Egypt. J. Agric. Res., 79 (3), 2001.

OPTIMIZING TIME OF MICRONUTRIENT APPLICATION TO WHEAT PLANTS GROWN ON SANDY SOILS

NEGM, A.Y. AND F.A. ZAHRAN

Soils, Water and Environment Res. Inst., Agric. Res. Centre, Giza, Egypt

(Manuscript received 31 December, 2000)

Abstract

A 2-year field study was carried out at Ismailia Agricultural Research Station during the two growing winter seasons of 1997/1998 and 1998/1999 to evaluate the optimum physiological stage of wheat plants for micronutrients Fe, Zn and Mn application. Mixture of Fe-chelate (6 % Fe), Zn-chelate (12 % Zn) and Mn-chelate (13 % Mn) at the ratio of 3:2:2 respectively was foliar applied (1 g mixture/L of water) at different physiological growth stages, i.e. tillering, elongation, booting and heading. The wheat plants received a single spray at each of these stages or two sprays at each pair of these stages alternatively.

The obtained results revealed that foliar applications of the studied micronutrients at booting stage only or along with either tillering or elongation stage had the most significant effect on increasing wheat grain and straw yields along with the investigated yield attributes as well as grain protein content. This may suggest that booting stage is the most suitable stage to apply micronutrients for wheat plants, another spray at tillering or elongation stage being favorable. Grain contents of P, Fe, Zn and Mn were not significantly affected by the time of micronutrient application whereas grain K content did.

INTRODUCTION

Supplying nutrient elements to plants as foliar application, at a specific physiological growth stage, is undoubtedly of great importance especially in micronutrient deficient sandy soils. Researches showed that increased growth and yields of different crops were frequently obtained by foliar spray with micronutrients even where there were no deficiency symptoms. However, application of excessive amounts may lead to toxicities with severe consequences for the following crops in the rotation. So, micronutrients should not he applied as a "shotgun" application to cover possible deficiencies. The problem of deficiencies or unavailability of micronutrients have been demonstrated in both calcareous and sandy soils, where wheat plants can do well. Foliar application of micronutrients for wheat plants proved to be useful in solving the problem of unavailability of micronutrients due to relatively high pH of Egyptian soils.

Many investigators have demonstrated the mode of response of wheat plants to micronutrients. Spraying zinc sulphate (0.3%) at 45 and 60 days from sowing on wheat plants grown at some Egyptian Governorates in the Delta and Nile Valley realized an increase of about 20% as an average (Sayed *et al.*, 1984). El-Awady and Abdel-Naim (1990) obtained the maximum yield of wheat by double foliar application of 0.4% Zn as $ZnSO_4$ at tillering and booting stages, at Sids Research Station. From 1981 to 1989, a series of field experiments was carried out by Abd el-Hadi *et al.* (1990) at some governorates in Nile Delta, Middle Egypt and Upper Egypt. The response of wheat to micronutrients (Zn and Fe) application was observed in some locations while no response was obtained in the others. Soil and foliar application of Zn and its interaction with N and P in highly calcareous soils had positive effects on wheat (EL-Bagoury, 1974). Grain and straw yields of wheat as well as protein yield responded also positively to Zn, Mn and Fe as well as some foliar fertilizers (Abdel-Hadi *et al.*, 1990 and Hassan *et al.*, 1992). Foliar application of micronutrients (Fe, Zn and Mn) after 40 and 60 days from sowing significantly increased grain and straw yields of wheat plants grown on sandy soils (Mousa *et al.*, 1994). Also, Dahdoh (1997) reported that the highest grain yield was obtained by foliar application of 0.5% Fe + 0.25% Cu or 0.5% Zn + 0.5% Mn (as sulphate form) on wheat plants grown on a sandy soil. Results of 33 on farm trials proved that grain yield responded positively to Zn, Mn, and Fe combinations in Egypt (Firgany *et al.*, 1983). The objective of this study is to optimize the time of micronutrients (Fe, Zn and Mn) application to wheat plants to maximize wheat production grown on sandy soils.

MATERIALS AND METHODS

Two successive field experiments were carried out during 1997/1998 and 1998/1999 growing winter seasons at Ismailia Agricultural Research Station (sandy soil) to investigate the optimum physiological stages of wheat plants for micronutrients (Fe, Zn, and Mn) application and their effect on wheat grain and straw yields as well as some grain chemical contents. Wheat cultivar Sakha 69 was planted in both seasons. A randomized complete block design with four replications was followed. The plot area was 12 m^2. Wheat grains were sown at the rate of 60kg/fed in raws, 20 cm apart under sprinkler irrigation system. Chemical analysis of the experimental soil was performed (Table,1). Chelate mixture from Fe(6%), Zn(12%) and Mn(13%) at the ratio of 3:2:2 respectively was prepared and applied as a foliar spray at the rate of 1 g chelate mixture/litre of water at the following physiological stages:

1. control (without spraying)
2. one spray at tillering stage (one month after sowing)
3. one spray at elongation stage (45days after sowing)
4. one spray at booting stage (55-60 days after sowing)
5. one spray at heading stage (70-75 days after sowing)
6. two sprays at both tillering and elongation stages
7. two sprays at both tillering and booting stages
8. two sprays at both tillering and heading stages
9. two sprays at both elongation and booting stages
10. two sprays at both elongation and heading stages
11. two sprays at both booting and heading stages

All the experimental plots received 30 kg P_2O_5 as ca-superphosphate (15% P_2O_5) and 24 kg K_2O as K-sulphate (48% K_2O) / fed. as recommended rates before sowing, while the recommended N rate (120kg/fed.)as ammonium sulphate (20.6% N) was applied in five equal doses starting from planting and every two weeks. At harvesting, both grain and straw yields / fed. as well as some yield characters were recorded. Grains were digested and their contents of N, P and K were determined in the digestion solution. Nitrogen was determined by micro-Kjeldahl method then multiplied by 5.7 to obtain protein content. Phosphorus was determined colorimetrically (Jackson, 1967) whereas K was determined using the flame photometer. Grain contents of Fe, Zn and Mn were also determined in the digestion solution by atomic absorption spectrometer. Standard analysis of variance and combined analysis overall the two years were performed according to Snedecor and Cochran (1969)

Table 1. Chemical analysis of the experimental soils

Soil properties	1997/1998	1998/1999
pH (1 :2.5, soil: water, suspension)	7.50	7.95
EC, mmhos/cm (1: 5, soil: water)	0.23	0.35
$CaC0_3$ (%)	0.16	0.33
Available N (ppm)	40.0	30
Available P (ppm)	2.4	4.0
Available K (ppm)	53.5	107.0
Available Fe (ppm)	1.22	1.48
Available Zn (ppm)	0.56	0.30
Available Mn (ppm)	0.60	0.76

RESULTS AND DISCUSSION

1. Effect of time of micronutrient application on some yield components:

The efficiency of micronutrients Fe, Zn and Mn in sandy soils is an important factor affecting wheat production in such soils, which are characterized by most micronutrient deficiency. The statistical analysis of the data given in Table 2 showed that foliar application of the studied micronutrients at elongation and / or booting stages as well as two sprays at both tillering and booting stages gave the most highly significant increases in plant height, spike length and 1000-grain weight during the two growing seasons, over the control. This was confirmed by the combined analysis, but there were no significant differences between these stages. This indicates that both elongation and booting growth stages, and in some cases tillering stage, are the most vigorous and optimum stages to apply these micronutrients. The plant at these stages is in high vigour and needs these microelements which have very essential functions in plant metabolism concerning growth, respiration, chlorophyll synthesis, photosynthesis and so on. In this connection, Amberger (1974) reported in experiments with cultured explants that Fe acts as a "trigger" in stimulating cell division and growth in quiescent carrot tissues. He also indicated that lack of Mn blocks chlorophyll synthesis and interrupts synthesis of cell walls (lipid metabolism). Also, one of the most important action of Zn is its effect on growth regulation by controlling auxine metabolism via the amino acid tryptophane. Worth mentioning that the plants received sprays at heading stage, at both tillering and elongation stages or at both elongation and heading stages showed no significant effects on the above mentioned yield attributes in most cases.

2. Wheat yields as affected by time of micronutrient application:

The result of the wheat yield in Table 3 revealed that although foliar application of micronutrients at any growth stage gave significant increases in grain yield /plant, plants which received one spray at booting stage or two sprays at both tillering and booting stages gave the highest grain yield /plant. However, foliar application of the micronutrients at booting stage only or two sprays at any two growth stages except tillering + elongation stages showed significant increases in wheat grain yield as shown in Table 3. Again, plots receiving one spray at booting stage, two sprays at both tillering and booting stages or at both elongation and booting stages gave the highest grain yields (7.66, 8.01 and 7.86 ardab/fed. respectively) showing that spraying the micronutrients was most effective at these growth stages, especially booting stage, since it alone or along with other stages, recorded the highest grain yield. This could be due to that the used micronutrients have the most effective functions on plant metabolism at these specific growth stages especially booting stage.

Table 2. Plant height, spike length and 1000 - grain weight as affected by micronutrients (Fe, Zn and Mn) application at different physiological stages of growth

Micronutrient application time (stage)	plant height (cm)			spike length (cm)			1000 - grain weight (g)		
	97/98	98/99	Mean	97/98	98/99	Mean	97/98	98/99	Mean
Control (No spraying)	77.0	80.4	79.1	7.33	8.03	7.68	37.6	38.6	38.1
Tillering stage	81.0	84.6	82.8	9.10	9.07	9.08	41.8	42.0	41.9
Elongation stage	85.1	87.3	86.2	9.70	9.30	9.33	40.8	41.2	41.0
Booting stage	87.4	90.0	88.7	9.93	9.67	9.80	42.0	43.6	42.8
Heading stage	82.4	82.3	82.3	8.87	8.67	8.77	39.5	40.8	40.2
Tillering + Elongation	80.4	83.7	82.1	8.27	8.23	8.25	41.2	40.1	40.7
Tillering + Booting	87.0	87.4	87.2	10.20	9.93	10.07	43.7	43.7	43.7
Tillering + Heading	84.3	84.0	84.2	9.70	8.63	9.17	39.5	40.3	40.0
Elongation + Booting	86.6	87.5	87.1	9.00	9.33	9.17	43.5	42.3	43.0
Elongation + Heading	82.3	82.0	82.1	8.27	8.20	8.23	37.6	40.0	38.8
Booting + Heading	81.6	82.1	81.8	8.80	8.93	8.87	41.6	41.9	41.8
L. S. D at 0.05	4.9	3.8	4.2	0.93	0.73	0.81	3.00	2.2	2.5

The obtained results of straw yield in Table 3 showed nearly the same trend of grain yield as the spraying of micronutrients was most effective when plants received two sprays at both tillering and booting stages or at both elongation and heading stages, which recorded the highest straw yield (5.26 and 5.13 t/fed. respectively).

It could be concluded that wheat plants grown on such deficient micronutrient soils should receive two sprays of micronutrient solution, one of them must be at booting stage and the other at either tillering or elongation stage.

3. Grain contents of P, K and protein as affected by time of micronutrient application:

Wheat grain protein content was significantly increased over the control by foliar application of micronutrients at any growth stage except for wheat plants receiving single spray at tillering stage, where protein content was not significantly affected. However the combined analysis over all the two years showed that plants which received a single spray at booting stage or two sprays at both tillering and booting stages recorded the highest significant protein content (13.26 and 13.15% respectively). Here again, the wheat plants showed a higher utilization of the sprayed micronutrients which play an important function in protein formation. In this connection, Amberger (1974) mentioned that the amount of protein in iron deficiency leaves is lower but the total concentration of free amino acids is much higher than that in the control. Manganese also has important functions in plant metabolism especially in photosynthesis, nitrate reduction, amino acids and protein synthesis. Zinc is necessary for RNA and protein synthesis (Amberger, 1974). On the other hand, the combined analysis over the two years showed that grain P content was significantly affected only by two sprayings of the micronutrients at both booting and heading stages, whereas grain K content was significantly affected by foliar micronutrient application at most physiological stages. In this regard, El-Bagouri (1974) and EL-Kadi *et al.* (1975) reported that Zn application did not show an apparent effect upon P concentration in barley and wheat; Mn being effective.

Table 3. wheat yield as affected by micronutrient Fe, Zn and Mn application at different physiological stages of wheat plant growth.

Micronutrient application time (stage)	grain weight / plant (g)			Grain yield (ardab / fed)			Straw yield (ton /fed)		
	97/98	98/99	Mean	97/98	98/99	Mean	97/98	98/99	Mean
Control (No spraying)	0.803	0.957	0.880	5.97	5.70	5.83	3.38	3.50	3.44
Tillering stage	1.380	1.613	1.496	6.81	6.20	6.51	4.04	4.33	4.18
Elongation stage	1.481	1.783	1.632	6.69	6.55	6.62	4.07	4.12	4.09
Booting stage	2.165	2.076	2.121	7.71	7.61	7.66	4.84	4.73	4.79
Heading stage	1.495	1.668	1.582	6.86	6.42	6.64	4.06	4.86	4.46
Tillering + Elongation	1.413	1.499	1.456	6.63	5.90	6.27	4.61	4.40	4.51
Tillering + Booting	2.324	2.290	2.307	8.09	7.92	8.01	5.37	5.16	5.26
Tillering + Heading	2.006	1.529	1.767	7.38	6.60	6.99	4.82	4.63	4.73
Elongation + Booting	1.467	2.037	1.752	8.07	7.64	7.86	5.00	4.38	4.69
Elongation + Heading	1.227	1.312	1.270	7.12	7.34	7.23	5.27	4.99	5.13
Booting + Heading	1.725	1.855	1.790	7.23	6.86	7.04	4.45	4.37	4.41
L. S. D at 0.05	0.413	0.192	0.311	0.88	0.83	0.83	0.88	0.71	0.77

Table 4. Grain contents of P, K and protein % as affected by the time of foliar micronutrient application

Micronutrient application time (stage)	Protein (%)			P(%)			K(%)		
	97/98	98/99	Mean	97/98	98/99	Mean	97/98	98/99	Mean
Control (No spraying)	7.93	8.44	8.18	0.277	0.332	0.305	0.37	0.37	0.370
Tillering	10.72	9.54	10.13	0.349	0.421	0.385	0.43	0.43	0.428
Elongation	10.26	11.25	10.75	0.268	0.348	0.308	0.47	0.40	0.433
Booting	13.26	13.25	13.26	0.398	0.347	0.373	0.48	0.45	0.465
Heading	12.58	12.88	12.73	0.347	0.386	0.366	0.48	0.42	0.450
Tillering + Elongation	10.72	11.10	10.91	0.308	0.413	0.360	0.47	0.42	0.445
Tillering + Booting	13.39	12.91	13.15	0.351	0.419	0.385	0.47	0.47	0.465
Tillering + Heading	10.93	12.66	11.79	0.277	0.361	0.319	0.41	0.44	0.423
Elongation + Booting	12.41	12.56	12.46	0.380	0.341	0.361	0.49	0.44	0.463
Elongation + Heading	10.27	10.97	10.62	0.317	0.418	0.367	0.54	0.45	0.493
Booting + Heading	12.15	11.25	11.70	0.411	0.427	0.419	0.48	0.46	0.468
L. S. D at 0.05	2.78	2.58	2.43	N.S	0.056	0.088	0.08	0.05	0.057

4. Grain contents of Fe, Zn and Mn as affected by time of micronutrient application:

The obtained results in Table 5 showed that grain contents of Fe, Zn and Mn were not significantly affected by foliar application of these micronutrients at any physiological stage of growth, except Zn during one season only where it was significantly increased by micronutrient spraying at heading stage, or with elongation or booting stages.

Table 5. Grain contents of Fe, Zn and Mn as affected by the time of micronutrient application

Micronutrient application time (stage)	Fe (ppm)			Zn (ppm)			Mn (ppm)		
	97/98	98/99	Mean	97/98	98/99	Mean	97/98	98/99	Mean
Control(No spraying)	255.0	330.8	292.9	58.2	72.9	65.5	23.5	22.8	23.1
Tillering stage	293.8	441.0	367.4	59.7	86.8	73.2	27.5	25.3	26.4
Elongation stage	303.8	462.3	383.0	60.6	81.5	71.0	26.3	30.0	28.1
Booting stage	344.0	473.3	408.6	61.2	83.2	72.2	25.0	25.3	25.1
Heading stage	364.5	362.3	364.9	63.6	87.1	75.3	27.5	30.0	28.8
Tillering + Elongation	330.0	410.3	370.1	59.6	86.8	73.2	31.3	30.0	30.6
Tillering + Booting	318.8	450.3	384.5	60.3	84.3	72.3	27.5	27.5	27.5
Tillering + Heading	332.5	476.3	404.4	58.2	78.2	68.2	31.0	32.5	31.8
Elongation + Booting	311.3	405.3	358.1	61.3	83.8	72.5	32.5	28.8	30.7
Elongation + Heading	315.0	436.3	375.6	66.2	80.8	73.5	30.0	35.0	32.5
Booting + Heading	322.5	488.8	405.6	65.2	78.0	71.6	28.0	28.75	28.4
L. S. D at 0.05	N.S	N.S	N.S	4.06	N.S	N.S	N.S	N.S	N.S

REFERENCES

1. Abdel-Hadi, A. H. ,M. A. M. Hassan, A. A. F. Moustafa and S. A. Shalaby 1990. Effect of Zn, Mn, Fe and some different foliar Fertilizers on wheat production in Egyptian soils. Proc-of Soil Fertility and foliar fertilization conf., Giza, Egypt ,48-67.

2. Amberger, A. 1974. Micronutrients, dynamics in the soil and function in plant metabolism. Proc-Egypt. Bot. Soc. Work Shop 1, Cairo, pp - 81-111.

3. Dahdoh, M. S. A. 1997. Mutual effect of some nutrients on wheat plants. Egypt. J. Soil Sci., 37, 4: 485 - 497.

4. EL-Awady, R. M. and M. Abdel-Naim. 1990. Effect of foliar application of zinc on the crop yields of corn and wheat in clay soils. Proc.of soil fertility and foliar fertilization conf., Giza, Egypt,187-196

5. EL-Bagouri, I. H., M. A. EL-kadi and S. A. Sabet. 1974. A preliminary study on the interrelationships of manganese, phosphorus and nitrogen in highly calcareous soils of Maryut. The desert Inst. Bull, A.R.E., 24, 219-312.

6. EL-Kadi, M. A., I. H. EL-Bagouri and S. A. Sabet. 1975. Effect of soil and foliar application of Zn and interactions with N, P on yield and chemical composition of some crops under the conditions of highly calcareous soils. Egypt. J. Soil. Sci., special Issue, 339-349.

7. Firgany, A. H., A. I. Rezk, A. I. A. Fawzi and A. A. EL-Sayed. 1983. Response of nutritive status and grain yield of wheat to nutrient supply in Egypt. Egypt. J. Bot., 26, 101-112.

8. Hassan, M. A. M., A. Y. Negm, M. H. Rabie and M. S. Khadr. 1992. Response of wheat plants grown in Middle and Upper Egypt to micronutrients and some foliar fertilizers Proc. 5th Conf. Agron, Zagazig, 1: 56-63.

9. Jackson, M. L. 1967. Soil chemical analysis. Prentice Hall- New Delhi, India.

10. Mousa, I. A., A.Y. Negm, A.Y. El-Bashbishy and Hanyat M. EL-Nemr. 1994. Effect of different levels and sources of nitrogen fertilizers and foliar application of ascorbic acid and some micronutrients on wheat production in sandy soils. Fayoum J. Agric. Res. & Dev., 8, 1: 73-84.

11. Sayed, A., E. A. Abdel-Latif and A. F. Mohamed. 1984. Maximizing wheat production by Zinc sulphate. Agric. Res. Rev., 62, 427-432.

12. Snedecor, G. W. and W. Cochran. 1969. Statistical Methods. 6th Ed. Iowa State Univ. Press, Ames, Iowa, U.S.A.

المواعيد المثلى لإضافة العناصر الصغرى لنباتات القمح المنزرعة فى الأراضى الرملية

عبد الواحد يوسف نجم، فهمى عبد المنعم زهران

معهد بحوث الأراضى والمياه والبيئة - مركز البحوث الزراعية - الجيزة - مصر

أقيمت تجربة حقلية فى محطة البحوث الزراعية بالإسماعيلية خلال موسمى الزراعة ١٩٩٧/١٩٩٨، ١٩٩٨/١٩٩٩ لتحديد المراحل الفسيولوجية المثلى لنباتات القمح لرشه بمحاليل العناصر الصغرى حيث استخدم مخلوط من الحديد المخلبى (٦ ٪ حديد) والزنك المخلبى (١٢٪ زنك) والمنجنيز المخلبى (١٣٪ منجنيز) بنسبة ٣:٢:٢ على التوالى رشا على النباتات بمعدل ١جم مخلوط/لتر ماء عند المراحل الفسيولوجية المختلفة للقمح وهى التفريع، والإستطالة، الحمل، طرد السنابل. وقد تم رش النباتات إما رشة واحدة عند أحد هذه المراحل أو رشتان عند مرحلتين من هذه المراحل بالتبادل.

أظهرت النتائج المتحصل عليها أن رش النباتات بمحلول هذه العناصر الصغرى عند مرحلة الحمل فقط أو الرش مرتان عند مرحلة الحمل ومرحلة التفريع أو مرحلة الحمل ومرحلة الاستطالة كان أكثر فعالية فى زيادة محصول القمح وبعض مكونات المحصول المدروسة بالإضافة إلى محتوى الحبوب من البروتين، وهذا يوضح أن مرحلة الحمل فى نباتات القمح هى أكثر المراحل الفسيولوجية استجابة لرش العناصر الصغرى مدعمة برشة أخرى عند مرحلة التفريع أو مرحلة الإستطالة. هذا ولم يتأثر معنوياً محتوى الحبوب من الفوسفور والبوتاسيوم والحديد والزنك والمنجنيز بمواعيد رش العناصر الصغرى بينما تأثر محتواها من البوتاسيوم.