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Effect of Different N Management on Improving N Efficiency in Rice- tarom Variety

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The chlorophyll meter (SPAD) and leaf colour chart (LCC) are simple, portable diagnostic tools that can measure the crop N status in situ in rice fields to determine the timing of N top dressingAn experiment was carried out in Rice Research Institute in Mazandaran, in 2019. A test material has been evaluated in a Randomized Complete Block Design with three replications. Tarom variety were grown under eight treatments at plant density of 25*25 cm. Eight treatments included a zero-N control, o splits, chlorophyll meter 35, 37, 40, LCC 4 and 5. Result showed that Both LCC and SPAD can be used to improve N management for rice. The optimal SPAD threshold for determining the timing of N-application was 35. LCC treatments indicated that N-management based on LCC shade 4 helped avoid over application of N. Critical value of LCC 4 was more beneficial in enhancing the growth and agronomic, physiologic and internal efficiency. It is suggested that when N-management technology such as real time N-management (SPAD and LCC) were used, would avoid to over application of N fertilizer by rice farmers. The objective of this study is to determine critical threshold SPAD and LCC value of Tarom variety of rice(*Oyiza Sativa L*).

Keywords: N management; efficiency; LCC; SPAD; rice.

1. INTRODUCTION

Nitrogen is without doubt the nutrient that most limits rice production. It is typically required in greater quantities than any other nutrient if rice farmers are to reap high yields and profits. As a general principle,about one-third of the fertilizer N applied by conventional farmers practices to

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irrigated rice in Asia is lost within two weeks to the atmosphere as gases. About one-third of the fertilizer N remains in the soil at crop harvest, and only about one-third of the fertilizer N is taken up by the rice crop [1,2]. Crop-demand based N application is one of the important options to reduce N loss and to increase N use efficiency of a crop. Chlorophyll meter (SPAD) or leaf color chart (LCC) can be used for adjustment of fertilizer N application based on actual plant N status [3,4].

2. MATERIAL AND METHODS

An experiment was carried out in Rice Research Institute in Mazandaran, in 2019. A test material has been evaluated in a Randomized Complete Block Design with three replications. Tarom variety were grown under eight treatments at plant density of 25*25 cm. Eight treatments included a zero-N control, two splits, chlorophyll meter 35, 37,40, LCC 4 and 5. Chlorophyll meter reading, were taken weekly starting from 2 weeks after transplanting and 16 kg N ha^{-1} was applied whenever SPAD readings were below the critical value of 35, 37 and 40. Thershold SPAD values were picked up from studies carried out by Peng and his colleagues.

Two treatments with LCC consisted of applying N (16 kg ha^{-1}) when rice leaf colour was less than shade 4 (LCC < 4 and 5). Control plot received a full dose of phosphorous, potassium and zinc but no N.

2.1 General Site Characteristics

Field experiment was conducted on Typic dysterudept in Mazandaran Rice Research center of IRAN in 2019. The experimental site was located in Amol ((Latitude 36º_ 28 'N; Longitude 52º_23' E at the 40 m altitude) the area receives on average 743 mm year-1 rainfall. Mean maximum and minimum temperatures are 31.2 and 15.3 ºC during rice cropping (April to August). Soil are well drained Table 1 show the physical and chemical properties of soil sample (0-15 cm) field site.

2.2 Nitrogen Treatments

Experiment was laid out in a randomized complete block design with three replicates with rice variety of Tarom. Eight fertilizer N (as urea) management treatments are described in Table-2. In the recommended splits N was applied at transplanting and 7 days after transplanting, midtillering and panicle initiation. Chlorophyll meter reading, were taken weekly starting from 2 weeks after transplanting and 16 kg N ha^{-1} was applied whenever SPAD readings.

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2.3 Crop Establishment and Management

Widely grown variety of rice *i.e,* Tarom was used. Transplanting was done in April. Seedling age was 20-35 d. Transplanting spacing was 20 cm × 20 cm with two seedlings per hill. Plot size was 12 m2. Phosphorus at 50 kg ha^{-1}, potassium at 100 kg ha^{-1} and zinc at 25 kg ha^{-1} were applied at basal. The plots were kept flooded throughout the growing season. Pests, disease and weeds were intensively controlled to avoid yield loss.

Crops were harvested by hand at ground level at maturity on 26 August, 2019. Grain and straw yields were determined from an area (5 m^2) located at the center of each plot. Grains were separated from straw using a plot thresher, dried in a batch grain dryer and weighed. Grain moisture was determined, immediately after weighing and subsamples were dried in an oven at 65 ºC for 48 h. Grain weights for rice expressed at 140 g kg^{-1} water content. Straw weights were expressed on oven dry basis.

2.4 Plant Sampling and Analysis

Grain and straw subsamples were dried at 70 ºC and finely ground to pass through a 0.5 mm sieve. Nitrogen content in grain and straw was determined by digesting the samples in sulfuric acid (H_2SO_4), followed by analysis for total N by a micro-Kjeldahl method7. The N in grain plus that in straw was taken as a measure of total N uptake.

2.5 Chlorophyll Meter and Leaf Color Chart Measurements

Chlorophyll meter reading weekly with a Minolta SPAD-502 chlorophyll meter, starting 14 DAT. Ten hills of rice were chosen at random in each plot. From each hill three reading were taken from the uppermost fully expanded leaf. SPAD reading were taken up to 50 % flowering stage.

Table 1. The general characteristics of the soil

Organic carbon (%)	Clay (%)	Texture	Electrical conductivity(ds/m)	Ph	P (Olsen)	Ammonium acetate extractable potassium
8 . 2	27	Silt loam	1 . 4	7 .1	11 .5	120

Table 2. Treatments used in rice experiments during 2008, Mazandaran, Iran

Number	Treatment details	Time of nitrogen application
Zero-N control	**Zero-N control**	**- -**
Split 1	Fixed-N split with total N rate of 138 kg N ha^{-1}	Application of N in three equal splits at basal, early tillering and panicle initiation
Split 2	Fixed-N split with total N rate of 138 kg N ha^{-1}	Application of N in three equal splits at Seven days after transplanting, early tillering and panicle initiation
S35	16 kg N ha-1 with 30 kg ha^{-1} at basal	Whenever SPAD < 35
S37	16 kg N ha-1 with 30 kg ha^{-1} at basal	Whenever SPAD < 37
S40	16 kg N ha-1 with 30 kg ha^{-1} at basal	Whenever SPAD < 40
LCC4	16 kg N ha-1 with 30 kg ha^{-1} at basal	Whenever SPAD LCC< 4
LCC5	16 kg N ha-1 with 30 kg ha $^{-1}$at basal	Whenever SPAD LCC< 5

The leaf colour chart (LCC) developed by IRRI 1996 consisted of six green strips showing increasing greenness with increasing number. As with the chlorophyll meter, the chart was use to take weekly reading starting 15 DAT. Ten disease free rice plants were randomly selected in the plot and the colour of the youngest fully expanded leaf of selected plants was compared by placing its middle part on top of the colour strip in the chart. Like chlorophyll meter, reading was taken up to 50 % flowering stage. If more leaves read below a critical value (LCC 4 and 5) a dose of 16 kg N ha^{-1} was applied.

2.6 Data Analysis

Analysis of variance was performed on yield parameters to determine effect of N management treatments using SAS. Duncan's multiple range tests were used at 0.05 level of probability to test difference, between treatment means. The N use efficiency measures, RE, AE, PE and IE were calculated as follows:

RE (%) = [(TNU in N-fertilized plot - TNU in zero -N plot)/quantity of N fertilizer applied in N-fertilized plot] × 100.

AE (kg grain/kg N applied) = (grain yield in N-fertilized plot- grain yield in zero- N plot)/ quantity of N fertilizer applied in N-fertilized plot.

PE (kg grain/kg N uptake)=(grain yield in N-fertilized plot-grain yield in zero-N plot)/ (N uptake in N-fertilized plot- N uptake in zero- N plot).

IE (kg grain/kg N uptake) = (grain yield in N-fertilized plot)/ (N uptake in N-fertilized plot) where, TNU is the total N uptake in grain and straw.

3. RESULTS AND DISCUSSION

-S_{35} and LCC_4 resulted the highest grain yield (3880 and 3980 kg/ha respectively relative to 2480kg ha^{-1} in control). Using of LCC and SPAD tools for nitrogen management resulted higher grain yield than split method at less N rate. These results suggests that (i)a basal use of nitrogen was not efficiently used by the crop and is possibly prone to losses or immobilization and (ii)N applied starting at seven days after transplanting based on crop need determined by the chlorophyll meter and leaf color chart were used more efficiently [5,6,7,8].

-The grain yield of split2 (applying nitrogen 7 days after transplanting) was higher than split1(applying nitrogen at transplanting) due to better time of N application. Rice seedlings need about seven days to recover from transplanting shock [2,9]; thus, N uptake within one weeks of transplanting should be very small [3,10,11,12,13].

-All nitrogen management treatments increased the nitrogen concentration of grain and straw. Split treatments had the highest N concentrations [14,15,16,17]. Seed and straw nitrogen concentration increased by increasing fertilizer application (Fig. 1).

-A significant positive response of total nitrogen uptake to N application relative to zero N control was observed in all treatment. LCC treatments showed highest N uptake, due to high grain and straw yield. N uptake increased as N rates increased (Fig. 2).

-AE was greater when less N fertilizer was used, but this was achieved with the use of the chlorophyll meter and leaf colour chart without sacrificing yield. All LCC and SPAD treatments had higher AE, PE, RE and IE relative to split treatments. S_{35} had highest RE, PE, AE and IE relative to S_{37} and S_{40}.

Based on this results, it is found that real time N management based on LCC and SPAD are better management than split method for increasing N use efficiency of irrigated rice [1,16,17]. LCC treatments indicated that N-management based on LCC shade 4 helped avoid over application of N. Critical value of LCC 4 was more beneficial in enhancing the growth and agronomic, physiologic and internal efficiency [5]. It is suggested that when N-management technology such as real time N-management (SPAD and LCC) were used, would avoid to over application of N fertilizer by rice farmers [18,19,20,21]. The optimal SPAD threshold for determining the timing of N-application was 35.

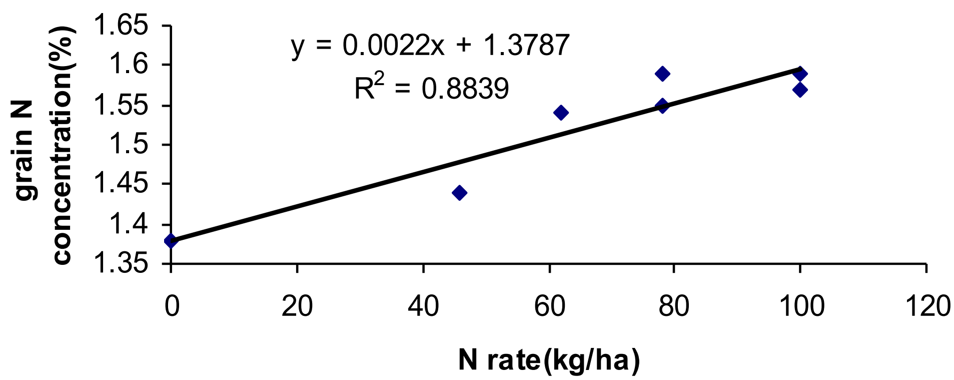

Fig. 1. Relationship between grain nitrogen concentration and N fertilizer rate

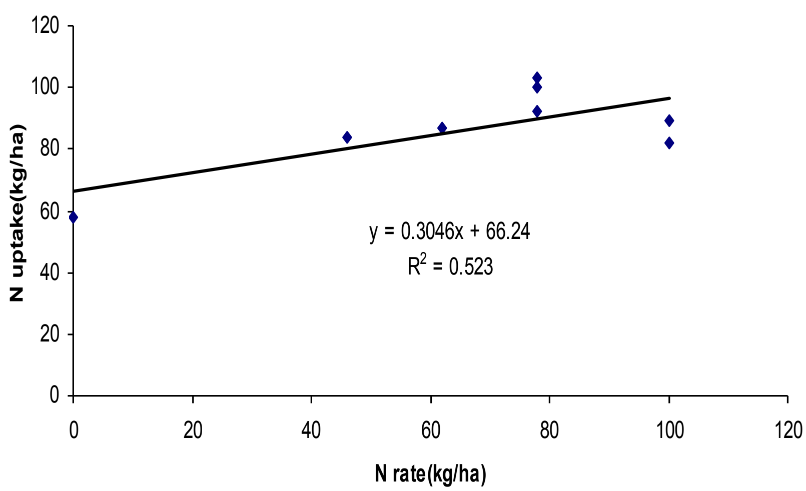

Fig. 2. The relationship between the total nitrogen uptake and N fertilizer rate

Table 3. N uptake, total fertilizer n applied and recovery, physiologic, internal and agronomic efficiencies (re, pe, ie and ae, respectively) using different need-based fertilizer n management at Mazandaran, Iran

Treatment	N rate (kg ha^{-1})	N concentration (%)		Grain yield (kg ha^{-1})	Total N uptake (kg ha^{-1})	AE (kg kg^{-1})	RE (%)	PE (kg kg^{-1})	IE (kg kg^{-1})
		grain	Straw						
Zero- N control	0	1.38c	0.61c	2480c	58d	-	-	-	42.7a
Split 1	100	1.59a	0.97a	3024b	82c	5.4c	24e	45.8d	36.9b
Split 2	100	1.57a	0.92a	3352ab	89b	10.4b	31d	33.7c	39.6ab
S35	46	1.44b	0.65c	3880a	84c	30.4a	56.5d	53.8a	46.2a
S37	62	1.53a	0.82a	3186b	87b	11.4b	42.7c	24.3d	36.6b
S40	78	1.55a	0.88ab	3113b	92b	8.1c	43.6c	18.6d	33.8b
LCC4	78	1.55a	0.83b	3970a	100a	19.1b	63.8a	35.5c	39.7ab
LCC5	78	1.59c	0.98ab	3406ab	103a	11.9b	57.7d	20.6d	33.1b

Within a column means followed by the same letters are not significantly different according LSD (0.05).

4. CONCLUSION

We used the cholorophyll meter and leaf color chart to determine the right time for N topdressing of Tarom rice variety.Results showed that SPAD value of 35 and LCC 4 – based application of nitrogen produced rice yields higher or similar to dose of splits.However chlorophyll meter and leaf color chart-based N management saved 64 and 22% of the splits respectively. The SPAD value 35 and LCC 4were found to be critical for Tarom variety in Iran. In this study data also showed the need for more N application at tillering and up to flowering stage instead of basal application at the beginning of crop grows.data presented in this study suggest that applying 100 kg N/ha in three splits has lead to the lower AE and RE. The cost of chlorophyll meter restricts its wide spread use by farmers. But the LCC is a simple and easy tool. Results of nitrogen applications to rice based on Lcc shade4 reasonably consistent with those using the chlorophyll meter. Result presented in this study provide strong evidence that current fertilizer N recommendation lead to application of excess N fertilizer to rice. It has also been suggested that different threshold SPAD values may have to be used for different varietal groups.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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