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Investigation the sink characteristics of contrast rice (*Oryza sativa* L.) cultivars under different nitrogen applications

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Abstract

In order to study nitrogen applications and cultivar effects on some traits in relation to sink characteristics in the contrast rice (*Oryza sativa* L.) cultivars, a field experiment was carried out in the Rice Research Institute of Iran-Deputy of Mazandaran (Amol) - during 2005. A split plot experiment on the basis of randomized complete block design with 3 replications and 3 factors were used. It includes 3 levels of fertilizer rates (100, 150 and 200 kg.ha^{-1} from urea source) as main plots, and 3 split levels of nitrogen at transplanting S_1 (50%, 25% and 25%) , tillering S_2 (25%, 50% and 25%) and heading stages S_3 (25%, 25% and 50%) as sub plots and three cultivars (Tarom, Shafagh and Bahar1 hybrid) were raised in as ultimate plots. Results showed that nitrogen management and cultivar had significant effects on all the traits studied in relation to sink (grain number per panicle, panicle length and panicle number of m^2). Shafagh and Bahar1 were found superior than Tarom for all traits except for grain weight. Interaction effects between cultivar and transplanting showed highest paddy yield related to Shafagh cultivar. Among sink characteristics, grain number per panicle had the highest and positive correlation with paddy yield. In general, modern cultivars (Shafagh and Bahar1) had higher sink capacity than Tarom a traditional cultivar (considered as a sink -limiting cultivar).

Key words: Rice, sink, nitrogen fertilizer, split application, contrast cultivars.

Introduction

Modern production agriculture requires efficient, sustainable, and environment sound management practices (Fagaria and Baligar, 2001). Rate and timing of nitrogen application are critical in terms of their effects on yield. Nitrogen increases panicle number, spikelet number and number of filled spikelets which largely determine the yield of rice plant. Howere, it is important to determine the optimum rate and proper application of nitrogen fertilizer(De-datta, 1981). Ohnish *et al.* (1999) compared 18 cultivars of different origins in northeast Thailand and reported that the optimum nitrogen uptake was obtained in 40, 80, 90 kg.ha^{-1} at panicle initiation, heading and maturity, respectively. Saha *et al*. (1998) noted that spikelet differentiation and degeneration were greatly influenced by time of nitrogen application and nitrogen absorption at the spikelet differentiation. Heading stages was significantly correlated with both greater spikelets differentiation and per cent degeneration, respectively.

The sink capacity in rice panicle includes sucrose unloading, its breakdown and starch biosynthesis (Ohsugi, 2004). Cao *et al*. (1992) classified rice varieties into sink-limiting, source-limiting, and intermediate types according to their source- sink relationships. Most Indicia/Indica or Japonica/Japonica hybrid rice belong to source-limiting type, with a high ratio of spikelet number to leaf area at heading and low spikelet filling percentage.Yang *et al.* (2002) reported that in Japonica/Indica may result in poor translocation and partitioning of assimilates into low sink activity grains, leading to more resource for vegetative parts.

Sink size in rice can increased either by increasing panicle number or panicle size or both. Sink size would be increased by selecting large panicles only if the panicle number per m^2 were maintained (Ohsugi, 2004). The number of spikelets per unit land area, or sink size, primary determine grain yield of cereal crops growing high-yield environments without stresses. In rice, number of spikelets per m^2 were highly related to dry matter accumulation from panicle initiation to flowering stage (Kropff *et al*. 1994). Kobata *et al.* (2006) suggested that inferior assimilate supply is the main cause of lower grain ripening in Akenohoshi (Indica * Japonica), whereas the earlier decrease in grain ripening, probably due to higher number of spikelets in non fertilizer, is the factor responsible for a new plant type IR65564-44-2-2. The objectives of this study was determining the nitrogen management and cultivar effects on sink characteristics of contrast rice cultivars in north Iran.

Materials and methods

This study was conducted at the Rice Research Institute of Iran, Deputy of Mazandran-(Amol) located in north of Iran (52° 22´ E, 36° 28´ N). The experiment was conducted in split plot based on randomized complete block design with three replications. Three nitrogen fertilizer levels (including 100, 150 and 200 Kg.ha^{-1}), three split application levels of nitrogen fertilizer (including before transplanting time as the basal dressing, tillering time and before heading) (Table 1) and three rice cultivars (Tarom a old cultivar, Shafagh and Bahar1, modern cultivars) considered as the main plot, sub plot and the sub-sub plots respectively. P and K fertilizers were applied at rate of 100 Kg.ha^{-1} before transplanting time. Ten plants were selected from each plot for determination of sink characteristic (grain number per panicle, panicle length and grain weight). For determination of biomass and grain yield, 16 hills (1 m^2) were selected from each plot and then dried till 14% moisture. Analysis of variance was preformed by SAS and Duncan's multiple ranges test was used. Difference between treatment means was tested at 0.05 probability level.

Table 1. Nitrogen split application types

Heading	Tillering (%)	Basal fertilizer	Split application
25	25	50	S_1
25	50	25	S_2
50	25	25	S_3

Results and discussion

Grain weight: Results of variance analysis (Table 2) showed that cultivars had significant difference in grain weight and nitrogen fertilizer management had not significant effect on this trait. The highest and lowest of grain weight was related to Tarom or Shafagh and Bahar1 cultivars, respectively(Table 3). Some studies showed that grain weight of rice is consistent than other components yield and this trait affect only by genotypes (Venkates *et al.* 1987). Also, rice grain in spikelets show different patterns of grain filling depending on their position within a panicle (Ohsugi, 2004).

Grain number per panicle: Results of Variance analysis (Table 2) showed that cultivar and nitrogen rates were affected significantly in grain number per panicle. The highest of grain per panicle was related to Bahar1 cultivar (Table 3). Among interaction effect between nitrogen rate whit split application and nitrogen rate whit cultivar the highest grain number per panicle were observed in 100 kg ha^{-1} in the second split application and 200 kg ha^{-1} in Bahar1 treatments, respectively (Table 4 and 5). Findings by Fageria and Baligar (2001), Singh *et al*. (1996) were agreement to these results. In this experiment, grain number per panicle had a positive and significant correlatin (r=0.76**) to grain yield (Table 7). Qian *et al.* (2004) reported that nitrogen fertilizer application increase the grain number per panicle but reduce the effective spikelets in panicle. Yang *et al*. (2002) resulted that Japonica/Indica hybrid cultivars are source limiting due to poor filling in panicle.

Table 2. The analysis of variance of under nitrogen applications and cultivar effects on sink characteristics of rice

S.O.V.	df	Paddy Yield	Biomass	Panicle number	Panicle length	Grains per panicle	Grain weight
R	2	0.13	0.016	12.55	5.60	720	2.04
N	2	0.43**	13.05*	1463.74**	2.97ns	1534.27*	1. 70^{ns}
Error (a)	4	0.0055	0.11	56.11	0.62	218.52	1.91
S	2	0.46^{ns}	6.01*	51.88^{ns}	5.31^{ns}	690.64^{ns}	0.44^{ns}
S*N	4	0.135^{ns}	6.5**	79.36^{ns}	3.01^{ns}	1008.25**	4.11*
Error (b)	12	0.192^{ns}	0.83	79.141	1.17	263.08	0.32
C	2	44.30**	6.58**	831.03**	46.45**	54935.82**	0.47**
C*S	4	0.27**	4.60**	50.44^{ns}	0.58^{ns}	129.86^{ns}	3.03^{ns}
C*N	4	0.089^{ns}	3.29^{ns}	69.95^{ns}	2.97^{ns}	935.34**	1.95^{ns}
N*S*C	8	0.38**	3.26**	108.01^{ns}	2.54^{ns}	228.36^{ns}	2.02^{ns}
Total error	36	0.05	1.10	51.90	10.30	224.37	1.20
C.V (%)	-	3.91	7.65	11.0	4.94	9.14	4.75

R:Replication- N: Nitrogen rates- S: Split application- C: Cultivar
.**Significant at the 5% and 1% levels of probability, respectively *****and
n.s: non- significant

Table 3. Results of means comparison of studied sink traits in nitrogen fertilizer rates, split application and cultivars

Treatment	Paddy Yield (ton/ha^{-1})	Biomass (ton/ha^{-1})	Panicle number/m^{-2}	Panicle length (cm)	Grain no. per panicle	Grain weight (mg)
Nitrogen fertilizer rates(kg.ha^{-1})						
100	5.92c	13.11c	59.55b	28.27a	170.93a	23.13a
150	6.00b	13.58b	63.11b	27.62b	164.4ab	22.81a
200	6.17a	14.48a	73.70a	27.81ab	155.9b	33.31a
Split application						
S_1	6.17a	14.03a	64.82a	27.64b	157.9a	22.94a
S_2	6.01a	13.96a	64.52a	27.89ab	166.54a	23.18a
S_3	5.91a	13.18b	67.04a	28.35a	113.79a	23.13a
Cultivar						
Tarom	4.56c	14.29a	60.70b	26.39b	113.79c	24.16a
Shafagh	6.88a	13.47b	64.12b	28.5a	175.94b	23.56a
Bahar1	6.66b	13.40b	71.55a	28.76a	201.49a	21.52b

Means within the same column followed by the same not significantly different according to DMRT ($P \leq 0.05$)

S_1, S_2 and S_3: Nitrogen fertilizer split application levels (Table 1)

Panicle length: Different studies showed that panicle length has not important role, but it is a traits for evaluation of yield in rice plant (Fagaria and Baligar, 2001). Result of Table 2 showed that panicle length was affected by cultivar types. Among cultivars Bahar1 and Shafagh had the highest panicle length (Table3). Fagaria and Baligar (2001) reported that panicle length and spikllet number had the highest correlation with grain yield in which was affected significantly by 210 kg.ha^{-1} nitrogen fertilizer. Panicle length had the high positive and significant correlation (r=0.66**) to number grain per panicle and significant and negative correlation to grain weight (-0.27*) (Table 7).

Panicle number: Sink size in rice can be increased either by increasing number or size of panicle or both (Ying *et al.* 1998). Result of variance analysis showed that nitrogen fertilizer rates and cultivar had significant effect on panicle number per m^2 (Table 2). The highest of panicle number per m^2 was obtained in the second and third split application levels whit 200 kg.ha^{-1} nitrogen fertilizers (Table 4). Findings by Fagari and Baligar (2001) are agreement to these results. Sink size would be increased by selecting for large panicle only if the panicle number per m^2 were maintained (Ying *et al.* 1998).

Table 4. Interaction effect of nitrogen fertilizer rates with split application

Treatment	Paddy Yield (ton/ha^{-1})	Biomass (ton/ha^{-1})	Panicle number/m^{-2}	Panicle length (cm)	Grain no. per panicle	Grain weight (mg)
N_1S_1	5.95b	13.75a	59.53b	28.21a	162.12b	23.06a
N_1S_2	6.03b	13.88a	60.08b	28.64a	185.96a	23.18a
N_1S_3	5.00b	11.70b	58.32b	27.96a	165.71b	23.14a
N_2S_1	6.14b	13.28ab	64.08b	27.11a	163.71b	21.88a
N_2S_2	5.91b	13.27a	61.15b	27.41a	164.64b	23.10a
N_2S_3	5.94b	14.08a	64.10b	28.35a	165.08b	23.45a
N_3S_1	6.43a	15.05a	70.84b	27.07a	149.12b	23.86a
N_3S_2	6.10a	14.63a	78.72a	27.63a	149.75b	23.26a
N_3S_3	5.99b	13.57a	60.97a	28.74a	168.82b	22.80a

Means within the same column followed by the same letter not significantly different according to DMRT ($P \leq 0.05$)

N_1, N_2 and N_3: nitrogen fertilizer rates in levels of 100, 150 and 200 kg.ha^{-1} respectively- S_1, S_2 and S_3: nitrogen fertilizer split application levels (Table 1).

Paddy yield and biomass: Result of Table 2 showed that biomass of rice was affected by nitrogen fertilizer, cultivar and split application in 1%, 1% and 5% levels of probability, respectively. Table 3 showed that the first and two split application treatments had a similar group. The highest amount of biomass was obtained in 200 kg.ha^{-1} nitrogen fertilizer (Table 3).

Among different cultivars, Tarom had maximum biomass because of high photosynthesis rate but Shafagh and Bahar1 hybrid cultivars had the least biomass (Table 3). Because of these cultivars had the high sink potential and fertilizer acceptance rather than Tarom cultivar.

Table 5. Interaction effects of nitrogen fertilizer rates with variety

Treatment	Paddy Yield (ton/ha^{-1})	Biomass (ton/ha^{-1})	Panicle number/m^{-2}	Panicle length (cm)	Grain no. per panicle	Grain weight (mg)
N_1V_1	4.54e	13.34a	54.36b	26.45a	116.40de	24.54a
N_1V_2	6.82a	12.67a	55.95b	29.65a	195.07ab	23.74a
N_1V_3	6.42bc	13.32a	68.08ab	28.70a	201.32a	21.11b
N_2V_1	4.72cd	14.37a	58.93b	26.63a	117.13e	23.41a
N_2V_2	6.82a	13.84a	60.80b	27.73a	175.14bc	23.26ab
N_2V_3	6.70ab	12.51a	69.61b	28.76a	200.93a	21.76b
N_3V_1	4.66de	15.16a	68.53a	26.35a	107.84e	24.53a
N_3V_2	7.00a	13.90a	75.61a	28.26a	157.62cd	23.68a
N_3V_3	6.85a	14.38a	76.97a	28.83a	202.00a	21.71b

Means within the same column followed by the same letter not significantly different according to DMRT ($P \leq 0.05$)
N_1, N_2 and N_3: nitrogen fertilizer rates in levels 100, 150 and 200 kg ha^{-1}- V_1, V_2 and V_3: Respectively, cultivar levels Tarom, Shafagh and Bahar1 cultivars.

Table 6. Interaction effect of fertilizers with split application

Treatment	Paddy Yield (ton/ha^{-1})	Biomass (ton/ha^{-1})	Panicle number/m^{-2}	Panicle length (cm)	Grain no. per panicle	Grain weight (mg)
V_1S_1	5.95b	15.04a	61.42a	26.23a	110.58b	24.37a
V_1S_2	6.03b	14.06a	72.06a	28.11a	168.58ab	23.55a
V_1S_3	5.00b	12.92a	72.06a	28.05a	194.54a	24.55a
V_2S_1	6.14b	14.06a	59.06a	26.16a	11.97b	23.18a
V_2S_2	5.91b	13.32a	62.53a	28.53a	182.56a	23.81a
V_2S_3	5.94b	14.49a	71.92a	28.98a	205.82a	23.70a
V_3S_1	6.43a	13.77a	62.05a	26.78a	118.81a	21.25a
V_3S_2	6.10b	12.96a	68.41a	29.01a	176.68a	22.18a
V_3S_3	5.99b	12.97a	70.67a	29.26a	204.12a	21.14a

Means within the same column followed by the same letter not significantly different according to DMRT ($P \leq 0.05$)
S_1, S_2 and S_3: Respectively, nitrogen fertilizer split application levels (Table 1) - V_1, V_2 and V_3: Respectively, cultivar levels, Tarom, Shafagh and Bahar1 cultivars.

Table7. Correlation coefficients among studied traits

Traits	Biomass	Panicle number	Panicle length	Grains per panicle	Grain weight	Paddy Yield
Biomass	1	0.07	-0.19*	-0.27*	-0.27ns	-0.15ns
Panicle number		1	0.22*	0.19	-0.18	0.34**
Panicle length			1	0.66**	-0.26*	0.5**
Grain number per panicle				1	-0.54**	0.76**
Grain weight					1	0.36**
Paddy Yield						1

Significant at the 5% and 1% levels of probability, respectively - *and **; n.s = non- significant

Results showed that among cultivars, Shafagh had the highest paddy yield (Table 3). Also, Bahar1 had the lower paddy yield than Shafagh that had higher unfilled grain number per panicle. Effects of nitrogen fertilizer rate and cultivar were significant at 5% and 1% levels of probability (Table 2). Results of means comparisons showed that 200 $kg.ha^{-1}$ nitrogen fertilizers caused the highest paddy yield (Table 3). In this experiment, among sink characteristics, grain number per panicle had the highest positive and significant correlation (r=0.76**) whit paddy yield (Table 7). Interaction effects between cultivar in split application showed that the highest paddy related to Shafagh cultivar whit first split application treatment (Table 6). Final paddy yield in rice plant is determined by some sink traits such as panicle number in m^2, grain number per panicle and grain weight. Singh *et al*. (1996) obtained the highest paddy yield in 150 to 200 $kg.ha^{-1}$ nitrogen fertilizer in Philippine. In general, modern cultivars (Shafagh and Bahar1) had the higher sink function than Tarom (traditional cultivar) whereas Tarom considered as a sink -limiting cultivar.

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