtained in 20cm×20cm planting space in 138 kg N ha^{-1} nitrogen fertilizer level while the least grain yield (7 t ha^{-1}) was produced in 25cm×25cm planting space in case of 92 kg N ha^{-1} nitrogen fertilizer level (Table 4). Interaction effect of transplanting date, planting spaces and nitrogen fertilization on grain yield showed that the most grain yield (9.18 t ha^{-1}) was produced in May 12 transplanting date in 20cm×20cm planting space in case of 138 kg N ha^{-1} nitrogen fertilization level (Table 5).

CONCLUSION

Results of this experiment indicated that nitrogen fertilization amount management had an important role in increase of rice yield. Among nutritional factors, N plays a very important role in differentiation and degeneration of spikelets. Split application of N is very often used in rice cultivation to increase its availability in the critical growth stages. In this experiment, most Flag Leaf Area, panicle length and grain yield were produced in use of 138 kg N ha^{-1}. Nitrogen in appropriate rate could increase Leaf Area Index of rice. Especially flag leaf area would be influenced by nitrogen fertilizer and its activity would be increased. Flag leaf activity have effective role in rice grain filling period that could increased grain weight in amount of 41 to 43 percent. In federroz 50 variety increase in flag leaf area and increase in grain matuarity duration cause increasing in grain yield [22]. For this research, transplanting date at May 12, 20cm×20cm planting space and use of 138 kg N ha^{-1} for the best performance of agronomical attributes were recommended.

REFERENCE

1. Rosegrant, M.W., M.A. Sombilla and N. Perez, 1995. Global food projections to 2020: Implications for investment. In food, Agriculture and the Environmental Discussion paper no. 5/. (IFPRI. Washington D.C).
2. Cassman, K.G., 1999. Ecological intensification of central production systems yield potential, Soil quality and precision agriculture. Proc. National Acad. Sci. (USA). 96: 5952-5959.
3. Tilman, D., K.G. Cassman, P.A. Matson, R. Naylor and S. Poasky, 2002. Agricultural sustainability and intensive production practices. Nature, 418: 671-677. Wells, B.R. and W.F. Faw, 1978. Short stature rice response to seeding and rates. Agron. J., 70: 477-480.
5. Adair, C.R., 1940. Effect of time of seeding on yield, milling quality and other characters of rice.
6. Adair, C.R. and E.M. Cralley, 1950. 1949 Rice yield and disease control tests. Arkansas Agric. Exp. Stn. Rep. Ser. 15. Univ. of Arkansas, Fayetteville, AR.
7. Faw, W.E. and T.H. Johnston, 1975. Effect of seeding date on growth and performance of rice varieties in Arkansas. Arkansas Agric. Ex. Stn. Rep. Ser. 224. Univ. of Arkansas, Fayetteville, Ar.
8. Gravois, K.A. and R.S. Helms. 1998. Seeding date effects on rough rice yield and head rice and selection for stability. Euphytica. 102: 151-159.
9. Jenkins, J.M. and J.W. Jones, 1944. Results of experiments with rice in Louisiana, Loisiana Agric Exp. Stn. Bull. 384. Louisiana State Univ, Baton. Rouge, La.
10. Jodon, N.E. and W.O. McIlrath, 1971. Response of rice to time of seeding in Loisiana. Louisiana Agric. Exp. Stn. Bull. 649. Louisiana State Univ, Baton Rouge, La.
11. Nguu, N.V. and S.K. De Data, 1979. Increasing efficiency of fertilizer nitrogen in wetland rice by manipulation of plant density and plant geometry. Field Crop Res., 2: 19-34.
12. Akita, K., 1982. Studies on competition and compensation of cropplants: Xi. Effects of planting density on the yield component in rice plant. Sci. Rep. Fac. Agric. Kobe Univ. 15: 17-21. J.Am. Soc.Agron. 32:697-706.
13. Wu, G., L.T. Wilson and A.M. Mcclung, 1998. Contribution of rice tillers to dry matter accumulation and yield. Agron. J., 90: 317-323.

14. Counce, P.A., 1987. Asymptotic and parabolic yield and linear nutrient content responses to rice population density. Agron. J., 79: 864-869.
15. Gravois, K.A. and R.S. Helms, 1992. Path analysis of rice yield and yield components as affected by seeding rate. Agron. J., 84: 1-4.
16. Yang, W.H., S. Peng, J. Huang, A.L. Sanico, Buresh, and R.J. Witt, 2003. Using leaf color charts to estimate leaf nitrogen status of rice. Agron. J., 95: 212-217.
17. Horie, T., 2001. Increasing yield potential in irrigated rice. Breaking the yield behavior. In Rice Research for Food Security and Poverty Alleviation. Eds. Peng S and B. Hardy. Inti. Rice Res. Inst. pp: 3-25.
18. Fageria, N.K., V.C. Baligar and C.A. Jones, 1997. Rice. In growth and mineral nutrition of field crops. Marcel Dekker, New York, Basel, Hong Kong, pp: 283-343.
19. Norman, R.J., N.A. Slaton, K.A. K. Moldenhauer and D.L. Boothe, 2001. Influence of seeding date on the degree day 50 thermal heat unit accumulations and grain yield of new rice cultivars. Irr. B. R. Wells Rice. Research Studies 2000. Norman, R. J., (ed) Res. Ser. 485. Arkansas Agric. Exp. Stn, Fayetteville, Ar., pp: 189-196.
20. Norman, R.J., N.A. Slaton, K.A.K. Moldenhouer and D.I. Boothe, 2000. Influence of seeding date on the degreeday 50 thermal heat unit accumulations and grain yield of new rice cultivars. In: B. R. Wells Rice Research Studies. 1999. Norman, R.J. and C.A. Beyrouty (eds.), Res. Ser. 476. Arkansas Agric. Exp. Stn. Fayetteville, Ar., pp: 261-266.
21. Balasubramanian, V., A.C. Morales, R.T. Cruz, T.M. Thiagarajan, R. Nagarajan. M. Babu, S. Abdulrachman and L.H. Hai, 2000. Adaptation of the chlorophyll meter (SPAD) technology for real- time N management in rice.
22. Yoshida, S., 1981. Fundamentals of rice crop science, International Rice Research Institute, Los Banos, Philippines.
23. Peng, S., F.V. Garcia, R.C. Laza, A.L. Sanico, R.M. Visperas and K.C. Cassman, 1996. Increased nitrogen use efficiency using a chlorophyll meter in high-yielding irrigated rice. Field Crop Res., 47: 243-252.
24. Rao, S.D., 1997. Flag leaf a selection criterion for exploting potential yields in rice. Indian. J. Plant. Physio, 25(3): 265-268
25. Dutta, R.K, M.A. Baser Mia and S. Khanm, 2002. Plant architecture and growth characteristics of fine grain and aromatic rices and their relation with grain yield.
26. SAS Institute, 1996. SAS/STAT User's Guide, Version 6.12. SAS Institute, Cary, NC
27. Jennings, P.R, L.E. Berrio, E. Torres and E. Corredor, 2003. A breeding strategy to increase rice yield potential. www.crop.scijournals.org/cgi/content/full/430504715.