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Influence of Drought and Foliar Application on Nutrients Status in Shoots of Barley Plants

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TWO FIELD experiments were conducted in the Experimental Farm of the National Research Center, Shalakan, Kaliobia Governorate, during the two successive winter season 2001/2002 and 2002/2003 to evaluate the effect of drought and foliar application on growth and nutrients status in shoot of barley plants (Giza 124). Application of foliar fertilizers to plants increased the weight of dry matter. The highest dry matter (10.0 g/plant) of barley was obtained with addition of Amino + Potassium treatment under normal irrigation. The highest increase in N uptake was by Amino + Potassium under drought at normal irrigation followed by that received Amino + Potassium at dough stage, the lowest by spraying Potassium under drought at elongation and regular condition followed by sprayed Amino when plants at elongation and normal condition followed by the sprayed Amino and drought at dough stage. Both fertilizers improved the uptake of Fe, Zn and Cu in straw shoots under regular irrigation or drought conditions. These improvements in most cases, resulted by Amino + Potassium over that resulted under moisture deficit during elongation or when plants irrigated regularly.

Keywords: Barley, Drought, Foliar, Fertilization, Potassium, Amino, Shoots, Macronutrients, Micronutrients

Barley is one of the important and major cereal corps in Egypt for food, feed, and industrial proposes. The expansion of areas cultivated by this crop is now a national target in order to its successful growth in the new areas especially those suffer from poor fertility, shortage of water and salinity problems.

The availability of water has an important influence on crop productivity (Satorre and Slafer, 1999) and the capacity of the soil to retain water. Furthermore, the ability of plants to improve their resistance to drought plays an important role under adverse environment condition. One of mechanisms for improving plant tolerance to drought is to lower the osmotic potential by increasing the concentration of cell solutes. Common solutes such as organic acids, carbohydrates and ions are usually accumulated in vacuoles, because they can inhibit the activity of the plant cell.

In several areas of Egypt, an essential part of the agrarian areas consists of permeable and light textured soils and which periodic drought and nitrogen and potassium deficiencies are the major limiting factors. Therefore more effective cultivars of better adaptation to the limited N and K availability appear to be an important objective for local crops.

Foliar application is a direct way for nutrient supplementation via leaves tissues to enhance physiological processes and to correct elements deficiencies which accrued in the new cultivated areas (Mc-Conary 1997). The interaction between water deficit and fertilization on physiological processes and mineral status of cereal plants were reported by Hussein *et al.* (1978), Hussein and Riead (1979), Hussein and Mandour (1980), Ibrahim *et al.* (1986) and Hussein *et al.* (2002) .

Angum *et al.* (2002) in desert plants, noticed that the majority of ions (K, Ca, Mg, Cl, and Na) increased with decreases in soil moisture, whereas, the concentration of P and K diminished with deficiency in soil moisture. Hussein and Mandour (1980) on corn found that the total N tended to increase with increased the depletion of available soil moisture before irrigation. El-Zeiny *et al.* (1990) found that water deficit increased the concentration of both N and P in stem, leaves, and roots of barley plants but the total amount was decreased. Tocker *et al.* (1999) reported that chloride accumulation in the leaves was generally higher in drought and saline treatments, where the control K concentration remained higher in both treatments. Nevertheless, El-Kholy and Hamed (2002) revealed that the drought caused reduction in sodium and potassium uptakes of barely shoots.

Interaction of soil water and nitrogen fertilizer application on the quality of barley for malting were studied in Grain Shelter Experiment at Lincoln , New Zealand by Ruiter (1999) and found, the level of N fertilizer had little effect on the Kernel size properties . Grain N concentration responds to N fertilizer application but it was unresponsive to water treatment.

This work was done to investigate the effect of drought by omitting one irrigation during different growth stage and foliar fertilization, namely; Amino, Potassium and their mixture on mineral status of barley plants.

Material and Methods

Two field experiments were conducted in the Experimental Farm of the National Research Center, Shalakan, Kaliobia Governorate during 2001/2002 and 2002/2003 winter seasons to evaluate four different foliar fertilization and water deficit on nutritional status in shoots of barley plants. Physical and chemical composition of soil in the experimental sites were noted in Table (1).

The treatments were as follows:

1-Drought treatments

A-Without (normal irrigation)
B-Omitting of irrigation at elongation stage
C-Omitting of irrigation at dough stage

TABLE 1. Some physical and chemical properties of the experimental sites.

Soil properties	Studied soil
Location	El-Kanater
Texture	Clay
Ec (dS/m)	1.63
pH	7.96
Total N(mg/100g)	110
NH_4(mgN/100g)	3.59
NO_3(mgN/100g)	5.95
Available K(ppm)	410
Available P(ppm)	10.8
Available SO_4(ppm)	900
O.M%	1.77
$Ca(CO_3)$2%	3.48

2-Foliar fertilization treatments

A-Without

B- Potassium-P fertilizer (8% P_2O_5- 45% K_2O) at the rate kg/fed.

C-Amino fertilizer (Amino acids + Zn (24%) +Mn (2%) + Fe (2%)+Mg (1%)) at the rate litter/fed.

D- Potassium -P fertilizer in combined with Amino fertilizer .

The experimental design was split-plot in sex replicates which the drought treatments were allocated in the main plots where the foliar fertilization treatments were distributed in sub plots.

Grain of barley (*Hardium vulgare*.L.) Giza 124 was sown in the 1st of December in both seasons. Calcium super phosphate (16% P_2O_5) and Potassium sulfate (48.5% K_2O) were broadcasted before sowing at the rate of 200 and 100 kg/fed, respectively. Ammonium sulfate (20.5 % N) at rate of 100 kg as N/fed was applied in two equal portions; the 1st was applied after 21 days from sowing and the other was added two weeks latter in both seasons. Amino and Potassium-P fertilizer were sprayed at 30 day from sowing. The other cultural practices were done as practiced locally in the province.

The plants from every plot before harvesting were collected, cleaned, dried at 70° over night and ground in a stainless steel mill. Samples were digested using mixture of sulfuric acid and perchloric acids. Macro and micronutrients were determined using the methods described by Black *et al.* (1982).

Statistical analysis were carried out according to Snedecor and Chochran (1980)

Results and Discussion

Dry matter

Data presented in Fig. 1 show the effect of drought and foliar application on

dry matter production. The dry matter varied between 2.5-10.0 g/plant. Dry matter differed between absences of irrigation and foliar application treatments. Application of foliar fertilizers to plants increased the dry matter. The highest dry matter of barley (10.0 g/plant) was obtained with addition of Amino + Potassium treatment under normal irrigation. This treatment significantly increased the dry matter by 2.7 times that of the without foliar application. The dry matter was increased from 2.5 (without foliar) to 6.7, 7.5 and 10 g/plant when applied Potassium, Amino and Amino+Potassium, respectively.

Water deficiency during the period of anthesis is critical to normal barley production, causing significant dry matter losses. In absences of irrigation, addition of Potassium, Amino or Amino + Potassium to the crop through the application of the foliar fertilizer increases the dry matter of barley. Dry matter of treatments with absences of irrigation at dough stage was higher than of absences of irrigation at elongation stage. This means that the response of barley plants to absence irrigation at dough stage was more than that for absence of irrigation at elongation stage.

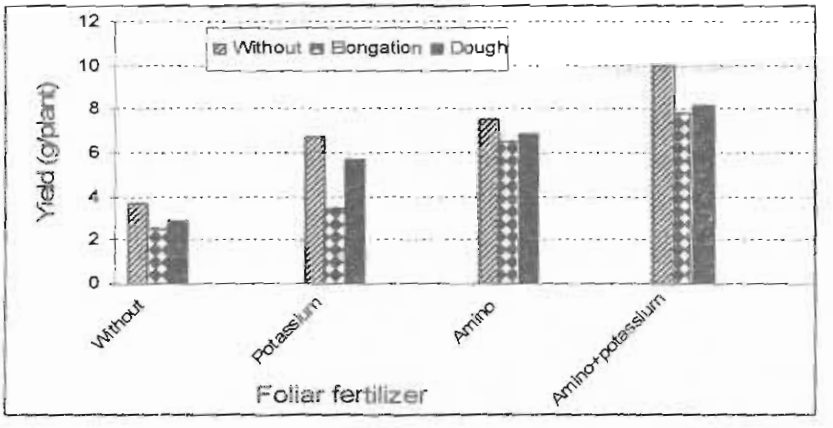

Fig. 1. Effect of drought and foliar fertilizers on dry matter production(g/plant) (average of two growing winter season 2001/2002 and 2002/2003).
LSD (0.05%) Foliar fertilizer (F) : 2.07 LSD (0.05%) drought (I) :1.79
LSD (0.05%) FxI : 4.22

Drought

Data presented in Table 2 and Fig. 2 show the effect of omitting of one irrigation at two stages of growth of barley plants on nutrients status of barley plants. Nitrogen concentration slightly increased when omitting of irrigation was applied at elongation stage. K concentration slightly increased when omitting of irrigation at either stage but the increase at dough stage was more than that caused under omitting of irrigation at elongation stage. However, the percentage of P was not affected by omitting of irrigation.

TABLE 2. Effect of drought on mineral concentrations in shoots of barley plants (average of two growing winter season 2001/2002 and 2002/2003).

Absence of irrigation	Macronutrients (%)			Micronutrients(ppm)			
	N	P	K	Fe	Mn	Zn	Cu
without	1.3	0. 2	3.5	1470	69	61	17
Elongation	1.6	0. 2	4.0	1296	68	50	19
Dough	1.3	0. 2	4.3	1229	68	47	19

The concentration of Fe and Cu clearly decreased by omitting of irrigation and the rate of decreased raised by delaying the omitting of irrigation. Mn slightly increase by both irrigation treatments while Zn showed approximately the same response of P. Hussein *et al.* (1978) demonstrated that slight water deficit increased the concentration of micronutrients (Zn, Cu, Mn and Fe), while under other moderate or sever stress the opposite result was true.

Uptake of macro and micronutrient in shoot of barely plants were illustrated in Fig 2. Nitrogen uptake was decreased by 11.96 % when irrigation omitting at elongation and dough stages compared with that irrigated regularly. In the case of P, uptake decreased by the drought treatment and raised up by delaying subjection to drought to be more than that of the control treatments. Concerning K uptake, moisture stress either at dough or elongation stage negatively affected on K uptake but the effects of the two irrigation treatments seemed to be equal The effect of drought on uptake of nutrients in barley plants were reported by Asghori *et al.* (2000) who indicated that the ratio of K and Ca may regulate the position of stomata in different conditions.

Copper uptake gave the same trends by shortage of water at both stages. Mn uptake increased only by omitting of irrigation at elongation stage but slightly decreased by irrigation omitting at dough stage in comparable with that of control irrigation treatment. Whereas, Zn uptake slightly decreased by the two water deficit treatment.

The increase in macro- elements might be attributed to the much inhibited growth by shortage of water rather than to the related accumulation of element. Further explanation for this effect, such as the effect of water deficit in root volume, surface area and distribution, root /shoot ratio, the depression on the other metabolic processes and in metabolites concentration or/and the mineral absorption by roots (Levitt, 1980, Simpson, 1981 and Kramer, 1983).

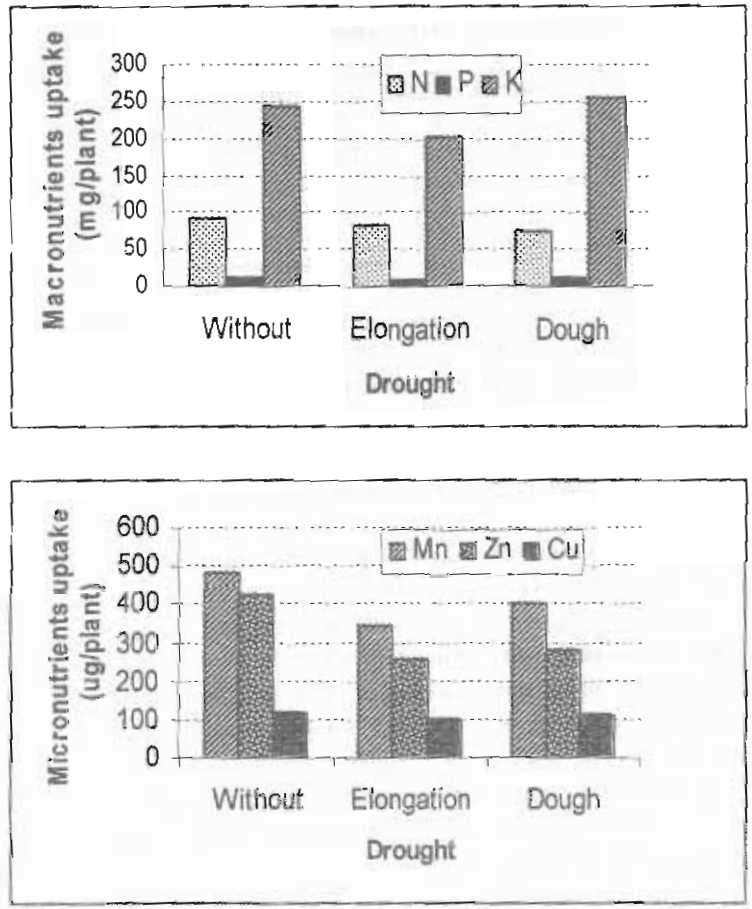

Fig. 2. Effect of drought on nutrient uptake in shoot barley plants.

Foliar fertilization

Table 3 shows that N and K concentration in shoots of barley from foliar fertilizer application was higher than that of control. On the other hand, P concentration did not show any response to foliar fertilizers. Zinc concentration show the same trend of P while Cu concentration responded as K concentration. Nevertheless, Fe concentration was sharply decreased by addition of Amino + Potassium foliar treatment. While iron concentration was increased by spraying Potassium or Amino which amounted by 7.1 or 11.6%, respectively.

TABLE 3. Effect of foliar fertilizers on mineral concentration in shoots of barley plants (average of two growing winter season 2001/2002 and 2002/2003).

Foliar fertilizer	Macronutrients(%)			Micronutrients(ppm)			
	N	P	K	Fe	Mn	Zn	Cu
Without	1.1	0. 23	3.9	1281	64	54	18
Potassium	1.4	0. 23	3.5	1372	63	50	16
Amino	1.6	0. 16	4.1	1430	68	50	19
Amino+Pot.	1.5	0. 20	4.3	1244	73	48	20

A clear positive correlation was detected between addition of foliar fertilizer on the uptake of Fe, Cu and Zn (Fig. 3). The increment induced in Fe or Zn by Amino+ Potassium exceeded those resulted from each one alone. Meanwhile, Mn uptake decrease by addition of Potassium and tended to increase by addition of Potassium +Amino but still less than those in plants without receiving foliar fertilizers.

Eid (1994) found that micronutrient foliar spray in maize at 75% silking increased dry matter and micronutrient uptake. Skiba *et al.* (1998) demonstrated that the balance of the amount of applied N minus its recovery in the aerial parts was much greater for foliar than for soil application . On wheat, Socpardi (1998) revealed that use of Fasfon N, it contains high N and P concentrations and enriched with Zn, Cu, Fe, Mn, B and Mo absorbed improving in nutrients uptake. He added that early senescence that takes place prior to harvest may decrease the final dry matter of crop. This phenomenon has been related to depletion of carbohydrates, N, P, and K from all plants parts which are being translocated to the seeds during seed filling.

Foliar application of K may offer the opportunity of correcting these deficiencies more quickly and efficiently especially late in the season when soil application of K may not be effective.

Drought x foliar fertilization

The interaction effect of drought and foliar fertilizer on macro and micronutrients in barley shoots were recorded in Table 4. A positive and clear correlation was detected between addition of foliar fertilizers and nutrients but the degree of increase varied according to type of fertilizers and the time of drought subjection. The uptake of macro and micronutrients by barley plants increased with foliar application. The highest uptake of N, P, K, Fe and Zn was observed with addition of Amino+ Potassium treatment under normal irrigation. The efficiency of the used foliar fertilizers application on increasing uptake of

nutrients could be arranged in the following descending order; Potassium + Amino > Amino > Potassium > without foliar. Nitrogen uptake by plant from treatments at dough stage was higher than elongation treatment. This means that the response of barley plants to irrigation absence at dough stage was more than that for absence of irrigation at elongation stage.

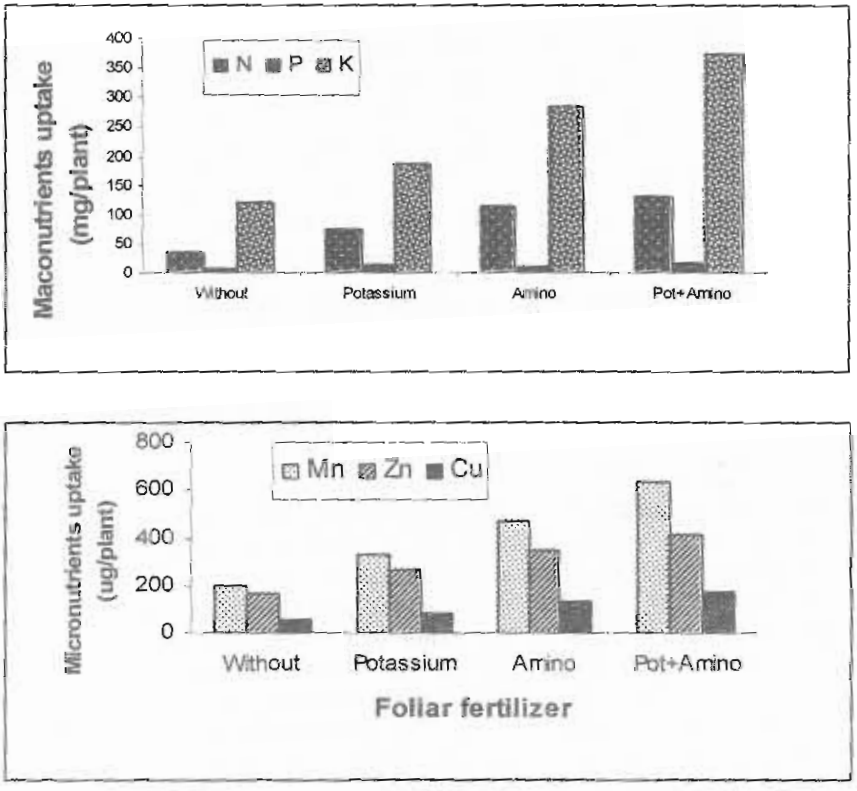

Fig. 3. Effect of foliar fertilizers on nutrients uptake in shoot barley plants.

In general, the effect of foliar fertilizers on N uptake was almost similar to the effect on K uptake. These results are in harmony with those obtained by Hussein and Khadir (1979) on barley, Hussein and Mandour (1980) and Hussein *et al.* (1984) on maize and Ibrahim *et al.* (1986) on wheat. El-Zeiny *et al.* (1990) found that addition of Potassium as a soil application tend to increase N and P uptakes of stem as well as leaves and roots of barley plants and this increase raised by decreasing the depletion percentage of available soil moisture before irrigation. El-kholy *et al.* (2001) concluded that root may rapidly responses to drying and rewetting the top soil by locally increasing root growth together with the ability of fast recovery of the physiological ability for nutrients uptake after drought stress.

Phosphorus uptake significantly increased with foliar fertilizer application. Potassium+ Amino caused little variation in P uptake compared to Amino or Potassium foliar treatment.

Data in Table 4 indicated that either Potassium or Amino improved the uptake of Fe and Zn in barley plants under normal irrigation or drought conditions. There improvements in most cases, resulted from spraying of Amino in combined with Potassium over that resulted under moisture deficit during dough or when plants irrigated regularly. Under moisture stress at elongation stage, uptake of Fe and Zn was lowest than normal irrigation or absence of irrigation at elongation stage.

Concerning Mn and Cu uptake by barley plants, there was no significantly increase with foliar fertilizer application.

TABLE 4. Effect of drought and foliar fertilizers on mineral uptake in shoots of barley plants (average of two growing winter season 2001/2002 and 2002/2003).

Absences of irrigation	Foliar fertilizers	Macronutrients(mg/plant)			Micronutrients(mg/plant)			
		N	P	K	Fe	Mn	Zn	Cu
without	Without	41	9	126	5.1	0.2	0.19	.05
	potassium	80	14	235	12.2	0.4	0.35	0.10
	Amino	120	15	255	10.2	0.53	0.58	0.14
	Pot+amino	135	20	350	13.0	0.7	0.62	0.20
Elongation stage	Without	32	5	113	3.4	0.18	0.17	0.10
	Potassium	63	14	147	4.4	0.22	0.18	0.20
	Amino	103	10	260	9.4	0.47	0.3	0.20
	Pot+amino	117	10	326	10.0	0.6	0.34	0.10
Dough stage	Without	33	8.7	116	3.5	0.19	0.13	0.10
	Potassium	74	10.3	211	5.7	0.37	0.25	0.10
	Amino	118	13.4	311	10.3	0.4	0.3	0.12
	Pot+amino	122	13.6	405	11.2	0.4	0.23	0.10
L.S.D 5%	F	8.95	2.02	17.7	1.93	0.014	0.073	0.08
	I	5.35	1.88	14.9	1.83	0.017	0.083	0.33
	FxI	15.4	4.8	25.8	2.96	2.95	0.16	0.11

F = Foliar fertilization
I = Irrigation
F x I =foliar fertilization x Irrigation

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تأثير الجفاف والرش بالسماد الورقى على التركيب المعدنى للمجموع الخضرى لنباتات الشعير

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أجريت تجربتان حقليتان خلال موسمى شتاء متتاليين ٢٠٠١/٢٠٠٢ و٢٠٠٢/٢٠٠٣ بمحطة التجارب التابعة للمركز القومى للبحوث بشلقان- محافظة القليوبية لدراسة تاثير الرش بالسمادين الورقيين الأمينو والبوتاسيوم ومخلوطهما على تركيز ومحتوى العناصر الغذائية فى المجموع الخضرى (سوق +اوراق) قبل الحصاد. وكانت أهم النتائج هى:

١- زاد تركيز البوتاسيوم بمعاملتى الجفاف بينما النتروجين زاد زيادة طفيفة مع الجفاف بغياب رية أثناء طور الاستطالة بينما لم يتاثر تركيز الفسفورفى أنسجة النباتات. تركيز كل من الحديد والزنك إستجاب عكسيا للجفاف وكان ذلك اكثر وضوحا.
٢- عند غياب رية أثناء الطور العجينى ولم يكن لمعاملات الجفاف تاثيرا ملموسا على تركيزالنحاس.
٣- نقص محتوى النتروجين والبوتاسيوم بمعاملتى الجفاف وكان النقص أكبر عند تأخر التعرض للجفاف أثناء الطور العجينى بالنسبة للنتروجين أما الفسفور فقد نقص عند حدوث الجفاف أثناء طور الاستطالة ثم عاد للأرتفاع عند تاخير الجفاف ليصبح أعلى من معاملة المقارنة.
٤- محتوى كل من الحديد والنحاس اوضح نفس الاستجابة لتركيزهما أما محتوى المنجنيز فقد زاد لمعاملة الجفاف المبكرة أثناء طور الاستطالة ثم قل بتاخير معاملة الجفاف . أما محتوى الزنك فقد انخفض قليلا بدرجة متساوية بمعاملتى الجفاف.
٤- أدى التسميد إلى زيادة محتوى العناصر الصغرى والكبرى تحت ظروف الجفاف والرى العادى ولكن نسبة الزيادة كانت أكبر تحت معاملات الجفاف.