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Effect of Levels and Splitting of N-fertilization on Growth, Yield Components, Yield and Grain Quality of Some Rice Cultivars

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Abstract: Two field experiments were conducted at the experimental farm of the Institute Efficient Productivity, Zagazig University, located at Ghazala village, Sharkia Governorate. The aim of the study was to know effect of nitrogen fertilization levels and its splits on growth and yield of three rice cultivars. The experiments were conducted during 2005 and 2006 summer growing seasons. The tested cultivars were Giza 178, Sakha 103 and Sakha 104. Two nitrogen fertilizer levels 40 and 60 kg were split and applied at two, three and four equal doses. The most important results were: the rice cultivars differed in their growth, grain yield, yield components and quality characters. Where, Sakha 103 was the superior in most characters and Sakha 104 in the second order. Increasing nitrogen fertilization levels from 40 to 60 kg N/fad increased the most yield components which led to significant increase in grain yield/fad. Meantime, rice grain quality was improved significantly with increasing nitrogen fertilizer level. Increasing of N splitting caused significant increases in growth, yield and yield components. Since four splits was the superior and three splits came in the second rank but two splits treatment was the latter in most characters. Rice grain quality was not affected by nitrogen fertilizer splitting. Interaction effect between nitrogen fertilizer levels and its splitting was significant on number of unfilled grains/panicle, number of filled grains/panicle and grain yield/fad.

Key word: Rice cultivars, nitrogen fertilization, N splitting, growth, yield components and grain quality

INTRODUCTION

Rice (*Oryza sativa L.*) is considered one of the most important source for human food and hard currency earned exportable crop. However, the need to raise its productivity more and more per unit land area is a major goal to meet the increasing demands from this crop. Raising rice production can be achieved through optimizing the agricultural practices such as nitrogen fertilization levels and splitting of nitrogen fertilizer. In this regard, many researchers have shown that rice cultivars differ in their growth, grain yield, yield components and quality. This views were reported by Abd El-Wahab[2], El-Kady *et al*.[10], El-Hosary *et al*.[9], Omar[19], El-Rewainy *et al*.[12], Abd El-Maksoud and Omar[1] and Sallam[20]. Bassal *et al*. stated that increasing N-levels from 0, 20, 40 to 60 kg N/fad significantly increased plant height, panicle length, panicle grain weight, 100- grain weight, straw and grain yield per fad of Gz 1368 cultivar. The same results were reported by Ebaid[6] Awad and El Rewainy *et al*.[12]. El-Sheref *et al*. reported that increasing N-levels to 60 kg N/fad significantly increased panicle length, panicle grain weight, number of field grains/panicle, 100- grain weight, grain yield and straw yield ton/fad. These results are in agreements with those obtained by Ebaid and Ghanem[6], Ibrahim[16], Omar[19] and Sallam[20].

Rice quality, hulling %, milling % and head rice % were significantly increased by increasing nitrogen fertilization levels. Similar results were reported by Ebaid and Ghanem[6], Omar[19], El-Sheref *et al*. and Sallam[20]. Yield of the newly recommended rice cultivars is not only influenced by nitrogen fertilizer but also by splitting of nitrogen. In this respect, Abd Alla stated that adding nitrogen fertilizer in two equal doses significantly increased grain yield and most of its components compared with one or three doses. Abd El-Wahab[2] reported that the highest grain yield and its attributes were recorded when two thirds of the applied nitrogen was incorporated with the dry soil just before transplanting and third one at panicle initiation. In this regard, many researchers like have Sorour *et al*.[22], El-Hosary *et al*.[9] Xiao *et al*.[24], Surekha *et al*.[23], Omar[19] and Sallam[20] shown that rice cultivars (growth, yield and quality) responded to splitting nitrogen fertilizer. El-Hosary *et al*.[9] reported that splitting nitrogen to three equal splits increasing milling %, Hulling % and head rice % compared with two splits. The same results were reported by El-Refee[11], Bassal *et al*.,

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Sorour *et al*.[22], El-Rewaing *et al*.[12], Ebaid and Ghonem[6], El-Kady and Abd El-Wahab[10] and Sallam[20].

Therefore, this investigation was carried out in order to study the effect of nitrogen fertilizer levels as well as number of splits of its application on productivity of three rice cultivars.

MATERIALS AND METHODS

Two field experiments were carried out at Farm of the Institute Efficient Productivity in Ghazala village, Zagazig District, Sharkia Governorate, at 2005 and 2006 summer seasons. These experiments were conducted to investigate the effect of nitrogen fertilization levels (40 and 60 kg N/fad) and nitrogen splitting (two, three and four equal splits) on growth, yield, yield components and grain quality of three rice cultivars (Giza 178, Sakha 103 and Sakha 104). The split-split plot design with three replications in both seasons was followed. The main plots are assigned for rice cultivars. The nitrogen fertilizer levels were allocated in the sub-plots and the nitrogen fertilizer splitting treatments were distributed randomly in the sub-sub plots,

The nursery seedbed was well prepared and fertilized with calcium super phosphate (15.57% P_2O_5) at the rate of 100 kg/fad. After two weeks from sowing, a rate of 40 kg N /fad was added as urea (46% N). The seeding rate used was 60 kg/fad. Rice grains were soaked in running water for 48 hours and incubated for 48 hours. Thereafter, they were hand broadcasted in May 25th in both seasons. At seven days age, weeds were chemically controlled using Saturn 50% at the rate of 2 litres dissolved in 100 litres of water/fad which sprayed using knopsack sprayer.

The preceding crop was wheat in both seasons. The permanent field was well prepared and calcium super phosphate (15.5 % P_2O_5) was added at the rate of 100 kg/fad. After one month, seedlings were transplanted, five seedlings per hill, with hill arrangement at 15 x15 cm. The plot area was 9m^2 (3x3 m) including 20 rows/plot. After four days from transplanting weeds were controlled with saturn 50% at the rate of 2 litres/fad dissolved in 100 litres of water and sprayed using knapsack sprayer. The tried two N fertilizer levels were added at equal doses starting from transplanting time and every 15 days later was added at transplanting time and every 15 days later (equal doses) for both tow nitrogen fertilization levels and nitrogen splitting. The other cultural practices for rice were kept the same as usually recommended in the district. Crop duration for rice cultivars was 125 days for Giza 178 and Sakha 103 and 135 days for Sakha 104.

Studied Characters:

Growth: In each sub-sub plot ten hills from the second row were marked after transplanting (each hill was thinned to five plants). At 70 days from transplanting, five marked hills were taken from the second row and the following data were recorded:

1- Plant height (cm).
2- flag leaf area (cm^2).
3- SPAD values for flag leaf were estimated by using chlorophyll meter (SPAD-50Z, Soil Plant Analysis Development SPAD Section, Minolta Camera Co. Asaka Japan.

Yield and Yield Components: At harvest time, ten guarded hills were taken from the two inner rows and the following data were recorded:

1- Panicle length (cm).
2- Panicle grain weight (g).
3- Number of grains/panicle
4- Unfilled grain number/ panicle.
5- 1000-grain weight (g).

The central area of each sub- sub-plot 5.4 m^2 (1.8 x 2 m) were harvested and the following characters were recorded.

1- Grain yield (ton/fad)
2- Above ground biomass (ton/fad).

Grain Quality Characters: Two hundred grams were taken from each treatment and sent to the grain quality Lab of the Rice research and Training Center (RRTC) in Sakha to determine technological characters of grain according to the methods described by Julian[17] and Khush *et al*.[18].

1- Hulling recovery (brown rice) percentage.
2- Milling out percentage.
3- Head rice percentage.

Statistical analysis: The Obtained data were subjected to the statistical analysis according to Snedecor and Cochran[21]. Duncan's multiple range test was used for the comparison between means[4]. Means having the same letters are not significantly different.

RESULTS AND DISCUSSION

Data of the Tables (1-5) show the response of three rice cultivars to N-fertilizer levels and its splits on growth, grain yield, its components and grain quality.

Table 1: Effect of rice cultivars, nitrogen fertilizer levels and nitrogen fertilizer splits on plant height (cm), SPAD value and Flag leaf area (cm^2) in the two seasons and their combined.

Main effects and interactions	Plant height (cm)			SPAD value for flag leaf			Flag leaf area (cm^2)		
	1st season	2nd season	combined	1st season	2nd season	combined	1st season	2nd season	combined
Rice cultivars (CV):									
Giza 178 (CV_1)	100.29c	81.50c	90.90c	38.49	39.08	38.79	19.628	20.341	19.984
Sakha 104 (CV_2)	103.49b	85.08b	94.27b	38.95	39.53	39.24	20.210	22.210	22.036
Sakha 103 (CV_3)	110.58a	92.89a	101.73a	37.83	38.72	38.28	20.124	21.650	20.887
F-test	**	**	**	NS	NS	NS	NS	NS	NS
Nitrogen fertilizer levels (N):									
40 kg N/fad (N_1)	103.87	87.06	95.46	38.20	38.47b	38.33b	19.610	21.321	20.47
60 kg N/fad (N_2)	105.71	85.92	95.81	38.66	39.76a	39.21a	20.363	21.364	20.86
F-test	NS	NS	NS	NS	**	**	NS	NS	NS
Nitrogen fertilizer splits (S):									
Two splits (S_1)	105.98	88.03a	97.00a	38.23	37.70b	37.97b	20.071	21.372	20.72
Three splits (S_2)	104.59	83.79b	94.19b	38.38	39.42a	38.90ab	19.615	20.511	20.06
Four splits (S_3)	103.80	87.65a	95.73ab	38.66	40.21a	39.43a	22.143	22.143	21.21
F-test	NS	**	**	NS	**	**	NS	NS	NS
Interactions:									
CV x N	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV x S	NS	**	NS	NS	NS	NS	NS	NS	NS
N x S	NS	0	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of rice cultivars, nitrogen fertilizer levels and nitrogen fertilizer splits on number of panicles/hill, panicle length (cm) and number of unfilled grain/panicle in the two seasons and their combined.

Main effects and interactions	Number of panicle/hill			Panicle length (cm)			Number of unfilled grains/panicle		
	1st season	2nd season	Combined	1st season	2nd season	Combined	1st season	2nd season	Combined
Rice cultivars (CV):									
Giza 178 (CV_1)	10.74b	16.47a	13.61b	22.80a	19.99a	21.40a	14.56	16.83	15.69a
Sakha 104 (CV_2)	13.38ab	13.52b	13.70b	18.74b	17.37c	18.06c	12.41	14.46	13.43b
Sakha 103 (CV_3)	15.47a	14.47b	14.86a	20.49c	18.77b	19.63b	13.11	14.96	14.03ab
F-test	**	**	0	**	**	**	NS	NS	0
Nitrogen fertilizer levels (N):									
40 kg N/fad (N_1)	13.74	14.55b	14.14	20.35	18.74	19.55	13.49	16.87a	15.18a
60 kg N/fad (N_2)	12.84	15.09a	13.97	21.00	18.68	19.84	13.23	13.96b	13.59b
F-test	NS	0	NS	0	NS	NS	NS	0	0
Nitrogen fertilizer splits (S):									
Two splits (S_1)	12.81	14.34	13.58	20.45	19.10	19.78	16.24a	18.42a	17.33a
Three splits (S_2)	13.54	14.42	13.98	20.97	18.53	19.75	12.83b	13.64b	13.24b
Four splits (S_3)	13.51	15.71	14.61	20.61	18.50	19.55	11.01b	14.18b	12.59b
F-test	NS	NS	NS	NS	NS	NS	0	**	0
Interactions:									
CV x N	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV x S	NS	0	NS	NS	0	**	NS	NS	NS
N x S	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Effect of rice cultivars, nitrogen fertilizer levels and nitrogen fertilizer splits on number of filled grains/panicle, 1000-grain weight (g) and grain weight (g)/ panicle in the two seasons and their combined.

Main effects and interactions	Number of filled grain/panicle			1000-grain weight (gm)			Grain weight (gm)/ panicle		
	1st season	2nd season	Combined	1st season	2nd season	Combined	1st season	2nd season	Combined
Rice cultivars (CV):									
Giza 178 (CV_1)	125.11a	121.10a	123.10a	22.817c	23.906c	23.362c	2.856	2.898c	2.877c
Sakha 104 (CV_2)	124.301a	114.76c	119.38b	26.089b	26.439b	26.264b	4.822	3.037b	3.929a
Sakha 103 (CV_3)	117.03b	118.45b	117.74b	28.218a	27.743a	27.980a	3.403	3.288a	3.296b
F-test	**	**	**	**	**	**	**	**	**
Nitrogen fertilizer levels (N):									
40 kg N/fad (N_1)	119.94b	116.26b	118.10b	25.592	25.587a	25.590	4.118	2.974b	3.546
60 kg N/fad (N_2)	124.16a	119.95a	122.05a	25.824	26.470b	26.150	3.204	3.174a	3.189
F-test	**	**	**	NS	**	NS	NS	**	NS
Nitrogen fertilizer splits (S):									
Two splits (S_1)	117.67b	112.16b	114.91b	25.516	25.338c	25.430b	2.992	2.841c	2.916b
Three splits (S_2)	123.27a	120.78a	122.03a	25.454	26.051b	25.750b	3.133	3.141b	3.137b
Four splits (S_3)	125.21a	121.37a	123.29a	26.154	26.699a	26.430a	4.857	3.241a	4.049a
F-test	**	**	**	NS	**	0	NS	**	**
Interactions:									
CV x N	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV x S	NS	0	0	NS	NS	NS	NS	NS	NS
N x S	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4: Effect of rice cultivars, nitrogen fertilizer levels and nitrogen fertilizer splits on grain yield , above ground biomass (ton/faddan) in the two seasons and their combined

Main effects and interactions	Grain yield (t/fad)			Above ground biomass (ton/faddan)		
	1st season	2nd season	Combined	1st season	2nd season	Combined
Rice cultivars (CV):						
Giza 178 (CV_1)	2.967b	3.350b	3.159b	7.575	7.590a	7.582a
Sakha 104 (CV_2)	3.188ab	3.647a	3.417a	7.707	7.079b	7.393ab
Sakha 103 (CV_3)	3.368a	3.597a	3.483a	7.463	6.998b	7.231b
F-test	0	0	**	NS	**	0
Nitrogen fertilizer levels (N):						
40 kg N/fad (N_1)	3.089	3.449b	3.269b	7.339	6.885b	7.212b
60 kg N/fad (N_2)	3.259	3.614a	3.437a	7.625	7.559a	7.592a
F-test	NS	0	0	NS	**	0
Nitrogen fertilizer splits (S):						
Two splits (S_1)	2.574c	2.662c	2.618c	7.056b	6.652b	6.854b
Three splits (S_2)	3.247b	3.725b	3.486b	7.711ab	7.435a	7.573a
Four splits (S_3)	3.702a	4.207a	3.954a	7.980a	7.579a	7.780a
F-test	**	**	**	**	**	**
Interactions:						
CV x N	NS	0	NS	NS	NS	NS
CV x S	NS	NS	**	NS	NS	NS
N x S	NS	NS	NS	NS	NS	NS

Varietal Variations: Sakha 103 cultivar was the tallest followed by Sakha 104 and then by Giza 178 cultivar. The three cultivars did not show significant variation in SPAD value and flag leaf area as well. Sakha 103 cultivar produced significantly higher panicle number/hill than the other ones, this was true in the 1st season as well as in the combined analysis. Giza 178 cultivar had the tallest spike followed by Sakha 103 and the shortest panicles were produced by Sakha 104. The latter cultivar had lower number of unfilled grains

Table 5: Effect of rice cultivars, nitrogen fertilizer levels and nitrogen fertilizer splits on hulling %, milling % and head rice % in the two seasons and their combined.

Main effects and interactions	Hulling %			Milling %			Head rice %		
	1st season	2nd season	Combined	1st season	2nd season	Combined	1st season	2nd season	Combined
Rice cultivars (CV):									
Giza 178 (CV_1)	78.908	80.400	79.654	72.294	70.344c	71.319c	66.878	65.665b	66.289b
Sakha 104 (CV_2)	80.956	80.950	80.953	73.117	73.878a	73.497a	67.400	67.533a	67.467a
Sakha 103 (CV_3)	81.293	80.822	81.058	73.339	71.833b	72.586b	67.289	66.444ab	66.867ab
F-test	NS	NS	NS	NS	**	**	NS	0	0
Nitrogen fertilizer levels (N):									
40 kg N/fad (N_1)	79.518b	81.119a	80.318	72.433b	72.178	72.306	66.511b	65.782b	66.146b
60 kg N/fad (N_2)	81.254a	80.329b	80.791	73.400a	71.859	72.630	67.867a	67.377a	67.626a
F-test	**	0	NS	0	NS	NS	NS	0	NS
Nitrogen fertilizer splits (S):									
Two splits (S_1)	80.821	79.978b	80.400	73.333a	71.928	72.581	67.500	65.467a	66.483
Three splits (S_2)	80.608	80.655ab	80.632	71.994b	72.089	72.042	67.094	66.723ab	66.914
Four splits (S_3)	79.727	81.539a	80.633	73.522a	72.039	72.781	66.972	67.511a	67.242
F-test	NS	**	NS	0	NS	NS	NS	0	NS
Interactions:									
CV x N	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV x S	NS	0	NS	NS	NS	NS	NS	NS	NS
N x S	NS	0	NS	NS	0	NS	NS	NS	NS

than Giza 178 as shown in the combined analysis Giza 178 was more efficient in producing more filled grains /panicle than the other two. Grain weight of the three cultivars showed also significant variation. The heaviest grains were of Sakha 103, followed by Sakha 104 and the lightest grains were of Giza 178. The significantly light grains of Giza 178 could not be compensated for by increasing number of filled grain resulting in lowest grain weight/panicle. The two Sakha cultivars outyielded Giza 178. Their yields were significantly higher than that of Giza 178. Though Giza 178 produced more number of filled grain, yet its light grains was the main reason of its yield deteriorily. Generally, these varietal variations were due to differences in their genetical make up. These results are in agreement with those obtained by El-Kady *et al*.[10], El-Hosary *et al*.[9], Omar[19], El-Rewainy *et al*.[12], Abd El-Maksoud and Omar[1] and Sallam[20].

Effect of Increasing N-level: Increasing nitrogen fertilizer level from 40 to 60 kg N/fad caused affect the other characters i.e. plant height, flag leaf area, number of panicle/hill, panicle length, 1000-grain weight and grain weight/panicle all were not affected by increasing the nitrogen level. The grain yield was increased significantly. The number of filled grain was increased by 3.3 % while number of unfilled grains was decreased by 10.4 %. These two characters may be the reason of increase grain yield by 5 %. The same results were reported by Ebaid[5], Awad, Ibrahim[16], Omar[19], El-Shereif *et al*. and Sallam[20].

Number of Splits of Nitrogen Fertilizer: Plant height as measurement of vegetative growth was affected by splitting of N-fertilizer. Early application of N-fertilizer favored plant height and this could seen when two splits (ended at 15 days after transplanting) gave the tallest plants than three splits (ended at 30 days). SPAD value (monitoring chlorophyll content) was benefited by splitting to 4 doses. Flag leaf area, number of panicles/hill and panicle length were not influenced by the splitting process. Numbers of unfilled and filled grains/panicle were affected significantly. The former was reduced and the latter was increased by delaying N-fertilizer application likewise, the 1000-grain weight was favored by such delay. Panicle grain weight was affected significantly by the splitting process. It seems that splitting N-application to four doses i.e. delaying to N-application from 15 days (two splits), to 30 days (three splits) and to 45 days (four splits) provided the rice plants with nitrogen throughout the vegetative growth period (all 75 days). This may explain the favour effect of splitting N-fertilizer on these yield attributing traits. These effects led the grain yield and above ground biomass to be affected positively by splitting the nitrogen fertilizer to 3 or 4 doses. Similar results were obtained by Abd El-Wahab[2] El-Hosary *et al*.[9] Ebaid and Ghanem[6] Omar[19] and Sallam[20].

Effect of Nitrogen Fertilizer Levels and Splitting on Grain Quality of Rice Cultivars: Sakha 103 and Sakha 104 cultivars gave better milling head rice percentages than Giza 178. This was due to the gentical make up of the three cultivars. These results are in agreement with those reported by El-Hosary *et al*.[9] El-Rewainy *et al*.[12] and Abd El- Maksoud and Omar[1] (2004).

Table 6: Interaction effect between nitrogen fertilizer levels and nitrogen fertilizer splitting on unfilled grain/panicle (combined data)

Nitrogen fertilizer levels	Nitrogen fertilizer splitting		
	S_1	S_2	S_3
40kg N/fad (N_1)	A	B	B
	18.30a	13.53a	13.71a
60kg N/fad (N_2)	A	B	C
	16.37b	12.94b	11.48b

Table 7: Interaction effect between rice cultivars and nitrogen fertilizer splitting on number of filled grains/panicle (combined data).

Rice cultivars	Nitrogen fertilizer splitting		
	S_1	S_2	S_3
CV_1	C	A	B
	118.97a	125.73a	124.60a
CV_2	C	B	A
	112.53b	121.64b	123.98a
CV_3	C	B	A
	113.25b	118.70c	121.27b

Table 8: Interaction effect between rice cultivars and nitrogen fertilizer splitting on grain yield (t/fad) (combined data).

Rice cultivars	Nitrogen fertilizer splitting)		
	S_1	S_2	S_3
CV_1	C	B	A
	2.659a	3.103b	3.714b
CV_2	C	B	A
	2.572a	3.611a	4.069a
CV_3	B	A	A
	2.624a	3.745a	4.080a

Increasing N-fertilizer level from 40 to 60 kg N/faddan caused significant increase in head rice %. The other to characters was not (as pooled data) influenced by the increase N–fertilizer level. The same results were obtained by Ebaid[5], Awad, El-Sheref *et al*. and Sallam[20].

Finally increasing number of splits of N-fertilizer application had no effect of rice on grain quality.

Effect of Interactions: The data in Table (6) show the significant interaction effect of N-levels and number of splitting of N-fertilizer on number of unfilled grains/panicle.

The higher N-level reduced number of unfilled grains/panicle irrespective to the number of splits. On the other direction, splitting of 40 kg N/fad more than two doses reduced the unfilled grain number, splitting of 60 kg N/fad more than three doses gave the least unfilled grain number (Table 6).

Number of filled grains showed differential response to number of splits of N-fertilizer. Three splits favoured to Giza 178 while four splits favoured both Sakha cultivars. In the other hand, Giza 178 had the higher number of filled grains /panicle than the other two irrespective to the number of splits (Table 7).

The three cultivars showed different behaviors in their grain yield will response to changing the number of doses of N-fertilizer as seen in Table (8). As seen, the Sakha cultivars outyielded Giza 178 cultivar when the doses increased to three or four times and all the three cultivars gave statistically equal yields when the N-fertilizer was divided to only two doses. On the other direction, Sakha 103 was not affected by increasing N-splitting more than three doses while the other two cvs. responded positively to increasing number of doses from three to four times.

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