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Study the Effect of Nitrogen Fertilizer Management on Dry Matter Remobilization of Three Cultivars of Rice (*Oryza sativa* L.)

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Abstract: In order to study the effect of nitrogen fertilizer management on dry matter remobilization among three rice cultivars, a field experiment was carried out at the Rice Research Institute of Iran-Deputy of Mazandaran (Amol). In 2005, a split-split experiment in the basis of randomized complete block design with 3 replications and 3 factors were used in which fertilizer rate (100, 150 and 200 kg ha^{-1} from urea source), fertilizer split application (3 levels in variable ratios in transplanting, tillering and heading stages and cultivars (Tarom, Shafagh and Bahar1) were the treatments. Results showed that nitrogen fertilizer rates and split application had significant effect on dry matter remobilization amount in total shoot, stem and leaves (except flag leaf) in which among cultivars, Shafagh had the highest amount in terms of stem and total shoot dry matter remobilization. This amount was obtained at the 100 kg ha^{-1} nitrogen fertilizer and the first split application treatment. The highest rate of dry matter remobilization in leaves (except flag leaf) related to Bahar1 that obtained in 200 kg ha^{-1} nitrogen fertilizer level. Also, flag leaf of Bahar1 had the highest dry matter remobilization amount, although was not affected by nitrogen fertilizer rates and split application. Thus, it seams that this part has important role in current photosynthesis at post anthesis stage compared with dry matter remobilization. According to our findings, flag leaf in Tarom cultivar not only has no significant role in dry matter remobilization, but also act as a powerful sink for photosynthetic assimilates.

Key words: Dry matter remobilization, nitrogen fertilizer, split application, rice cultivars

INTRODUCTION

Rice (*Oryza sativa* L.) is an important primary crop in the world. It is the staple food for more than two third of the world's population (Singh, 1993). Nitrogen is an important component of rice production technology with high yielding varieties and its immense role in increasing rice productivity is well documented (Kumar and Prasad, 2004). Rate and timing of nitrogen are critical in terms of their effects on yield. Nitrogen increases plant height, panicle number, leaf size, spiklet number and number of filled spikelets (Doberman and Fairhurst, 2000). Two physiological processes are involved in grain growth: Utilization of photosynthesis through current photosynthesis and remobilization and translocation of substance accumulated before anthesis (Tahmasebi Sarvestani and Pirdashty, 2001). In rice, available carbon assimilates for grain growth is determined by carbon assimilation during filling period plus assimilates reserve stored in the straw (Ntanos and Koutroubus, 2002). Tahmasebi Sarvestani and Pirdashty (2001) reported that dry matter and nitrogen remobilization of shoot (stem + leaf + flag leaf) had an important effect on grain dry matter and nitrogen accumulation.

Ntanos and Koutrobus (2002) reported that contribution of per-anthesis accumulated reserves to grain weight ranged from 9.1 to 42.2% indicating the importance of per-anthesis storage of assimilated for attaining high grain yield of rice and grain filling was positively and significantly correlated with dry matter and nitrogen translocation efficiency. Also, cultural practices have a strong influence on translocation of assimilate

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during the grain filling period. Results of studies showed that remobilization of reserves to grain is critical for grain yield, if the plants are subjected to different treatments for example water stress during grain filling (Kumar *et al*., 2006). However the early senescence induced by a moderate water deficit during grain filling can enhance the remobilization of stored assimilates and accelerates grain filling of rice (Yang *et al*., 2001). Also, Yang *et al*. (2000) and Yang *et al*. (2003) reported that controlled water deficit during grain filling enhanced whole plant senescence and such enhanced senescence can facilitate remobilization of carbon reserves, accelerate grain filling and increase grain yield. The objective of present study was to determine the effects of nitrogen fertilizers and split application on dry matter remobilization among different rice cultivars in north of Iran conditions.

MATERIALS AND METHODS

This study was conducted at the Rice Research Institute of Iran-Deputy of Mazandaran (Amol) located in north of Iran (52°22′ E, 36°28′ N). The experiment arranged in split plot in the basis of randomized complete block design with three replications. Three nitrogen fertilizer levels (including 100, 150 and 200 kg ha^{-1} from urea source) as the main plots, three split application levels of nitrogen (including before transplanting time as the basal fertilizer, tillering time and before heading) as sub plots (Table 1) and rice cultivars (including Tarom (traditional), Shafagh (improved) and Bahar1 (GRH1 hybrid) as the sub-sub plots were used. Phosphate and potassium fertilizers were applied at the rate 100 kg ha^{-1} at transplanting time. At the flowering and the maturity, plants were collected and separated to different parts (including stem, flag leaf and other leaves) and then dried in 75°C for 72 h and weighted. Amount of dry matter remobilization accounted as followed:

Amount of dry matter remobilization (g m^{-2}) = Amount of dry matter at flowering − Amount of dry matter at maturity grain.

Data were statistically evaluated by analysis of variance using of the SAS data processing package. Duncan multiply rang test was used to compare treatment means at 5% probability level.

Table 1: Split application levels of nitrogen fertilizer at different growth stages

	(Percentage of each fertilizer amount)		
Split application levels	Basal fertilizer	Tillering	Heading
S_1	50	25	25
S_2	25	50	25
S_3	25	25	50

RESULTS

Results of analysis variance (Table 2) showed that nitrogen fertilizer management had significant effects on dry matter remobilization amount in total shoot, stem and other leaves. Among cultivars, nitrogen fertilizer levels and split applications, Shafagh (improved cultivar), 100 kg ha^{-1} fertilizer level and S_1 (the first application) had the highest amount in terms of total shoot (78.98 g m^{-2}) dry matter remobilization, respectively (Table 3). Tarom (traditional cultivar) had least amount of dry matter remobilization from total shoot (Table 3). In this experiment interaction effects of nitrogen fertilizer with split application, nitrogen fertilizer with variety and variety with split application were significant at 1% probability level (Table 2). The highest amount of dry matter remobilization obtained in 100 kg ha^{-1} fertilizer level and the first level of split application (50, 25 and 25%) treatment (Table 4). Nitrogen fertilizer rate, split application and cultivars had significant effect on dry matter amount from remobilized stem (Table 2). Among cultivars, Shafagh had the highest amount of dry matter remobilization from stem (Table 3). This amount was obtained in 100 kg ha^{-1} nitrogen fertilizer and the first split application (S_1) (Table 4). Also dry matter remobilization from stem was much more in Shafagh with first split application interaction (Table 6). Results also showed that stem part has an important role in remobilization than other parts (other leaves and flag leaf).

Flag leaf of Bahar1 had the highest dry matter remobilization among cultivars. Although, it was not affected by nitrogen rate and split application (Table 3). On the other hands, interaction effects of nitrogen with split application and variety with nitrogen fertilizer and variety with split application were significant at 1, 1 and 5% probability levels, respectively (Table 2). Table 5 showed that Bahar1 with 200 kg ha^{-1} nitrogen fertilizer treatment has the highest amount of remobilization from flag leaf. Also, Other Leaves (all leaves except flag leaf) remobilization was affected by nitrogen fertilizer rate, split application and cultivars (Table 2). The highest amount of remobilization from other leaves (6.23 g m^{-2}) was obtained for Bahar1 and 200 kg ha^{-1} nitrogen fertilizer rate with first split application (S_1) treatments (Table 4). In this experiment, dry matter remobilization of total shoot, stem and other leave had a significant and positive correlation with yield (r = 0.60**, r = 0.62** and r = 0.34**, respectively) (Table 7).

Table 2: Analysis of variance of effects nitrogen rates, split application and variety on dry matter remobilization

		Total shoot	Stem	Flag leaf	Other leave	Grain yield
SOV	df	($g\ m^{-2}$)				
Replication	2	1496.00	15.55	0.27	0.30	1316.13
Nitrogen rates	2	1982.07**	2221.07**	8.68^{ns}	22.29**	4306.11**
Error (a)	4	21.52	13.23	1.13	0.22	53.56
Split application	2	1782.30**	1485.94**	6.36^{ns}	4.69*	4643.92^{ns}
Split application* Nitrogen rates	4	723.21**	686.65**	4.57**	2.49**	13.14.58^{ns}
Error (b)	4	23.66	98.25	0.97	0.40	1908.62
Variety	2	52071.29**	41681.58**	162.05**	365.63**	442983.18**
Variety *Split application	4	874.98**	890.16**	2.77**	6.30**	2696.27**
Variety *Nitrogen rates	4	1591.13**	1392.36**	10.93**	03.07**	896.64^{ns}
Variety *Split application* Nitrogen rates	8	659.29**	684.34**	3.58**	15.25**	3876.91**
Total error	44	40.71	40.48	3.58	0.50	562.79
C.V (%)	-	17.04	21.30	22	20.90	3.93

Significant at the 5% and 1% levels of probability, respectively. **, * ns: non-significant

Table 3: Results of mean comparison of studied traits in Nitrogen fertilizer rates, Split application and Variety

	Total shoot	Stem	Flag leaf	Other leave	Grain yield
Treatments	($g\ m^{-2}$)				
Nitrogen fertilizer rates (kg ha^{-1})					
100	487.89a	403.10a	37.53b	32.25b	592.93c
150	318.37b	253.39b	38.87b	26.09c	600.11b
200	331.48b	239.53b	47.96a	46.98a	617.49a
Split application					
S_1 (50, 25 and 25%)	467.76a	383.37a	46.56a	37.82a	617.49a
S_2 (25, 50 and 25%)	333.94b	257.43b	36.90b	60.29b	601.54a
S_3 (25, 25 and 50%)	320.03b	245.23b	40.90ab	34.89a	591.50a
Variety					
Tarom	-87.36c	-94.27c	14.39c	-7.59c	-456.15c
Shafagh	786.82a	691.55a	47.80b	46.47b	688.14a
Bahar1	423.28b	298.75b	62.17a	62.36a	666.24b

Means within the same column followed by the same not significantly different according to DMRT (p<0.05), S_1, S_2 and S_3: Nitrogen fertilizer split application levels (Table 1)

Table 4: Interaction effect of nitrogen fertilizer rates in split application

	Total shoot	Stem	Flag leaf	Other leave	Grain yield
Treatments	($g\ m^{-2}$)				
N_1S_1	556.91a	489.66a	36.30ab	30.64c	595.02b
N_1S_2	551.46a	444.17a	39.41a	27.88c	603.15b
N_1S_3	350.58bc	275.47b	36.88a	38.23a	580.61b
N_2S_1	475.36ab	390.36ab	49.94a	35.05ab	613.99b
N_2S_2	245.42c	197.87c	25.90b	21.64bc	591.43b
N_2S_3	234.32c	171.94c	40.77a	21.58c	592.92b
N_3S_1	371.32b	270.09bc	53.45a	47.77a	643.45a
N_3S_2	244.92c	160.25c	45.38a	39.28a	610.04b
N_3S_3	378.19b	288.26b	45.05a	44.87a	598.97b

Means within the same column followed by the same letter not significantly different according to DMRT (P<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, Respectively (Table 1)

Table 5: Interaction effects of nitrogen fertilizer rates in variety

	Total shoot	Stem	Flag leaf	Other leave	Grain yield
Treatments	($g\ m^{-2}$)				
N_1V_1	-107.94f	-101.14e	14.64c	-21.46d	454.10c
N_1V_2	1020.34a	909.78a	52.50b	58.06b	682.06a
N_1V_3	506.26cd	400.67cd	45.43b	60.16b	642.62bc
N_2V_1	-54.57f	-63.68e	12.25c	-3.14d	447.75c
N_2V_2	579.68bc	504.03bc	44.18bc	31.46cd	682.00a
N_2V_3	429.98de	319.83d	60.18b	49.96bc	670.58ab
N_3V_1	-99.57f	-117.96e	16.27c	2.12d	466.59c
N_3V_2	760.42b	660.84b	46.72b	52.85b	700.36a
N_3V_3	333.58ef	175.73de	80.89a	76.96a	685.51a

Means within the same column followed by the same letter not significantly different according to DMRT (p<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, variety levels tarom, Shafagh and Bahar1

Table 6: Interaction effect of urea fertilizer rates in split application

Treatments	Total shoot	Stem	Flag leaf	Other leave	Grain yield
	($g\ m^{-2}$)				
V_1S_1	-89.61e	-103.05e	22.24cd	-8.80de	426.64d
V_1S_2	-67.83e	-59.94e	10.20d	-18.09e	456.46cd
V_1S_3	-104.46e	-119.79e	10.73d	4.40cd	454.33c
V_2S_1	851.62a	743.84a	53.72b	54.06ab	709.16a
V_2S_2	762.38b	670.52b	46.54b	45.32b	670.76bc
V_2S_3	307.26de	191.72de	53.95b	61.58a	684.50ab
V_3S_1	641.28cd	509.33cd	63.73ab	68.21a	680.66b
V_3S_2	746.35bc	660.30bc	43.15bc	42.99bc	682.40b
V_3S_3	321.29d	195.18d	63.82a	57.29a	635.66de

Means within the same column followed by the same letter not significantly different according to DMRT ($p<0.05$), N_1, N_2 and N_3: Respectively, nitrogen fertilizer rates in levels of 100, 150 and 200 kg ha^{-1}. S_1, S_2 and S_3: respectively, nitrogen fertilizer split application levels (Table 1)

Table 7: Correlation coefficients between studied traits

Traits	Grain yield	Total shoot	Stem	Flag leaf	Other leave
Grain yield	1				
Total shoot	0.60**	1			
stem	0.62**	0.65**	1		
Flag leaf	0.052^{ns}	0.35**	0.087^{ns}	1	
Other leaves	0.34**	0.56**	0.28*	0.31**	1

Significant at the 5 and 1% levels of probability, respectively. ns: non-significant **and*

DISCUSSION

Results showed that dry matter remobilization in rice is affected by genotype and cultural practices. Palta and Fillery (1995) reported that with application of nitrogen fertilizer, role of dry matter at per-anthesis will increase in the yield of rice cultivars. In this experiment stem had higher amount of dry matter remobilization than other parts. Tahamasbi Sarvastani and Pirdashty (2001) also, reported that Fajr cultivar (improved cultivar) had the highest amount of remobilization of stem among the cultivars. Also, this result is consistent with the findings of Tahamasbi Sarvastani (1995), Ntanos and Koutrobus (2002), Yang *et al.* (2003) and Kumar *et al.* (2006). Flag leaf of Tarom cultivar (traditional cultivar) was not important in dry matter remobilization. Thus, it seems that flag leaf has important role in current photosynthesis at post anthesis stage compared with dry matter remobilization. Our findings showed that flag leaf in Tarom cultivar not only has not an important role in dry matter remobilization but also acted as a strong sink for photosynthetic assimilates. Cultivar and nitrogen fertilizer management affect other leaves dry matter remobilization. This result is consistent with the results of Tahamasbi Sarvastani (1995) and Tahamasbi Sarvastani and Pirdashty (2001). They reported that different rate of remobilization among the cultivars was related to their agronomic characteristics.

Thus, it seems that the first split application (S_1) has more important role in remobilization of dry matter than other split application types (S_2, S_3). This result can help physiologists and agronomists to determine physiological and agronomical characteristics of varieties that contribute most dry matter partitioning to increasing yield production.

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