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Evaluation of Magnesium and Iron Nutritional Status in Some Monocot and Dicot Crop Plants Using a Portable Chlorophyll Meter

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Abstract: A field study was carried out to determine magnesium and iron status in economically important field crops wheat, maize and sugarbeet as well as snap bean and potatoes grown under field conditions using the portable chlorophyll meter. The meter readings showed non-significant correlations with Mg-concentration in wheat leaves while iron concentrations were negatively correlated with the apparatus readings. Both Mg and Fe concentrations in maize leaves were negatively correlated with the meter readings. In contrast, Mg and Fe concentrations in sugarbeet, snap bean and potatoes leaves showed highly significant positive correlations with chlorophyll-meter readings. Thus, it is suggested that the apparatus can be used to predict Mg and Fe status for dicot short-life crops. Because of their accumulation under unbalanced fertilization, the meter, like any other tool, could not express the actual needs for Mg and Fe for monocot cereals.

Key words: Chlorophyll-meter, magnesium, iron, monocots, dicots

Introduction

Yield losses attributed to nutrient deficiency were found to depend upon the degree of nutrient(s) deficiency (Reuter, 1986). Addition of the deficient nutrients in the late stages of growth would not be beneficial for obtaining good yields. Monitoring of the nutritional status of a given crop plant is of great importance to meet nutritional requirements in the proper time. For many reasons, the conventional method used to evaluate nutrients in the plant through chemical analysis of the plant tissues, sometimes, can not rapidly help to correct the plant nutritional status in time. A faster and cheaper method is the portable meters, which possibly evaluate some of the essential nutrients under field conditions.

Portable chlorophyll-meters could be successfully used to determine N-status in several crops (Takebe and Motomatsu, 1987; Wood *et al.*, 1992, 1994 with corn; Takebe and Yoneyama, 1989; Takebe *et al.*, 1990 with rice; Kantety *et al.*, 1996 with tall fescue, Shaahan *et al.*, 1999 with mango, mandarin, guava and grapevine, Shaahan and El-Bendary, 1999 with snap bean, potato and cucumber). The apparatus could also be used in determining the status of some other nutrients closely related to chlorophyll formation such as magnesium and iron (Shaahan *et al.*, 1999; Alvarez-Fernandez *et al.*, 2002).

This work is an attempt to use the portable chlorophyll meter in evaluating the status of magnesium and iron in two main cereal crops (wheat and maize) representing monocot plants and sugar beet snap bean and potatoes representing dicot plants under field conditions.

Materials and Methods

The study was carried out at chosen locations in Ismailia governorate, Egypt during 1999/2000 and 2000/2001 seasons. The crops were grown in sandy soil. Ranges of physical and chemical characteristics of the surface soil layer are shown in Table 1.

Table 1: Mean values of physical and chemical soil characteristics

Physical characteristics		Nutrient concentration	
		Macro nutrients	(mg/100 g soil)
pH: (1.2.5)	7.9-8.2	P	05.0- 1.3
E.C. (dS/cm)	0.2-0.35	K	7.7-9.2
$CaCO_3$ (%)	1.0-1.8	Mg	32.0-46
O.M. (%)	0.3-0.52	Ca	90.0-130
		Micro nutrients	(mg/kg soil)
Sand (%)	86.0	Fe	5.0-12.0
Silt (%)	4.2	Mn	6.0-13.0
Clay (%)	9.8	Zn	1.5-2.5
Texture	Sand	Cu	0.8-1.6

Crops: Wheat (*Triticum aestivum* var. Sacha 69), maize (*Zea mays* var. Giza 310), sugarbeet (*Beta vulgaris* var. Corela), snap bean (*Phaseolus vulgaris* var. Bronco), potato (*Solanum tuberosum* var. King Edward) were chosen upon their economical importance and to express monocot and dicot plants.

Basic fertilization

NPK fertilization as units/hectare were in the following ranges (Kg/ha):

Crops	N	P	K
Wheat	120-180	72-108	58-115
Maize	180-288	72-108	58-115
Sugarbeet	108-144	72-108	115-230
Snap bean	96-192	72-108	72-144
Potato	120-360	120-144	115-172

Nitrogen fertilizers were added as ammonium sulphate (20.6% N), where P-fertilizers were added as superphosphate (15.5% P_2O_5) and K-fertilizers as potassium sulphate (48-52% K_2O). The fertilizers were applied as different splits as recommended.

Readings and sampling: The portable Hydro chlorophyll-meter (Minolta Co. Ltd. Japan) was used in this study. It is a dry battery energized and weighed about 225 g. Each reading is an average of 30 correct measurements.

Readings were carried out on the blades of the fully mature leaves of wheat at the tillering stage in the field. The used part in maize was the leaf blade below whorl before tasseling. As for sugarbeet, the readings were carried out on the fully mature leaf blades at 50-60 days after sowing. The blades of the young mature leaves of snap bean at the early flowering stage and the fully mature mid-stem blades (50-60 DAP) of potatoes were used.

A total of 20 measurements equal to 600 readings were carried out with each crop. The measured leaves were fast collected. Then, samples were kept in an ice-box and transported to the laboratory for analysis.

Determinations and measurements

Chlorophyll determination: Chlorophyll extraction and determination was carried out in the leaves according to the method of Maclachlan and Zalik (1963).

The rest sample was washed with tap water, 0.01 N HCl and distilled water, respectively. The sample was then oven-dried at 70°C and ground.

Nutrients determination: The dried sample was digested in a muffle furnace at 550°C (Chapman and Pratt, 1978). Mg and Fe were determined using an atomic absorption spectrophotometer PMQ3.

Statistical analysis: Data were statistically analyzed using Costat Statistical Package (Anonymous, 1989) to calculate the possible correlations and regression formulae. The records of Snedecor and Cochran (1967) were used to evaluate the significance.

Results

Monocots

Wheat: The correlations were measured between N-tester readings and total chlorophyll, total magnesium and total iron contents of wheat leaves (Fig. 1). Chlorophyll content was positively correlated with the meter readings ($P < 0.01$, $r = 0.97$).

Magnesium concentrations in the leaves showed a non significant positive correlation with the meter readings ($r = 0.067$), while iron concentrations even showed negative correlation with the meter readings ($P < 0.01$, $r = -0.88$).

Maize: It is clearly shown (Fig. 1) that chlorophyll is positively correlated with the meter readings ($P < 0.01$, $r = 0.98$). Both magnesium and iron concentrations in maize leaves are negatively correlated with the apparatus readings ($P < 0.01$, $r = -0.84$, -0.77 for magnesium and iron, respectively).

Dicots

Sugar beet: In addition to chlorophyll, magnesium and iron concentrations in the leaves of sugar beet were positively correlated ($P < 0.01$) with the chlorophyll meter readings (Fig. 2). Correlation coefficient (r) was 0.99, 0.62 and 0.92 for chlorophyll, magnesium and iron, respectively.

Adequate levels of magnesium in the leaves were found to be ranged between 0.25 and 0.7% as total Mg (Reuter, 1986, Benton *et al.*, 1991). These values are proportional to a meter reading of about 134 and 706, respectively. Less than 134 is considered in the Mg-deficient range and more than 706 in the high range.

A value of 55 ppm total Fe was considered as a critical concentration in the leaves of sugar beet, while the range 60-140 ppm was the adequate one (Reuter, 1986). These values

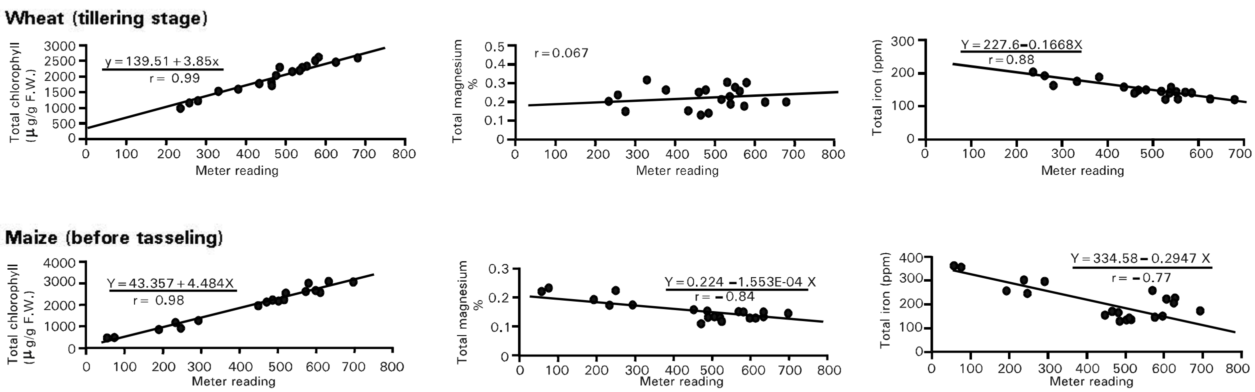

Fig. 1: Chlorophyll, magnesium and iron concentrations as correlated with chlorophyll-meter readings

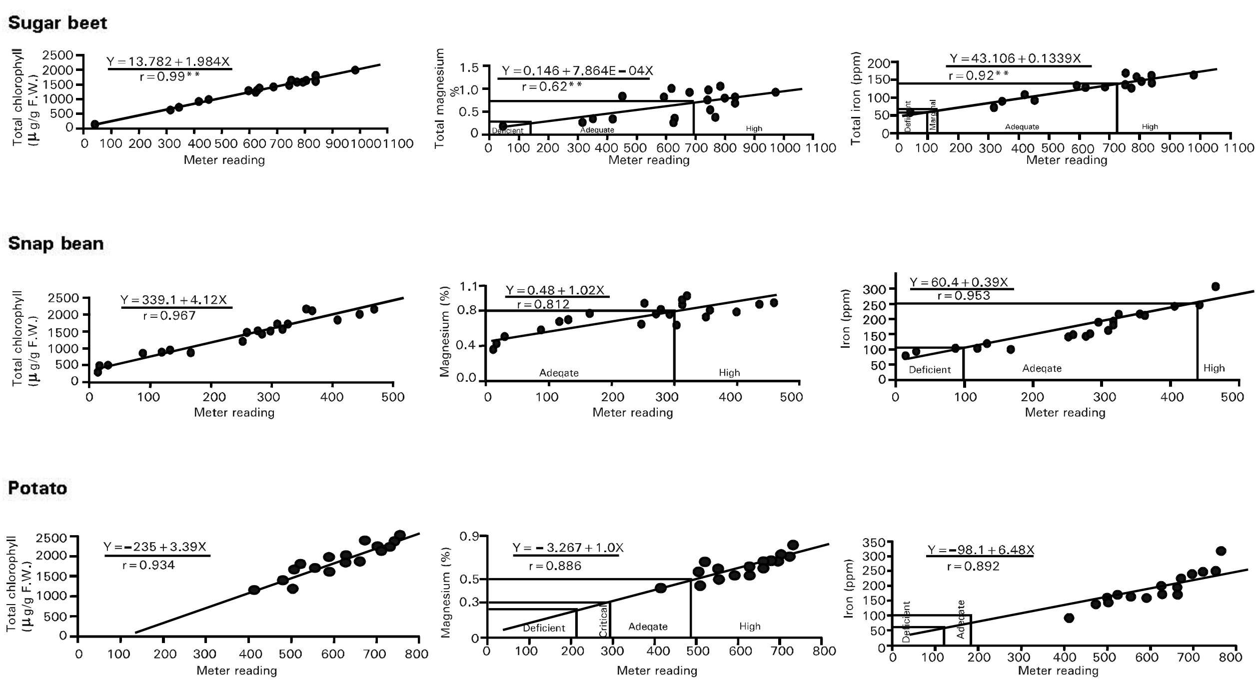

Fig. 2: Chlorophyll, magnesium and iron in sugar beet, snap bean and potato as correlated with chlorophyll-meter readings

were proportional to chlorophyll-meter readings of around 89 and 127-724, respectively.

Snap bean: Chlorophyll concentration of the snap bean blades in the early flowering stage was found to be positively linearly correlated with the readings of the chlorophyll-meter (P = 0.01, r = 0.96) (Fig. 2). Magnesium and iron concentrations in the leaves were also found to correlate positively with the meter readings (r = 0.81 for Mg and 0.95 for Fe). According to the values of Reuter and Robinson (1986), meter readings < 20 were in the magnesium deficient range, 20-300 in the adequate range and > 300 in the high range, while < 100 was proportional to deficient range, 100-440 to the adequate range and > 440 to the high range for iron.

Potato: Potato leaves chlorophyll concentrations were also found to correlate positively with the chlorophyll meter readings (P= 0.01, r = 0.93) (Fig. 2). Correlation coefficient of magnesium concentrations in the leaves (50-60 days age) with the meter readings was as high as 0.88. Using the values of Reuter and Robinson (1986), chlorophyll meter readings in the range of 210-290 was proportional to the critical Mg-range, while the readings of 290-490 were in the adequate range. Iron concentrations of the same leaves were highly correlated with the meter readings (r = 0.89). Readings < 100 referred to the deficient F-range and 100-180 to the adequate range.

Discussion

The obtained results of the investigated crops confirmed that the chlorophyll-meter readings are proportional to the chlorophyll density in the leaves. According to the results of Takebe and Yoneyama, (1989); Takebe *et al*, (1990); Wood *et al.* (1992, 1994); Kantety *et al.* (1996); Shaahan *et al.* (1999); Shaahan and El-Bendary, (1999), the chlorophyll meter can be accurately used to predict the N-status of the plant leaves under field conditions.

Besides, there were some attempts to use the chlorophyll-meter in determining the status of the closely related elements to chlorophyll formation like magnesium and iron. Shaahan *et al.* (1999) studied the relationship between the chlorophyll-meter readings and Mg and Fe status in mango, mandarin, guava and grape vine. They concluded that the apparatus can be used to predict Mg for some but not all crops and prediction of Fe is not yet possible. In contrast to these results, Alvarez-Fermandez *et al.* (2002) used the meter to determine Fe-status in the leaves of peach. The apparatus could also determine both Mg and Fe status in the leaves of dicots plants: sugar beet, snap bean and potato but not for monocots cereal crops: wheat and maize. In monocots, nitrogen deficiency was found to cause accumulation of both Mg and Fe in the leaves and once nitrogen status is improved, the two elements become physiologically active that their concentrations declined down to the normal ranges (Mengel and Kirkby, 1987). So, the contra relation between the meter readings and both Mg and Fe concentrations in wheat and maize is suggested to appear in case of nitrogen deficiency and hence, it can't be the status that express the actual requirements for the two elements.

In case of the dicot plants sugarbeet, snap bean and potato, magnesium and iron positive correlations were found to be similar to those of chlorophyll. It appears that the uptake and/or translocation of the two elements are closely related to that of nitrogen and hence, the chlorophyll-meter can also determine the status of Mg and Fe in all cases in the plant leaves in addition to nitrogen. However, one or more of the three nutrients can cause leaf chlorosis. To recognize the deficient element, chlorosis of the old leaves blade margin down the plant can distinguish Mg-deficiency, while in case of nitrogen the hole leaf turned pale yellow and the interveinal chlorosis of the new leaves is the symptom of Fe-deficiency (Shorrocks, 1964).

In conclusion the chlorophyll-meter readings were proportional to the chlorophyll density in the leaves of monocot cereals: wheat and maize and the dicot: sugarbeet, snap bean and potato. The apparatus can also be used to predict Mg- and/or Fe-status in the leaves of under investigation dicot plants and failed to determine the real status of the two elements in monocots. More studies should be carried out to clear possibility of using chlorophyll-meters in determining magnesium and iron in rest of the dicot plants.

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