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PHYSIOLOGICAL PERFORMANCE OF RICE PLANTS AS AFFECTED BY DIFFERENT LEVELS OF COPPER AND NITROGEN FERTILIZERS

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ABSTRACT

This investigation was carried out during 1998 and 1999 to identify the suitable levels of copper and nitrogen fertilizers for raising the productivity of rice through the enhancement of different physiological criteria. The most important findings revealed that :

- Foliar application of Cu had highly significant effect on plant height, number of tillers, leaf dry weight, aboveground dry weight, leaf area index (LAI), leaf area ratio (LAR), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR). The highest mean values were recorded when plants were sprayed with copper sulphate at the level of 11.5 kg/fed. However, increasing level of sprayed Cu resulted in significant reduction in all studied traits at different growth stages.
- Soil application of nitrogen had significant positive effects on all studied growth characteristics. The higher the nitrogen level the higher the mean values recorded for plant height, number of tillers, leaf dry weight, aboveground dry weight, LAI, CGR, RGR and NAR at all growth periods.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal crops in the world as well as in Egypt. More than half of the world population depends on rice as a staple food. The total planted area of rice in Egypt attains about 1,556,520 fed. according to the last report of Ministry of Agriculture (2001)*. Rice is usually grown in clay soil, where mud rich in macro- and micro-nutrients was sedimented by floods of the River Nile before the construction of the High Dam. In last years, the sedimentation process stopped and the soil became poor in micro-elements such as Cu.

Micro-nutrients deficiency may be due to the abovementioned reason and/or to the following reasons :

1- Many farmers do not apply enough micro-nutrients as fertilizers or in farmyard manure.
2- The interaction among the micro-nutrients may have negative effects on their movements to the plant roots and within the plant.
3- Flooding irrigation system leads to micro-nutrient leaching .

Several studies were devoted to investigate the effect of Cu on rice, Zheng and Huang (1986) indicated that rice yield increased by about 13.9% due to the application of 7.5 kg $CuSO_4$/ha. Maji and Bandyopadhyay (1990) found, in field trial

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* Extracted from Ann. Agric. Rev. Econ. Dept., Ministry of Agric., 2001

with rice cv. Pankaj, that soil or foliar application of 5 or 10 kg Cu/ha had no effect on dry matter or grain yields. Lidon and Henriquies (1993) found that increasing Cu beyond certain limit resulted in significant reduction in plant protein content, biomass yield, as well as shoot and root length. Sinclair and Withers (1995) concluded that foliar application of Cu is more reliable than soil application in increasing grain yield. Nautiyal *et al.* (1999) stated that the addition of 0.065 mg Cu/L resulted in highest biomass and grain yield.

Efforts are also concentrated on macro-nutrients especially nitrogen to find out its impact in the productivity of rice. Singh *et al.* (1991) revealed that grain yield of rice increased with increasing N level up to 180 kg/ha. However, N use efficiency and recovery were highest with 60 kg N/ha. Nitrogen content of grains and straw increased with N application. Shalaby *et al.* (1993) pointed out that the application of nitrogenous fertilizers increased plant height, tiller number, dry weight, RGR, CGR, grain protein content and grain yield. Thakur (1993) indicated that plant height, effective tillers/m^2 and grains/panicle, as well as grain and straw yields significantly increased by increasing nitrogen levels up to 120 kg N/ha, whereas panicle length and 1000-grain weight increased only up to 80 kg N/ha. Gorgy (1995) found that dry matter accumulation, plant height, LAI, CGR and RGR, as well as yield and its components increased with increasing N rates up to 65 kg/fed.

Therefore, the present investigation aimed to study the effect of Cu, N and their interaction on certain morphological and physiological characters.

MATERIALS AND METHODS

In two 1998 and 1999 summer seasons, a field experiment was conducted at Biddeen village, El-Mansoura district, Dakahlia Governorate, Egypt. The experiment aimed to study the effects of foliar application of four copper concentrations i.e. 0, 11.5, 23 and 34.5 kg $CuSO_4$/fed., as well as four levels of soil applied nitrogen namely, 0, 30, 60 and 90 kg N/fed. and their interaction on certain morphological and physiological aspects of rice cultivar Giza 178. The experiments were laid out following split-plot design with four replications. Copper treatments were randomly arranged in the main plots while the sub-plots received nitrogen level treatments. The plot size was 3.6x2.8= 10.08 m^2. Soil chemical analysis of the experimental site revealed the following; ph= 7.9, ECe= 1.9 ds/m, available nutrients in ppm: N= 55, P= 12 and K= 310. Soil type was clay in texture. The previous crop was wheat in both seasons. Copper in the form of copper sulphate was applied 20 days after transplanting (DAT) as per treatment by dissolving the exact amount of fertilizer in 100 /L of water and sprayed late in the afternoon before sunset. Nitrogen in the form of urea was applied as per treatment through soil in two splits; 2/3 was added at the last harrowing followed by flooding and the rest was applied 25 DAT. The other cultural practices were performed following the package of transplanted rice recommendations.

Three samples of five guarded hills were carefully uprooted and washed 30, 40 and 50 days after transplanting. These samples were moved to the Laboratory of Mansoura Seed Technology Unit, ARC, and the following data were collected :

1- Plant height (cm)
2- Number of tillers/hill
3- Leaves dry weight g/hill
4- Aboveground dry weight (g/hill) of aboveground parts of the plant
5- Crop growth rate (CGR) g/day, as

$$CGR = W_2 - W_1 / T_2 - T_1$$

Where :
W_1 = total dry weight at time (T_1)
W_2 = total dry weight after a period of time (T_2)
(T_1-T_2) = a period of time between two samples

6- Relative growth rate (RGR)* g/g/day

$$RGR = Log_e W_e - Log_e / T_2 - T_1$$

Log_e Nabarian logarithm = 2.303 x log

7- Leaf area index (LAI)*

$$LAI = \text{leaf area / hill } (cm^2) \text{ / ground area covered by hill } (cm^2)$$

8- Leaf area ratio (LAR)*

$$LAR = \text{total area / hill } (cm^2) \text{ / total dry weight/hill (g)}$$

9- Net assimilation rate (NAR)* $g/cm^2/day$

$$NAR = (w_2 - w_1)(\log_e A_2 - \log_e A_1) / (T_2-T_1)(A_2-A_1)$$

A_1 LA at time (1) A_2 – LA at time (2)

*** According to the formula mentioned by Charles (1982)**

Data were subjected to analysis of variance for each season and combined analysis was performed over seasons. The differences among means of the studied traits were judged by Duncan's multiple range test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

1.Effect of Cu levels :

Data presented in Tables (1, 2 and 3) at the different growth stages revealed that the application of Cu had highly significant effect on plant height, number of tillers, dry weight, aboveground dry weight, leaf area index (LAI), leaf area ratio (LAR), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR).

It was quite evident from the data that the foliar application of 11.5 kg copper sulphate per feddan produced the highest mean values of the studied characters. Increasing Cu beyond that level resulted in significant reduction in all the studied traits. These results are in harmony with those reported by Lidon and Henriquies (1993), Sinclair and Withers (1995) and Nautiyal *et al.* (1999).

It could be mentioned that the enhancement of the low level of Cu to the growth attributes may be due to its effect on the synthesis or stability of photosynthetic pigments (Boardman, 1975) or that Cu may be involved in the structure of some enzymes (Grinusalus *et al.*, 1975).

The retarding effect of higher levels of Cu may be attributed to the inhibition of root growth and the harmful effect on plant height, number of leaves and number of tillers, decreased translocation assimilates which lead to decreasing dry weight production (Agrawla *et al.*, 1995 and Mohammed *et al.*, 1991).

2. Effect of N levels :

Combined analysis of data over seasons at the different growing periods revealed that nitrogen levels significantly affected all the growth contributing characters (Tables 1, 2 and 3). Generally speaking, it could be mentioned that increasing nitrogen levels from 0 to 90 kg N/fed. resulted in significant increase in plant height, number of tillers, leaf dry weight, aboveground dry weight, LAI, LAR, CGR, RGR and NAR. These data are in accordance with those reported by Shalaby *et al.* (1993), Thakur (1993) and Gorgy (1995).

The enhancement of rice growth with N fertilization could be attributed to:

1) Increasing cell division and elongation through auxin production (Said and Keshta, 1999), 2) Its effect on the enhancement of the number of leaves and their area/leaf (Pradham *et al.*, 1994), 3) Enhancement of the vegetative growth especially leaf area and photosynthesis activity being reflected in dry matter accumulation during different periods of plant growth (Marchner, 1995).

Table (1):Plant height (cm) and number of tillers and leaves dry weight as affected by different levels of copper and nitrogen at different growth stages

Fertilizer treatment	Plant height (cm)			Number of tillers			Leaves dry weight (g)		
	30 DAT	40 DAT	50 DAT	30 DAT	40 DAT	50 DAT	30 DAT	40 DAT	50 DAT
Cu kg/fed.									
0	60.9 b	66.7 b	790.8 a	13.6 b	14.2 b	14.1 b	12.1 b	16.1 b	20.7 b
11.5	64.0 a	74.1 a	81.1 a	14.0 a	14.7 a	14.8 a	13.4 a	18.0 a	21.5 a
23.0	57.6 c	67.1 b	73.1 b	13.1 c	13.3 c	13.5 c	9.8 c	14.9 c	17.0 c
34.5	56.9 d	26.7 c	68.9 c	12.7 d	12.8 d	12.7 d	9.2 d	13.6 d	15.4 d
N kg/fed.									
0	56.5 b	64.7 d	72.3 d	12.8 d	13.2 d	13.4 d	9.6 d	14.3 d	16.7 d
30	59.2 c	66.0 c	74.6 c	13.2 c	13.6 c	13.6 c	10.9 c	15.1 c	18.4 c
60	61.1 b	68.8 b	77.0 b	13.5 b	13.9 b	14.0 b	11.6 b	16.3 b	19.4 b
90	62.1 a	70.6 a	78.6 a	13.8 a	14.3 a	14.3 a	12.3 a	17.1 a	19.8 a

Table (2: Aboveground dry weight, leaf area index (LAI) and leaf area ratio (LAR) as affected by different levels of copper and nitrogen at the different growing periods

Fertilizer treatment	Aboveground dry weight (g)			Leaf area Index (LAI)			Leaf area ratio (LAR)		
	30 DAT	40 DAT	50 DAT	30 DAT	40 DAT	50 DAT	30 DAT	40 DAT	50 DAT
Cu kg/fed.									
0	23.3 b	34.1 b	54.9 b	2.6 b	3.5 b	3.6 b	144 a	118 b	79 a
11.5	25.5 a	36.9 a	57.1 a	2.9 a	3.7 a	4.1 a	149 a	130 a	77 a
23.0	18.8 c	29.6 c	44.8 c	1.7 c	2.8 c	3.5 c	122 b	125 ab	73 b
34.5	17.2 d	27.2 d	41.6 d	1.5 d	2.3 d	2.4 b	115 b	111 c	67 c
N kg/fed.									
0	18.3 d	29.0 d	44.5 d	1.7 c	2.8 c	2.7 d	128 b	110 b	71 c
30	20.7 c	31.5 c	49.5 c	2.1 b	3.0 b	3.1 c	132 ab	120 ab	75 b
60	22.3 b	34.2 b	51.6 b	2.2 b	3.2 a	3.6 b	132 ab	120 ab	75 a
90	23.3 a	35.8 a	53.1 a	2.5 a	3.2 a	3.8 a	137a	127 a	75 a

Table 3. Crop growth rate as well as relative growth rate and net assimilation rate as affected by different copper and nitrogen levels at different growth stages

Fertilizer treatments	Crop growth rate (CGR)		Relative growth rate (RGR)		Net assimilation rate (NAR)	
	30-40 DAT	40-50 DAT	30-40 DAT	40-50 DAT	30-40 DAT	40-50 DAT
Cu kg/fed.						
0	1.45 b	1.75 b	0.054 c	0.042 b	1.41 b	1.31 b
11.5	1.51 a	1.85 a	0.062 a	0.045 a	1.50 a	1.44 a
23.0	1.41 c	1.48 c	0.058 b	0.040 c	1.40 b	1.31 b
34.5	1.20 d	1.43 c	0.055 c	0.037 d	1.32 c	1.22 c
N kg/fed.						
0	1.27 c	1.50 c	0.052 d	0.037 d	1.31 d	1.27 b
30	1.39 b	1.64 b	0.054 c	0.039 c	1.39 c	1.32 ab
60	1.40 b	1.66 ab	0.057 b	0.041 b	1.40 b	1.33 ab
90	1.52 a	1.69 a	0.061 a	0.047 a	1.46 a	1.36 a

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السلوك الفسيولوجى للأرز تحت تأثير معدلات مختلفة من الأسمدة النحاسية والأزوتية

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أجرى هذا البحث فى موسمى ١٩٩٨ و ١٩٩٩ لدراسة أنسب معدل من الأسمدة النحاسية والأزوتية يمكن إضافتها للأرز لرفع الإنتاجية عن طريق تحسين الصفات الفسيولوجية المختلفة . وكانت النتائج الهامة التى توصل إليها البحث ما يلى :

كان لرش النحاس تأثير معنوى على طول النبات – عدد الفروع – وزن الأوراق الجافة – الوزن الجاف للأجزاء فوق سطح الأرض – دليل مساحة الأوراق – نسبة مساحة الأوراق – معدل النمو المطلق/معدل النمو النسبى ومعدل التمثيل الصافى . وقد أعطى رش النبات بمعـــدل ١١,٥ كجم/فدان كبريتات نحاس أعلا المتوسطات من الصـــفات المدروســـة . غيـــر أن زيـــادة كبريتات النحاس عن هذا المعدل سبب نقصا ملحوظا فى جميع الصفات الفسيولوجية فى جميـــع مراحل النمو تحت الدراسة .

أثرت الإضافة الأرضية للنيتروجين تأثيرا معنويا على جميع الصفات الفسيولوجية التى شملتها الدراسة . أدى معدل التسميد الأزوتى العالى الى الحصول على أعلى متوسطات للصفات المدروسة مثل طول النبات – عدد الفروع – وزن الورق الجاف – وزن الأعضـــاء الهوائيـــة الجافة – دليل مساحة الأوراق – نسبة مساحة الأوراق – معدل النمو المطلق – معـــدل النمـــو النسبى – صافى التمثيل فى جميع مراحل النمو .