EFFICACY OF COMBINATION BETWEEN Mg AND N FERTILIZATION ON THE CHEMICAL COMPOSITION AND TECHNOLOGICAL PROPERTIES OF WHEAT GRAINS

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Abstract

The effect of Magnesium sulphate application at rates of 5 and 10 kg/feddan applied as either foliar or soil application under three nitrogen fertilizer levels, i.e. 0, 60 and 120 kg/feddan, on wheat grain yield, chemical analysis and technological properties were investigated. Two field trials were performed in 1995/1996 and 1996/1997 winter growing seasons, in the Experimental Farm of Sers El-Lian Agricultural Research Station. The bread wheat cultivar Gimmeiza 1 was used in this study.

The results revealed that fertilizing with 60 kg N/fd combined with 5 or 10, kg Mg^{+2}/fd produced highest grain yield, also soil application was the most beneficial followed by foliar spraying on the physical properties of wheat grains.

The data also revealed that Mg^{+2} soil application increased all chemical composition and wheat flour extraction.

It could be concluded that the most valuable treatment is 60 kg N/fd combined with 5 or 10 Kg Mg^{+2}/fd soil application.

INTRODUCTION

Magnesium is a key element in plant nutrition and the only metal in the chlorophyll molecule. It is, therefore, intimately involved in photosynthesis. It makes up 2.7% of the molecule and 10% of the total leaf magnesium in the chlorophyll (Quisenperry and Reitz, 1967). In addition, Singh and Gill (1987) indicated that foliar application gave a higher wheat grain yield than soil application.

Breadmaking quality of wheat depends on the quality and quantity of proteins in the endosperm. While the first parameter is genetically determined, the latter is highly influenced by the environment, especially by nitrogen fertilization. The success of breeding for high technological quality depends on improvements in both the potential level of genotypes and stability of quality expression. Several reports suggested that environmental conditions could affect storage protein components quantitatively

(Kruger and Marchylo 1985, Hubner and Bietz 1988, Marchylo *et al.*, 1990). The interesting question is; whether the composition of wheat flour protein changes when the total protein content is varied, such as when the wheat plant is fertilized with nitrogen? It is largely accepted that nitrogen fertilization affects the protein content and composition and directly influences the technological quality of wheat samples. For instance, strong effects of nitrogen fertilization (along with those of climate, growing year, and growing location) have been observed on both protein content and baking quality (Seroux and Metayer, 1990).

The objective of the present work is to study the effect of magnesium fertilization on chemical composition and technological properties of wheat either when applied to the soil or in foliar sprays under three nitrogen fertilizer levels.

MATERIALS AND METHODS

Materials:

The present work was carried out at the,,Experimental Farm of Sers El-Lian Agricultural Research Station, Agricultural Research Center (ARC), Menofia Governorate, Egypt. It was conducted during two successive seasons (1995/96) and (1996/97) to study the effect of nitrogen fertilization as ammonium nitrate (33.5% N) at three levels i.e. 0, 60 and 120 kg N/fd. in combination with magnesium sulphate at two levels i.e. 5 and 10 Kg Mg^{+2}/fd. either soil or foliar application on the chemical composition and technological properties of wheat grains (*Triticum aestivum*, Gimmeiza 1). Soil fertilization was performed before sowing and a spray foliar in two equal doses at tillering (after 21 days from sowing) spray at booting stage (after 70 days from sowing). Nitrogen was applied at the recommended dates. The experimental design was randomized complete blocks with four replicates. At harvest, the grain yield of each treatments were mixed together and a representative sample was taken for the chemical and technological analysis.

Methods:

I. Physical properties:

Hectoliter, 1000-kernel weight, wet and dry gluten, extraction and farinograph parameters were determined according to AACC (1985).

II. Chemical analysis:

Moisture, protein, ash, fiber, oil, total carbohydrate, and minerals were determined according to AOAC (1990). Phytic acid was determined by Camire and Clydesdole (1982) and as modified by Mohamed *et al.* (1986).

RESULTS AND DISCUSSION

Effect on the physical properties of wheat grains:

Table 1, shows the effect of nitrogen fertilizer at 0, 60 and 120 kg/fd combined with Mg^{+2} as micronutrient applied at 5 and 10 kg/fd in $MgSO_4$ from either soil or foliar on some physical properties of wheat grains. Hectoliter resulted in a range of 78.8-81.2, 78.4-80, 79.2-81.2 and 77.2-82 due to the treatments of 5, 10 kg Mg^{+2} as foliar and soil application combined with 0, 60 and 120 kg N/fd, respectively. Under same treatments, 1000-kernel/weight ranged 44.6-46.2, 45.1-46.8, 43.3-45.8 and 44.2-46.7 g, respectively. Also, grain yield resulted in 12.9-16.2, 14.0-17.7, 12.7-17.2 and 13.2-17.1 ard/fd, respectively.

From the above mentioned data, it could be concluded that treatment with 60 kg N/fd combined with 5 or 10 kg Mg^{+2}/fd produced highest grain yieid ranged from 16.2-17.7 ard/fd., when applied as foliar spray, while soil application showed the greatest grain yield at 60 kg N/fd combined with either 5 or 10 kg Mg^{+2}/fd being 17.2 and 17.1 ard/fd, respectively. Similar trend of 1000-kernel weight was formed as that of grain yield due to foliar spraying which showed its maximum value at 60 kg N/fd combined with 10 kg Mg^{+2}/fd being 46.8 g followed by 120 kg N/fd with 10 kg Mg^{+2}/fd (46.7 g). Concerning foliar application no clear trend was found. Hectoliter resulted in almost similar values except that of 120 kg N/fd combined with the two levels of Mg^{+2} under the two treatments of application which resulted in minimum value (77.2-79.2).

It could be concluded that application of 60 kg N/fd combined with 5 and 10 kg Mg^{+2}/fd by foliar spraying was the most benificial followed by soil application on the physical properties of wheat grains. The obtained data were agree with those of Samuel and Nelson (1975) and Singh and Gill (1987).

Effect on the chemical composition of wheat grains:

Table 2 shows the chemical composition of wheat grains resulted of fertilization with different levels of nitrogen i.e., 0, 60 and 120 kg/fd combined with Mg^{+2} at the ratio of 5 and 10 kg/fd either soil or foliar sprayed. Fertilization with N at 0, 60 and

Table 1. Effect of nitrogen fertilizer levels combined with Mg either soil or foliar on the physical properties of wheat grains.

Treatments		Hectoliter	1000-kernel weight	Grain yield Ard/fd
Fert. with N + $MgSO_4$ (foliar):				
N	Mg^{++}			
0	5	81.2	44.6	12.9
60	5	80.8	46.1	16.2
120	5	78.8	46.2	14.8
0	10	80	45.1	14.0
60	10	80	46.8	17.7
120	10	78.4	46.5	15.3
Fert. with N + $MgSO_4$ (soil):				
N	Mg^{++}			
0	5	80.8	43.3	12.7
60	5	81.2	45.8	17.2
120	5	79.2	45.3	14.0
0	10	82	44.2	13.2
60	10	80.8	46.2	17.1
120	10	77.2	46.7	14.2

Table 2. Effect of nitrogen fertilizer levels combined with Mg either soil or foliar on the chemical composition of wheat grains.

Treatments		Protein %	Ash %	Oil %	Fiber %	T.C. %	Phytic acid mg/g
Fert. with N + $MgSO_4$ (foliar):							
N	Mg^{++}						
0	5	10.9	2.3	3.2	1.7	80.5	0.72
60	5	11.9	1.9	3.2	1.9	77.9	0.93
120	5	12.8	1.8	3.3	1.9	82.0	0.71
0	10	11.0	1.6	2.9	2.1	77.2	0.62
60	10	11.9	1.2	3.4	1.6	80.6	0.52
120	10	13.4	Z.1	3.5	1.7	79.9	0.37
Fert. with N + $MgSO_4$ (soil):							
N	Mg^{++}						
0	5	11.0	2.1	2.9	2.2	84.3	0.68
60	5	12.5	1.8	3.4	2.0	77.8	0.51
120	5	12.7	1.6	3.4	2.1	76.8	0.95
0	10	11.7	1.1	3.3	1.9	82.7	0.97
60	10	12.6	1.8	4.2	1.2	83.5	0.60
120	10	13.2	1.6	3.7	1.9	76.9	0.76

120 kg/fd combined with 5 kg Mg^{+2}/fd as foliar application resulted in protein content ranged 10.9-12.8%, ash 1.8-2.3%, oil 3.2-3.3%, fiber 1.7-1.9, total carbohydrate 77.9-82.0% and phytic acid 0.71-0.93 mg/g. The corresponding values due to Mg^{+2} soil application were ranged 11.0-12.7%,1.6-2.1, 2.9-3.4, 2.0-2.2, 76.8-84.3 and 0.51-0.95 mg/g, respectively. The obtained data revealed that Mg^{+2} soil application increased all chemical composition than that of foliar application which 60 kg N/fd + 5 kg Mg^{+2}/fd was the optimum application. On the other hand, the three levels of N combined with 10 kg Mg^{+2}/fd show protein content was ranging between 11.0 and 13.4%, ash 1.2-2.1, oil 2.9-3.5, fiber 1.6-2.1, total carbohydrate 77.2-80.6%, and phytic acid 0.37-0.62 mg/g, while the corresponding values due to Mg^{+2} soil application were ranging from 11.7 to 13.2, 1.1-1.8, 3.3-4.2, 1.2-1.9, 76.9-83.5 and 0.60-0.97 mg/g, respectively. The results also exhibited the superiority of soil application of Mg^{+2}.

The above mentioned data revealed that the most valuable treatment was Mg^{+2} at 5 kg/fd soil application. The data were agree with those of Takahashi and Ito (1978) and Takahashi *et al.* (1979).

The effect on extraction ratio and gluten content of wheat grains:

Table 3 shows that the extraction ratio of flour ranged from 68.57 to 71.18%, bran 25.31-27.08 and short 3.51-4.35% under the three levels of N fertilizer combined with 5 kg Mg^{+2}/fd as foliar application, while it was ranged from 64.12 to 68.0%, 28.0-31.53% and 4.0-5.15% when Mg^{+2} was applied at 10 kg/fd. Using the same three levels of N as fertilizer combined with 5 kg Mg^{+2}/fd as soil fertilizer, the extraction ratio resulted in the range of 69.96-71.31%, 24.89-26.62%, and 3.42-4.88% for flour, bran and short, respectively, meanwhile, application of N levels combined with 10 kg Mg^{+2}/fd produced wheat flour ranged from 69.02 to 70.55%, bran 25.31-26.54% and short 4.14-4.65%. The obtained data revealed that 120 kg N/fd + 5 kg Mg^{+2}/fd followed by 60 kg N + 5 kg Mg^{+2}/fd produced flour at the ratio of 71.18 and 69.02% followed by zero N + 5 kg Mg^{+2}/fd (68.57%) . This was found to be more than that of the different levels of N combined with Mg^{+2} at 10 kg/fd applied as foliar spray. The same trend was found concerning soil application. From the above mentioned data, it could be concluded that Mg^{+2} at 5 kg/fd either foliar or soil application encourage photosynthesis and therefore increase the starch content which reflects the wheat flour extraction, while at 10 kg/fd, soil application showed some increase than the foliar application.

Table 3. Extraction ratios of wheat grain.

Treatments		Flour %	Bran %	Short %	Wet gluten %	Dry gluten %
Fert. with N + $MgSO_4$ (foliar):						
N	Mg^{++}					
0	5	68.57	27.08	4.35	20.6	7.4
60	5	69.02	26.92	4.06	20.7	8.7
120	5	71.18	25.31	3.51	31.7	10.6
0	10	65.88	28.97	5.15	28.1	10.0
60	10	68.00	28.00	4.00	25.3	9.2
120	10	64.12	31.53	4.35	26.2	9.3
Fert. with N + $MgSO_4$ (soil):						
N	Mg^{++}					
0	5	70.09	25.53	4.38	23.3	8.1
60	5	71.31	24.89	3.80	28.1	9.5
120	5	69.96	26.62	3.42	27.5	9.4
0	10	69.20	26.15	4.65	25.9	9.8
60	10	70.55	25.31	4.14	28.3	9.9
120	10	69.02	26.54	4.44	29.4	10.3

Regarding wet and dry gluten, 120 kg N/fd combined with 5 kg Mg^{+2}/fd, as foliar application, resulted in the maximum wet gluten (31.7%) while the other treatments (0-60 kg N) showed the same amount (20.6 and 20.7%), while 0 N/fd combined with 10 kg Mg^{+2}/fd (as foliar) showed the highest value of wet gluten (28.1 %). Dry gluten of the aforementioned treatments ranged from 7.4 to 10.6 and 9.2-10.0%, respectively which is parallel with the wet gluten.

The effect on minerals content of wheat grains:

Table 4 shows the elements content of wheat grains under three levels of nitrogen i.e. 0, 60 and 120 kg/fd combined with Mg^{+2} at 5 or 10 kg/fd either soil or foliar application. The data revealed that Ca^{+2} increased due to Mg^{+2} foliar application when combined with nitrogen at all levels of which Mg^{+2} at 5 kg/fd produced the maximum Ca^{+2} content followed by 10 kg Mg^{+2}/fd. Soil application showed an increase due to 5 Kg Mg^{+2}, while it is decreased at 10 Kg Mg^{+2}/fd. Mg^{+2} showed an increase in amount due to the Mg application as expected whether applied as foliar or soil. P^{-2}, Mn^{+2} and K^{+} increased due to Mg^{+2} application while Zn^{+2} increased due to 5 Kg Mg^{+2}/fd as foliar application combined with all N levels, while other treatments resulted a decrease due to N levels or Mg^{+2} application methods. The effect of N levels and Mg^{+2} application methods resulted in decreasing Fe^{+2} of grains, except that of 10 Kg Mg^{+2}/fd applied as foliar.

From the above mentioned data, it could be concluded that under 60 Kg N/fd combined with Mg^{+2} at 5 Kg/fd either soil or foliar application encourage the plant to absorb some minerals from the soil, but the competitive between the absorption of some minerals had taken place. The data were agree with the findings of Singh and Gill (1987).

The effect on farinograph parameters of wheat flour dough:

Table 5 shows the farinograph parameters, i.e. water absorption, mixing time, stability and weakning of wheat flour dough produced from three levels of nitrogen as fertilizer combined with Mg^{+2} applied either soil or foliar. Fertilization with N at 60 Kg/fd combined with Mg^{+2} at different levels (5 and 10 kg/fd) or application method resulted in highest water absorption (65.2-65.8%). This means that this N ratio was suitable for producing wheat flour with water absorption ranging from 65.2 to 65.8%. Mixing time showed no clear trend due to N or Mg^{+2} treatments, it ranged from 1.5 to 5.25, 1.75-5.0 min. for N levels combined with 5 or 10 kg Mg^{+2}/fd when applied as foliar spray, while the corresponding figures were 2.5-4.25 and 1.25-3.25 min., respec-

Table 4. Effect of nitrogen fertilizer levels combined with Mg^{+2} either soil or foliar application on the minerals of wheat grains.

Treatments		Ca^{++} m.eg	Mg^{++} mg/100g	Fe^{++} mg/100g	Mn^{++} mg/100g	Zn^{++} mg/100g	P^{--} %	K^{+} %
Fert. with N + $MgSO_4$ (foliar):								
N	Mg^{++}							
0	5	2.0	0.11	0.018	0.012	0.10	0.35	0.60
60	5	2.4	0.13	0.015	0.046	0.17	0.41	0.67
120	5	2.5	0.14	0.015	0.015	0.046	0.47	0.72
0	10	2.1	0.12	0.013	0.015	0.1	0.36	0.61
60	10	2.3	0.14	0.015	0.015	0.09	0.43	0.67
120	10	2.2	0.14	0.017	0.023	0.06	0.47	0.74
Fert. with N + $MgSO_4$ (soil):								
N	Mg^{++}							
0	5	2.1	0.12	0.045	0.03	0.123	0.35	0.62
60	5	2.3	0.13	0.013	0.045	0.129	0.44	0.70
120	5	2.3	0.15	0.013	0.013	0.073	0.48	0.72
0	10	2.9	0.13	0.023	0.02	0.078	0.42	0.63
60	10	2.4	0.14	0.013	0.043	0.042	0.47	0.71
120	10	2.3	0.15	0.013	0.013	0.054	0.49	0.75

Table 5. Effect of nitrogen fertilizer levels combined with Mg either soil or foliar application on the farinograph parameters of wheat flour dough.

Treatments		Water absorption %	Mixing time (Min.)	Stability (min.)	Weakening (B.U.)
Fert. with N + $MgSO_4$ (foliar):					
N	Mg^{++}				
0	5	65.6	1.5	3.25	140
60	5	65.8	3.5	3.5	160
120	5	65.2	5.25	2.5	115
0	10	64.0	5	3	140
60	10	65.8	1.75	5.75	150
120	10	62.2	4	4.5	100
Fert. with N + $MgSO_4$ (soil):					
N	Mg^{++}				
0	5	61.6	2.5	5	120
60	5	65.4	3	3.5	140
120	5	63.0	4.25	2.5	110
0	10	63.2	1.25	6.5	140
60	10	65.2	2.25	5.5	130
120	10	65.0	3.25	3.5	150

tively, when Mg^{+2} was applied as soil fertilizer. Stability (min.) showed its maximum value due to 60 Kg N/fd combined with either 5 or 10 Kg Mg^{+2} applied as foliar spray being 3.5 and 5.75 min., respectively. Meanwhile application of 0 N combined with 5 or 10 Kg Mg^{+2}/fd as soil fertilizer resulted in highest stability being 5 and 6.5 min., respectively. Similar observations were found due to weakning which showed that 60 Kg N/fd was the most effective than the other levels followed by resulted Mg^{+2} levels or application method. The data were agree with that of chemical composition, wet and dry gluten (Table 2 and 3).

REFERENCES

1. A.A.C.C. 1985. American Association of Cereal Chemists. Approved Methods. 8th Ed. St. Paul.; Minn., U.S.A.

2. A.O.A.C. 1990. Official Methods of Analysis of the Association of Official Analytical Chemists,15th Ed. Washington D.C., U.S.A.

3. Camire, A.L. and Clydesdole, M. 1982. Analysis of phytic acid in foods by HPLC. J. of Food Sci.,74, 575.

4. Hubner, F.R. and Bietz, J.A. 1988. Quantitative variation among gliadins of wheat grown in different environments. Cereal Chem., 65: 362-366.

5. Kruger, J.E. and Marchylo, B.A. 1985. Selection of column and operating conditions for reversed-phase high-performance liquid chromatography of proteins in canadian wheat. Can. J. Plant Sci. 65: 285-298.

6. Marchylo, B.A.; Kruger, J.E. and Hatcher, D.W. 1990. Effect of environment on wheat storage proteins as determined by quantitative reversed-phase high-performance liquid chromatography. Cereal Chem., 67: 372-376.

7. Mohamed, A.; Perera, P.A. and Hafez, Y. 1986. New chromophore for phytic acid determination. Cereal Chem., 63, 475.

8. Quisenperry, K.S. and L.P. Reitz 1967. Wheat and wheat improvement, physiology. American Society of Agronomy, Inc., Publisher, Madison, Wisconsin, U.S.A., pp.181-223.

9. Samuel, L.T. and W.L. Nelson 1975. Soil fertility and fertilizers, elements required in plant nutrition. 3rd edition, Macmillan Publishing Co., Inc., New York. pp. 66-104.

10. Sëroux, M. and Metayer, J.P. 1990. Qualite' nutritionnelle descèréales à paille et du sorgho. Etude des facteurs de variation. Ind. céréales 67: 41-48.

11. Singh, H. and H.S. Gill 1987. Interaction effects of magnesium with nitrogen on the growth and yield of wheat. J. Agric. Sci., UK, 109 (2): 399 403.

12. Takahashi, H. and S. Ito 1978. Physiological studies on zinc deficiency of maize (*Zea mays*, L.). 1. Influence of zinc concentration in the nutrient solution. J. Agron. Sci. Japan 21: 164. C.F. Seed Abst. 3 (1980) 931.

13. Takahashi, H., Rohyma and S. Ito 1979. Physiological studies on zinc deficiency of maize (*Zea mays*, L.). 2. Influence of zinc concentration in the nutrient solution on amounts of nitrogen, phosphorus and potassium contained in plants. Ibid 23: 44 C.F. Seed Abst. 3 (1980) 932.

تأثير التسميد بالماغنسيوم تحت مستويات من النتروجين على التحليل الكيماوى والصفات التكنولوجية لحبوب القمح

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يهدف هذا البحث إلى دراسة تأثير التسميد بكبريتات الماغنسيوم تحت مستويات من النتروجين على محصول القمح وكذلك على التحليل الكيماوى والصفات التكنولوجية للقمح. وقد أقيمت تجربتان حقليتان فى محطة البحوث الزراعية بسرس الليان فى محافظة المنوفية، مركز البحوث الزراعية، خلال موسمى الزراعة الشتويين ١٩٩٥/١٩٩٦ و١٩٩٦/١٩٩٧ وكان صنف القمح المستعمل هو قمح الخبز جميزة ١ . وكانت معاملات التسميد كالآتى: التسميد بكبريتات الماغنسيوم بمعدل ٥ و١٠ كجم مغنسيوم للفدان تضاف إما إضافة أرضية أو رشاً على النباتات تحت ثلاثة مستويات من النتروجين هى صفر و٦٠ و١٢٠ كجم للفدان. وقد أظهرت النتائج أن أعلى محصول من حبوب القمح للفدان كان عند إضافة ٦٠ كجم نيتروجين للفدان مع ٥ أو ١٠ كجم ماغنسيوم للفدان. وقد أدت إضافة الماغنسيوم أرضياً إلى زيادة استخلاص القمح وكذلك زيادة التركيب الكيماوى.

وخلاصة القول أن أفضل نسبة إضافة هى ٦٠ كجم نيتروجين للفدان مع ٥ أو ١٠ كجم ماغنسيوم/للفدان أرضاً.