Effect of level and time of nitrogen fertilizer application and cutting height on yield and yield component of rice ratooning

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Abstract

In order to study the effect of level and time of nitrogen fertilizer application and cutting height on yield and yield component of rice ratooning (Tarom genotype, a traditional cultivar in Mazandaran Province, Iran) an experiment was conducted at Rice Research Institute of Iran, Deputy of Mazandaran, Amol. The experiment was set-up in factorial design based on randomized completely block design with 3 replications. The level of nitrogen fertilizer in four levels (0, 11.5, 23 and 34.5 kg N ha^{-1}), time of nitrogen application in two levels (immediately and one month after main crop harvest) and cutting height in three levels (0, 20 and 40 cm from above ground) were the treatments. The results showed that different levels of N fertilizer did not significantly affect ratoon yield, harvest index, panicle number per meter squared, grain number per panicle, filled grain number and 1000-grain weight but N applied immediately after main crop harvest significantly affected ratoon yield and grain number per panicle. Cutting height had a significant effect on ratoon plant height, grain number per panicle and filled grain number. Ratoon yield, grain number per panicle and filled grain number was significantly higher when the main crop was cut at 40 cm above ground.

Key Words: Rice, ratoon, yield, nitrogen and cutting height

Introduction

Rice (*Oryza sativa* L.) is the important primary cereal crop in the world. It is the staple food for more than two-third of the world's population (Singh, 1993). The world population by the year 2050 has been projected to be approximately 11 billion people, of which 90% will reside in the developing countries of the South (Krattiger, 1996). Ratoon cropping of rice is the practice of obtaining a second crop from the stubble of a previously harvested (main) crop (Jones, 1993; Coale and Jones, 1994). Two rice crops per year are possible in tropical climates but the relatively short rice-growing season in the Iran prevents the production of two rice crops per year with currently acceptable rice cultivars. Rice ratooning has several stated advantages: low production costs, high water use efficiency, and reduced growth duration (Jones, 1993). In an effort to better understand the factors influencing rice ratoon crop growth, the International Rice Research Institute (IRRI) published a comprehensive report (Chauhan et al., 1988) identifying key factors influencing a rice cultivar's ratoon potential: plant maturity at main crop harvest, main crop harvest height, main crop cultural practices, temperature, sunlight, leaf senescence, and carbohydrate and N content of main crop stubble. Level and time of nitrogen application and the height of harvest of the main crop (cutting height) are critical management factors in ratoon cropping. Cutting or stubble height determines the number of buds available for re-growth (Chauhan et al., 1988; Vergara et al., 1988). Ratoon characters most affected by cutting height are grain yield, tillering, and growth duration (De Datta and Bernasor, 1982). Main crop cutting heights ranging from 0 to 0.5 m from the soil surface have been used for ratoon crop production. The effect of cutting height on ratoon grain yield performance varies. Generally, ratoon yield increased with increased cutting height (Vergara et al., 1988). On the other hands, Reddy et al. (Reddy et al., 1979) and Balasubramanian et al. (Balasubramanian et al., 1970) found no differences in ratoon yields with different cutting height. In other studies, several reports claim that higher cutting heights decreased ratoon yields (Parago, 1963, prashar, 1970). Nitrogen fertilizer is another important factor that greatly influences growth and yield of ratoons. Nitrogen has been observed to improve tillering and increase grain yield of the ratoon crop (Vergara et al., 1988; De Datta and Bernasor, 1988; Bahar and De Datta, 1977). Nitrogen application immediately after harvest of the main crop is recommended (Mengel and Wilson, 1981). The objective of the present study was to determine the effect of time and level of N fertilizer and cutting height on the ratoon crop yield of Tarom cultivar.

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 was conducted in a factorial arranged in a completely randomized block design with three replications. The first factor (cutting height) had three levels (0, 0.2, and 0.4 m above ground level), the second one (fertilizer level) had four levels (0, 25, 50, and 75 kg urea ha^{-1} or 0,11.5,23, and 34.5 kg N ha^{-1}) and the third one (time of N application) had two levels (immediately after main crop harvesting and 30 days after main crop harvesting). The seeds of Tarom cultivar (a traditional variety that generally uses for ratoon cropping in Mazandaran province) were sawn in seedbed and transplanted 35 d after sowing in lowland field under continuos condition. At maturity plots were drained approximately 1 wk before harvest. Entire plots were then cut, using a cutting guide at heights of 0, 0.2, and 0.4 m above the ground level. Three rates of N including 0, 25, 50 and 75 $kg.ha^{-1}$ were applied as urea. All N was applied immediately after main crop harvesting or 30 d after main crop harvesting. At maturity, plots were drained and mature plant heights were recorded. Grain yield was determined from a harvest area of 6 m^2 (96 hills). All plants from harvest area were dried at 70°C for total dry matter determination, and harvest index was calculated as yield/total dry matter. Panicle number per m^2 was determined at dough stage from five randomly sampled hills per plot. Before harvesting for determination of total dry matter and fertility of panicles, five randomly sampled panicles per plot were counted for filled and unfilled grains to determine percentage of filled grains. All grains were dried in the hot air oven at 70°C for 5 days and 1000 grain weight was calculated from the number and seed weight of filled grains. Data were statistically evaluated by analysis of variance using the SAS data processing package (SAS Institute, 1996).

Results and Discussion

Main crop harvest cutting height (CH) had a significant (P <0.01) effect on total grain number, filled grains number, and ratoon plant height (Table 1). However, main crop cutting height had not a significant effect on ratoon grain yield as well as one of the three yield components (Table 1). These findings are in agreement with some researchers (Reddy et al., 1979; Balasubramanian et al., 1970), yet conflict with others (Parago, 1963; Prashar, 1970). Ratoon tiller origin varies between cultivars, with some cultivars initiating the majority of ratoons at the either basal, near basal, or axillary nodes (Jones, 1993). Therefore, cutting heights can have variable effects on ratoon performance, depending on the characteristic of ratoon initiation of the cultivar studied. Such variability in ratooning habit may explain some of the disagreement in the literatures regarding the effect of CH on ratoon yield. Filled grain number was significantly (p <0.01) lower at the 0.0 m CH than at the 0.2 and 0.4 m CH. Plant height also was significantly (p <0.01) higher at the 0.4 m CH than at the 0.0 m CH (Table 2). Ratoon crop grain yield, yield components, and agronomic traits was not affected significantly (p > 0.05) by level of N application (Table 1). Although, Bahar (1976) has reported that N level did not affect tiller and panicle number, 100-grain weight of ratoon crop (Bahar, 1976) but some studies showed that tiller number (Balasubramanian et al., 1970; Sun et al., 1988) and grain yield (Prashar, 1970; Bahar and De Datta, 1977) increased with increasing N level. Significant differences (p < 0.01) were observed between the two time of N application for the ratoon grain yield and grain number per panicle (Table 1). Nitrogen application immediately after main crop harvest had significantly (p < 0.05) higher grain yields than N application 30 day after main crop harvest (Table 3). This yields advantage was due to more grain number per panicle in the N application immediately after main crop harvest (Table 4). Among yield components, panicle per meter squared and grain number per panicle has been reported to account for most of variations in ratoon grain yield (Jones and Snyder, 1987). Cutting height (CH) × level of N application interactions had a significantly (p<0.01) effect on ratoon grain yield and plant height (Table 1). Cutting height at 0.4 m above ground with 0, and 23 kg N per hectare had significantly (p< 0.05) higher grain yields than other conditions (Table 5). Cutting height and time of nitrogen application interaction, however, had not a significantly effect (p<0.01) on ratoon grain yield and agronomic traits (data not shown). Meanwhile, level of N fertilizer × time of N application interaction had a significantly (p<0.01) effect on ratoon grain yield and plant height. The level of 23 kg N per hectare that immediately after main crop harvest were applied had significantly higher grain yield and plant height than other treatments (data not shown). Results of this study indicated that ratoon (Tarom cultivar) can be optimized by leaving the main crop stubble at a height of 0.2 to 0.4 m and application of N fertilizer immediately after main crop harvest.

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Table 1: Grain yield and other plant characters of Tarom ratoon as affected by cutting height of main crop

CH (m)	Grain Yield (kg/ha)	Harvest Index (%)	Grain Number per Panicle	Filled Grain per Panicle	Unfilled Grain per Panicle	1000-Grain Weight (gr)	Panicle Number per m^2	Plant Height (cm)
0	873.0 b	27.8 a	39.2 b	31.8 b	7.3 b	22.3 a	156.8 a	84.8 b
0.2	899.7 ab	24.9 b	42.7 a	34.1 ab	8.6 a	22.3 a	149.6 a	84.8 b
0.4	973.8 a	25.3 ab	44.6 a	36.4 a	8.2 ab	22.3 a	154.2 a	95.9 a

Table 2: Grain yield and other plant characters of Tarom ratoon as affected by N level

N level (kg/ha)	Grain Yield ($kg.ha^{-1}$)	Harvest Index (%)	Grain Number per Panicle	Filled Grain per Panicle	Unfilled Grain per Panicle	1000-Grain Weight (gr)	Panicle Number per m^2	Plant Height (cm)
0	908.1 ab	24.85 b	40.36 a	32.47 a	7.89 ab	22.37 a	152.3 a	89.9 a
25	872.6 b	24.82 b	42.96 a	35.23 a	7.73 b	22.19 a	155.1 a	85.5 b
50	986.4 a	25.69 ab	42.18 a	34.71 a	7.42 b	22.71 a	154.7 a	89.5 ab
75	893.5 ab	28.7 a	43.16 a	34.12 a	9.01 a	21.95 a	146.9 a	89.0 ab

Table 3: Grain yield and other plant characters of Tarom ratoon as affected by time of nitrogen application

Time of N application	Grain Yield (kg.ha^{-1})	Harvest Index (%)	Grain Number per Panicle	Filled Grain per Panicle	Unfilled Grain per Panicle	1000-Grain Weight (gr)	Panicle Number per m^2	Plant Height (cm)
IAMH	978.8 a	26.6 a	44.1 a	35.8 a	8.5 a	22.1 a	156.8 a	92.2 a
AMH	851.5 b	25.5 a	40.3 a	32.8 a	7.6 b	22.9 a	148.8 a	84.8 b

Table 4: Grain yield and other plant characters of Tarom ratoon as affected by cutting height (CH) × N levels

CH (m)	N level (kg.ha^{-1})	Grain Yield (kg.ha^{-1})	Harvest Index (%)	Grain Number per Panicle	Filled Grain per Panicle	Unfilled Grain per Panicle	1000-Grain Weight (gr)	Panicle Number per m^2	Plant Height (cm)
0	0	905.2 bc	28.1 abc	36.4 c	29.6 c	6.7 b	22.6 ab	8.7 ab	82.1 de
0	25	843.8 bc	25.9 abc	38.2 bc	31.4 bc	6.8 b	21.9 ab	10.7 ab	76.8 e
0	50	888.6 bc	27.5 abc	40.4 abc	33.1 abc	7.2 b	22.6 ab	10.3 ab	88.1 bcd
0	75	850.6 bc	29.98 a	41.6 abc	33.2 abc	8.4 ab	22.1 ab	9.4 ab	92.2 bc
0.2	0	777.7 c	23.8 abc	40.8 abc	31.9 bc	8.9 ab	21.1 b	8.5 b	81.7 de
0.2	25	859.4 bc	23.1 a	43.8 ab	35.6 abc	8.1 ab	22.5 ab	8.9 ab	84.1 de
0.2	50	995 b	24.8 abc	43.3 ab	35.8 abc	7.5 ab	23.6 a	10.7 ab	87.1 cd
0.2	75	966.5 bc	28.7 ab	43.1 ab	33.3 abc	9.7 a	21.9 ab	9.3 ab	86.2 cd
0.4	0	1276.2 a	22.6 bc	43.8 ab	35.9 ab	8.1 ab	23.3 a	11.3 a	106.1 a
0.4	25	914.6 bc	26.5 abc	46.9 ab	38.6 a	8.3 ab	22.2 ab	9.4 a	95.5 b
0.4	50	1276.2 a	24.7 abc	42.8 ab	35.2 abc	7.6 ab	21.8 ab	8.9 ab	93.5 bc
0.4	75	863.6 bc	27.4 abc	44.8 ab	35.8 ab	8.9 ab	21.8 ab	8.8 ab	88.6 bcd

Table 5: Grain yield and other plant characters of Tarom ratoon as affected by cutting height (CH) ×Time of N application

CH (m)	TNA	Grain Yield (kg.ha^{-1})	Harvest Index (%)	Grain Number per Panicle	Filled Grain per Panicle	Unfilled Grain per Panicle	1000-Grain Weight (gr)	Panicle Number per m^2	Plant Height (cm)
0	IMAH	931.9 ab	29.2 a	40.9 bc	32.9 bc	8.1 ab	22.1 a	10.3 a	86.9 bc
0	AMH	812.2 b	26.5 a	37.3 c	30.8 c	6.7 b	22.5 a	9.3 a	82.6 c
0.2	IMAH	979.1 a	24.9 a	43.8 ab	35.2 ab	8.6 a	22.0 a	9.4 a	87.0 bc
0.2	AMH	820.3 b	24.8 ab	41.7 b	33.1 bc	8.5 a	22.6 a	9.3 a	82.5 c
0.4	IMAH	1025.5 a	25.5 ab	47.3 a	38.6 a	8.7 a	22.0 a	9.9 a	102.6 a
0.4	AMH	922.1 ab	25.1 ab	41.8 b	34.2 bc	7.7 ab	22.6 a	9.3 a	89.2 b

IAMH= immediately after main crop harvesting, and AMH= 30 d after main crop harvesting
In a column, means followed by a common letter are not significantly different at the 5% level