Critical Grain Nitrogen Content for Optimizing Nitrogen and Water in Rice *(Oryza sativa)*

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Abstract: The study was conducted to identify critical nitrogen percent in grain and optimum nitrogen and water level combination in low land rice in central Bihar where farmers apply meager amounts of fertilizer nitrogen. The critical limit technique and regression equation were used. There were significant relation ships between yield, grain nitrogen, fertilizer nitrogen and water levels (r = 0.942, 0.947). The critical level of grain nitrogen content found was 0.92% and was falling near to the optimum combination. The optimum combination found was 80 kg N ha^{-1} and 8 cm water level in relation to a yield of 5500 kg ha^{-1}. This GN index is useful for optimizing the available water resources as well as external nitrogen requirement of the rice crop and the technique used for derivations were practically simple.

Key words: Critical grain nitrogen, optimum grain yield, nitrogen level, rice

Introduction

Gangetic alluvium is most popular rice belt of India. The soils in this area are poor suppliers of nitrogen. The nitrogen use efficiency will never cross one third of available in the soil. It is manifested further with natural water levels that occur and non- systematic irrigation methods adopted in these plains. The farmers do not apply nitrogenous fertilizers with the apprehension that most of it will be lost by field-to-field irrigation, flooding and submergence. It is reported that the grain nitrogen content indicates the extent availability of nitrogen to the plants from different sources. Different workers expressed that grain nitrogen has a good correlation with available nitrogen and significant relationship with nitrogen remobilization in relation to nitrogen accumulation in grain (Dolmat *et al.*,1980; Dhillon *et al.*, 1999; Sarvestani and Pirdashty, 2001). In general, native soil available nitrogen would be uniform in a particular area and using external fertilizers to the soil only alters it. Hence, grain nitrogen was also used as index for available nitrogen. Since the above factors are directly affecting the dry matter and yield critical grain nitrogen content is essential to be identified.

The statistical technique used in critical level approach given by Cate and Nelson (1971) is a simple and good tool to know the point at which different contributing factors interact at most and yields an optimum. Having good yields, at the same time using the resources (natural and external) precisely is a challenge for sustainability. Hence the study was taken up to identify the critical nitrogen content in the grain, the optimum yield levels with different nitrogen and water levels for better resource management.

Materials and Methods

Based on the above concept, experiment has been initiated during 1999 kharif season in this experimental fields, which were lined with low-density polyethylene (LDPE) films up to one-meter length to avoid seepage from plot to plot during cultivation. Four (0, 40, 80, 120-kg N ha^{-1}) different nitrogen and water levels (0, 4, 8, 12 cm) were replicated thrice in a split plot design. Different water levels were maintained by increasing the bund levels respectively. The nitrogen was applied in three split doses at recommended intervals.

Rice (*Oryza sativa* cv. Sita) was taken as a test crop during three kharif seasons. The soils are Usti Psamments under Gangetic alluvium plains. The texture is silt loam (sl) to silt clay loam (scl). The initial soil fertility status was estimated using standard procedures after processing in the laboratory (Table 1).

Grain nitrogen content was estimated in (Kjeltec--2000II) automatic nitrogen analyzer using kjeldhal procedure given by Jackson (1973) after digesting samples with H_2SO_4 and H_2O_2. Mean values of the GN content were taken for multiple regression analysis. The relationship between water levels, nitrogen content and grain yield was studied using multiple regression analysis. The data was also analyzed by a split plot design for significance between treatments (Anonymous, 1989).

Table 1: Soil characteristics of the study area

Soil characteristics	
Soil texture:	Silt loam to silt clay loam
pH (1:2 ratio):	7.200
Electrical conductivity (1:2 ratio)(dS/m):	0.241
Organic carbon (%):	0.610
Fertility status:	
Available nitrogen (hg ha^{-1}):	2690.0
Available P_2O_5 (hg ha^{-1}):	280.2
Available K_2O (hg ha^{-1}):	3650.0

Table 2: Effect of fertilizer nitrogen and water level on percent grain nitrogen of rice

Nitrogen (kg ha^{-1})	Water level (cm)	Grain yield (kg ha^{-1})	Grain nitrogen (%)
0	0	2863	0.77
40	0	3433	0.80
80	0	4867	0.84
120	0	5167	0.90
0	4	3277	0.77
40	4	4730	0.87
80	4	6120	1.00
120	4	5740	1.13
0	8	4730	0.85
40	8	5673	0.91
80	8	6597	1.02
120	8	7197	1.14
0	12	3853	0.83
40	12	4767	0.93
80	12	6220	1.10
120	12	6270	1.18
	A	0.85	0.02
Cd (%)	B	0.74	0.02
	BXA	1.54	0.01
	AXB	1.49	0.02

Table 3: Relationship between various levels of fertilizer nitrogen, water depth, grain yield and percent grain nitrogen content in rice

Factors	Relationship	r-value
Fertilizer nitrogen and water depth	TN(%) = 0.707 + (0.00240x WD) + (0.0148xFN)	0.942
Fertilizer nitrogen, water depth and grain yield	T.N(%) = 0.636 + (0.00191x WD) + (0.0122xFN) + (0.00227xGY)	0.947

T.N: Total nitrogen %; WD: Water depth in cm; FN: Fertilizer nitrogen; GY: Grain yield

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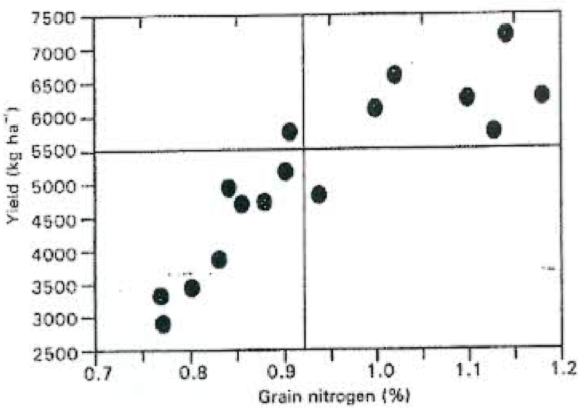

Fig. 1: Critical level for grain nitrogen of rice under different nitrogen and water levels

The critical level of total grain nitrogen content was identified using the procedure based on the critical level approach enumerated by Cate and Nelson (1971). Mean grain nitrogen content at different water and fertilizer levels was taken in this test against the grain yield values. The values were divided into four quarters such that left lower and right upper should contain maximum number of values in a scatter plot.

Results and Discussion

The grain yield showed an increasing trend with increase in the fertilizer nitrogen content as well as water levels. However, the linear relation was up to 80 kg nitrogen content and 8 cm water level. However, grain yield increased up to 120 kg but it was in decreasing returns. Grain yield ranged from 2863 to 7197 kg ha^{-1}. Similar relationship was also seen with total nitrogen content of grain where it ranged from 0.77 to 1.18 (Table 2).

The experimental results revealed that there is a significant effect of different nitrogen levels on grain yield. It is also established that there is a significant relationship ($r = 0.942$) between total nitrogen content of grain, water and fertilizer nitrogen (Table 3). Nitrogen effect is seen conspicuous as leaf colour increases in rice. It was observed by Okamoto (1994) that the nitrogen content of rice grain was closely correlated with the leaf color at full heading stage. Sarvestani and Pirdashty (2001) was also observed that among different parts of the shoot, leaves (flag leaf+leaves) had more important effect on grain nitrogen accumulation. Two physiological processes are involved in grain growth, utilization of photosynthates through current photosynthesis and remobilization and translocation of substance accumulated before anthesis (Akita, 1989).

Similarly significant relationship ($r = 0.947$) was observed between grain yield with grain nitrogen content (Table 3). Iwasaki *et al.* (1992) reported that during ripening, however, nitrogen accumulates in the spikelet of the ear mainly as protein and the protein content at harvest accounts for 8-10% of the final dry matter content. Dhillon *et al.* (1999) also observed the similar type of relationship in rice with available nitrogen in Punjab soils.

It was observed that excess water levels reduced the yields. Increased nitrogen availability and more nitrogen uptake and grain nitrogen was observed in delayed flooding conditions in Spain (Carreres *et al.*, 2001). During the grain filling period, N was gradually translocated from the vegetative plant parts to the developing rice panicles as reported by Sarvestani and Pirdashty (2001). The grain nitrogen content of all the rice plants grown under upland conditions was higher than that under paddy condition.

The critical limit (0.92%) has been identified for total nitrogen of rice grain in relation to the optimum grain yield at different combinations of water and nitrogen levels studied. The results revealed that a linear response up to the yield level of 5500 kg ha^{-1} after that the response was in decreasing trend with increasing fertilizer nitrogen. The harvest index decreased with increasing fertilizer levels. The grain nitrogen content was negatively correlated with harvest index and increase of the top dry weight (Kambayashi *et al.*, 1990).

The same can be correlated with total grain nitrogen content. 80 kg nitrogen and 8 cm water level was critical for getting optimum response to the added fertilizer but beyond that it is in decreasing trend.

The critical limit observed could be used to predict the optimum yield and to know up to which level of nitrogen the response to yield is seen under a moisture regime. The grain nitrogen content indicates the accumulation of the nutrient in final sink of the plant, since increase in grain nitrogen content with the availability at the source can be related to the response of crop to the nutrient under a certain favorable conditions.

Therefore, finding out a optimum level of nutrient and water requirement in relation to the optimum grain yield with the help of critical grain nitrogen content for different rice ecosystems under varied soil and economic groups would help in managing natural resources as well as nutritional requirements of the rice crop.

Besides, the critical level also is taken as criterion in estimating the total nitrogen requirement of a predicted cropped area in a region for achieving a targeted output. Similar critical limits can be established for different nutrients and crops in order to optimize resources in the light of sustainability.

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