Multi-KMg, a Superior Potassic Fertilizer for Side-dressing of Potatoes for Improved Yield and Quality.

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Abstract

Each and every possible way of increasing the supply of available potassium to the potato plant during the bulking up stage directly enhances tuber production. During this peak demand stage the application of potassium nitrate enriched with soluble magnesium in the form of Multi-KMg (12-0-43+2MgO) specialty fertilizer, has proven to be the most efficient method of increasing yields, quality and profitability. Extensive experimentation has been conducted with Multi-KMg in the UK, Holland, Egypt, South Africa, and Israel on the different varieties used for fresh consumption, interim storage, baking, seeds, fries, crisps and chips. Quantification of the benefits for side-dressing and fertigation with Multi-KMg has very consistently shown the following benefits:

1. Increased total yields (up to 32% above control).
2. Enhanced share of desirable tuber size (up to 35% above control).
3. Better external quality of the tubers (less bruising, scab and black spots and enhanced skin finish and curing capacity).
4. Better internal quality of the tubers (up to 2.5% higher dry matter, less internal browning and hollow heart).
5. Reduced incidence of Phytophthora.
6. And as a direct consequence of the aforementioned improvements there will be a considerable increase in grower profitability.

It is assumed that the well-known synergism among the nitrate anion and the potassium and magnesium cations enables the favorable phenomena and benefits described. This assumption is strengthened by the fact that similar results were also found with carrots, onions and sugar beets.

Key Words: *Magnesium, Potato (Solanum tuberosum L.), Potassium, Potassium fertilizer, Quality, Yield.*

Introduction

Potatoes (*Solanum tuberosum L.*) are produced at a large variety of soils and climatic and cultural conditions, for a vast array of end-products (fresh consumption, ware-potatoes, starch, chips, crisps and seeds). A crop of 50 tonne/ha of tubers will remove from the soil 80, 240 and 15 kg of N, K and MgO, respectively (Cooke, 1972).

Some of the largest producing regions have light soils with relatively low pH and low nitrification capacity. Such conditions favor the production of potatoes only when most of the nitrogen is applied as nitrate. Since the potato plant does not have a storage mechanism for ammonium, its uptake leads to an excess amount in the plant. This initiates transformation of the ammonium to ammonia, which damages the plant tissues.

Normal grower practice is to apply all N to the seedbed at planting, but in cases where leaching by rainfall is likely (e.g. on sandy soils), there are benefits from applying half in the seedbed and half at tuber initiation. One purpose of this paper was to establish the advantages of supplying the potato plant with high ratio of nitrate- nitrogen by fertigation throughout the growth season.

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Very high rates of K are required by the plant starting at tuber initiation and during tubers bulking up (Kolbe & Stephan-Beckmann, a &b; Perrenoud). Any failure to supply the plant with the large quantity required will result in a lower yield compared to the crop potential. Moreover, abundant K during bulking up of the tubers has been shown to contribute considerably to the external and internal quality of the tubers (tuber size distribution, tuber shape, skin finish, incidence of scab, black spots, specific gravity, internal browning and dry matter content).

Bester (1986) has shown that nitrate is the best potassium counter-ion for high yields in a number of potato cultivars. His studies have proven that potassium nitrate is superior to both potassium sulphate (SOP) and to potassium chloride (MOP), for higher yields and enhanced quality of the tubers.

Magnesium is generally considered a secondary nutrient. Many growers underestimate its necessity for optimum yields, and they apply sub-optimal magnesium fertilizer to their potato crop. Moreover, abundant applications of potassium interfere with the absorption of magnesium from the soil and considerably reduce magnesium content in potato tissues (Panique et al., Fontes et al,). Mondy et al have very clearly shown the contribution of Mg fertilization to the quality of potato tubers. Nogueira et al have shown that the application of soluble potassium and insoluble magnesium (as gypsum) resulted in enhanced yield quality by reducing tuber cracking.

Our study elucidates the advantage of combining K and Mg application in their soluble forms, to benefit both yield and quality.

Multi-KMg (potassium nitrate enriched with magnesium, 12-0-43+2%MgO) is a high quality specialty fertilizer. It is fully soluble and virtually chloride-free, consisting of 12% nitrate nitrogen, 43% K_2O, and 2% of MgO (available also with 4% MgO). The combination of the two important cation nutrients and the nitrate anion in this product creates synergy of all three nutrients for intensive absorption by the root system and efficient physiological availability within the plant.

Materials and Methods

Growing conditions

I. Trials conditions in UK, 1999.

An extensive series of experiments was carried out with many different cultivars, in 18 locations throughout the UK.

Soil type: sandy loam. Control treatments followed the commercial routine of local potato growers of applying some 65% N and all P and K as pre-plant, while the balance of N was applied as top dressing.

A complete nutrition scheme can be found in table 1.

II. Trials conditions in South Africa, 1999

Soil type- sand. Cultivar: *Up-to-Date (UTD).* Irrigation: Drip + fertigation. Control treatments followed the commercial routine of local potato growers. P was applied by broadcasting as DSP at planting. All other fertilizers were applied by 12 fertigation cycles. Three ratios of ammonium /nitrate (i.e.: 20:80, 50:50 and 80:20 percent) were used to determine crop response to these ratios under three levels of total N (120, 180 and 240 kg x ha^{-1}). K_2O rates were 183, 280 and 360 kg x ha^{-1}, respectively. Multi-KMg was used as the potassium and nitrate source. The balance was applied as follows: N as AN, CN and AS, K as MOP and Mg as $MgSO_4$.

III. Trial conditions in Israel, 1999.

An extensive series of experiments was carried out with many cultivars, in 14 locations in the southern part of Israel. Soil type: loess. Irrigation: sprinklers + fertigation Control treatments followed the commercial routine of local potato growers of applying FYM and all P as pre-plant, while the N was applied as top dressing. The growers usually apply no K since they believe that the high levels of exchangeable K in the soil (70-80 ppm in aqueous soil solution) supply the entire crop requirement. A complete nutrition scheme can be found in table 2.

IV. Trial conditions in Egypt, 1999.

Soil type: sand. Cultivar: *Nieta*.

Irrigation: fertigation by center pivots. A complete nutrition scheme can be found in table 3.

Bruising tests

Fifty tubers randomly collected from the control and Multi-KMg treatments in 1999 harvest were sent to the British Potato Council's Sutton Bridge Experimental Unit. The samples were rotated for ten revolutions in a "bruising barrel", and subsequently-stored for one week at 12 degrees centigrade and 95% R.H. After this incubation period, the tubers were inspected for bruising and categorized: Nil = no bruising detected; Slight = no bruising visible after two strokes of a domestic hand peeler; Severe = bruising still visible after two strokes of this peeler.

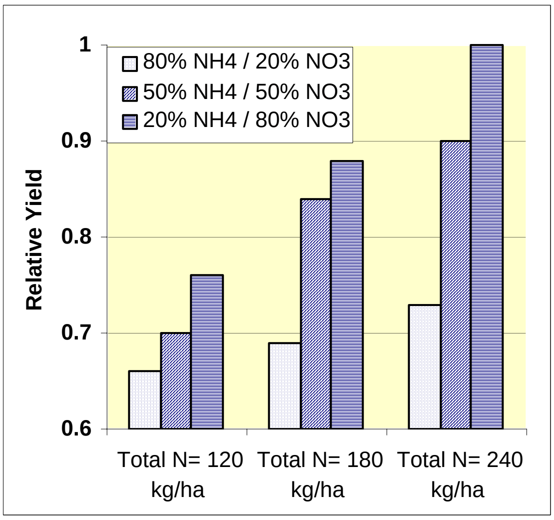
Results

A. Total yield and tuber size distribution.

A-1: The effect of various nitrate / ammonium ratios.

The results of this experiment show a significant positive yield response to the high nitrogen and to the high nitrate / ammonium ratio treatments, as seen in figure 1.

Figure 1: Effect of nitrogen form and rate on tuber yield in South Africa (cv. *UTD*).



A-2: The effect of split application with Multi-KMg.

Tables 4 & 5 depict total yield values of many experiments done in the UK and Israel, respectively. All data show a marked enhancement of overall yields following the use of Multi-KMg by side-dressing (UK) and fertigation (Israel).

Total yields and tuber size distributions harvested in the UK, Israel and Egypt are given in figures 2 - 4., respectively.

Figure 2: Effect of side-dressed Multi-KMg on total yield and tuber size distribution of potatoes (cv. Maris Piper) in UK.

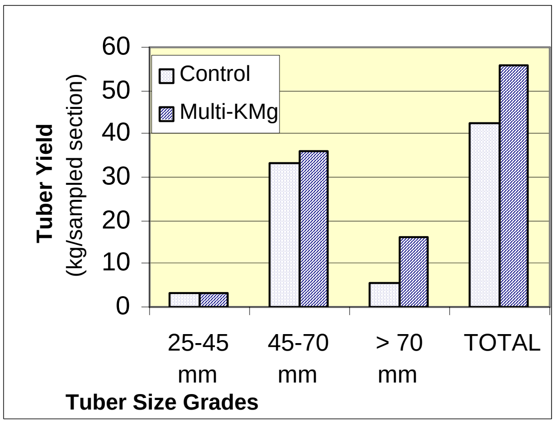


Figure 3: The effect of Multi-KMg on total yield and tuber size distribution of potatoes (cv. *Avandale*) in Israel.

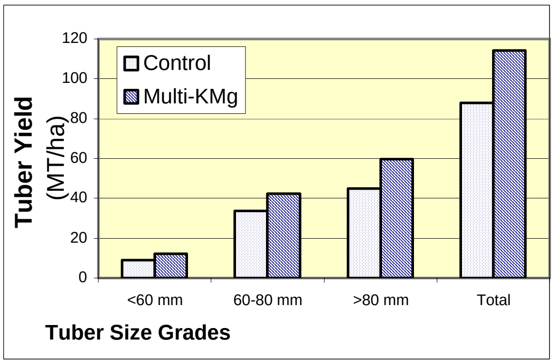
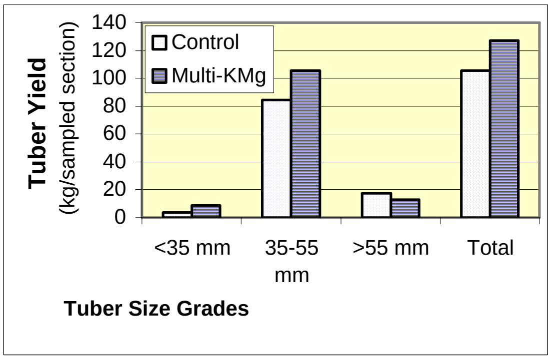
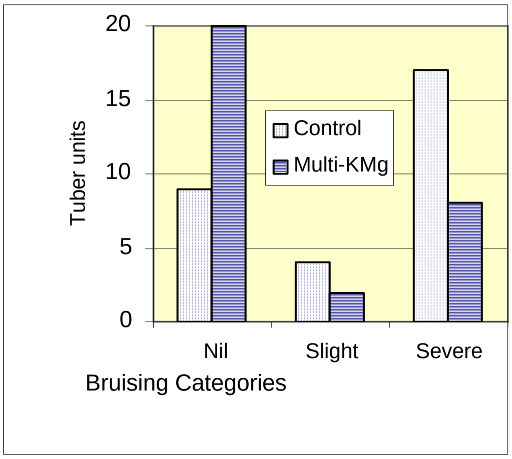


Figure 4: Effect of fertigated Multi-KMg on total yield and tuber size distribution of potatoes (cv. Nieta) in Egypt



The effect of Multi-KMg treatments on the tuber resistance to bruising, skin diseases and on their internal quality in Scotland and Egypt are shown in figure 5 and table 6.

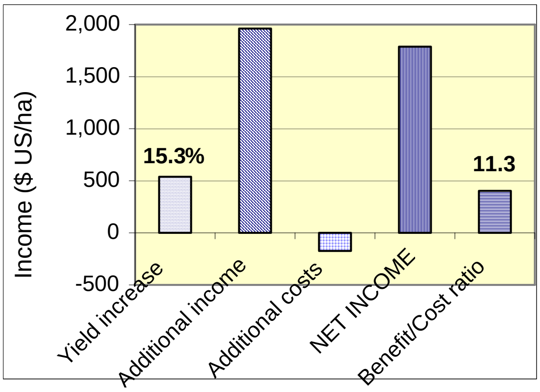
Figure 5: Results of bruising tests done on *Russet Burbank* tubers in UK.



B. Cost effectiveness of the Multi-KMg treatments.
In a cost comparison between the different ratios of ammonium / nitrate (experiment in South Africa), the higher nitrate levels were more cost effective. The 80:20 ratio resulted in an NPK cost of 16.9 \$US x MT^{-1} fresh potatoes as compared to 19.2 \$US x MT^{-1} of the 50:50 treatment at the high total N levels.

The effect of the treatments with Multi-KMg on the profitability of the crop for the UK grower is shown in figure 6.

Figure 6: Effect of Multi-KMg treatment on economical parameters of potato (c.v. *Estima*) production in the UK.



C. Tissue magnesium content.
As shown in table 7, treatment with Multi-KMg has prevented the decrease in magnesium content of the tuber.

Discussion

As shown in many studies with
potatoes (Cao & Tibbitts, and Bester) and many other crops, the nitrate form of nitrogen is advantageous vs. ammonium, and careful control of NH_4 concentration is necessary to minimize possible ammonium toxicity to potato plants. Our results harmonize with this concept too. As shown in figure 1, the higher the relative share of nitrate in the total nutrition scheme, the higher was the tuber yield. This pattern was very consistent, at all N rates tested. The good results can be attributed also to the constant nutrient application by the 12 fertigation cycles.
Potassium has an established reputation as a major controlling effect on tuber production in potatoes (Harrison et Al., Ulrich & Fong, and Perrenoud).
As shown by Bester (1986) potassium nitrate is the best carrier of potassium to the potato crop. We show here a multitude of evidence from many countries, representing some 16 cultivars and numerous growing conditions, that potassium nitrate indeed is a preferred form of both nitrogen and potassium for this crop. Figures 2-4 clearly show that Multi-KMg consistently increases both total yields and the relative share of the large tubers.

Mondy et al have very clearly shown the contribution of Mg minerals to the quality of potato tubers. Nogueira et al have established the advantage of applying bountiful rates of potassium, when the magnesium requirements of the potato plant are satisfied by a long term regime of gypsum. This scheme has brought about a considerable enhancement of tuber quality, in terms of skin integrity. We show in figure 5 and table 6 marked improvements in resistance to bruising and to scab disease (respectively), that were achieved by the combined application of K and Mg in the form of the soluble fertilizer Multi-KMg. Moreover, the results depicted in table 6 show how Multi-KMg considerably enhanced tuber internal and external quality by reducing the incidence of hollow heart and Phytophthora.
Table 7 indicates that the combined split application of K and Mg in the form of Multi-KMg could prevent the usual decrease in Mg content in plant tissues resulting from bountiful application of K fertilizers (Panique et al). The innovation of this study is that an exact combination was formulated to match precisely plant and tuber needs.

An important factor to bare in mind is that the application of Multi-KMg has exerted its highly positive effect when applied by side dressing (in UK and Israel conditions), as well as by fertigation (in Israel, Egypt and South Africa conditions). This fact clearly supports the concept that potassium, nitrogen and magnesium are most beneficial for the potato crop when split-applied during tuber development.

The direct result of all the advantages implied in the application of Multi-KMg is the overall benefit to the grower. As shown in figure 6 the application of Multi-KMg is very cost-effective and results in a remarkable positive benefit / cost ratio.

Conclusions

1. A considerable part (at least 50%) of total amount of K applied to potatoes should be administered starting at the physiological stage of tuber initiation onward. In the case of a rainfed crop, it is advisable to side-dress the field with a long duration K fertilizer, preferably in prilled form. In case of irrigated fields the best option is to fertigate the field with a

chloride-free and fully soluble K fertilizer such as Multi-KMg (potassium nitrate enriched with soluble magnesium salt).

2. Nitrate is the best K carrier, especially where nitrification capacity of the soil is low (sandy soil, low temperature, low bacterial activity, etc.).
3. A combination of K and Mg considerably enhances crop performances regarding total yield, tuber size distribution, external and internal quality of the tubers and resistance to drought and to plant diseases.

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Table 1. Trials conditions in UK, 1999. (Rates expressed as kg x ha^{-1})

	Control	**Multi-KMg**
Pre-plant	100 N; 250 P_2O_5; 250 K_2O; 50 MgO	100 N; 250 P_2O_5; 250 K_2O; 50 MgO
Top dressing Applied at tuber initiation	100 N	30 N + 110 K_2O + 5 MgO as 250 Multi-KMg

N as AN; P as TSP; K as MOP; Mg as $MgSO_4$.

Table 2. Trial conditions in Israel, 1999. (Rates expressed as kg x ha^{-1})

	Control	**Multi-KMg**
Pre-plant	3 m^3 of farmyard manure; 105 P_2O_5	3 m^3 of farmyard manure; 105 P_2O_5
Top dressing Applied at tuber initiation	420 N	420 N + 420 K_2O + 20 MgO as 950 Multi-KMg + 900 AN

N as AN; P as SSP

Table 3. Trial conditions in Egypt, 1999. (Rates expressed as kg x ha^{-1})

	Control*	**Multi-KMg****
Pre-plant	84 P_2O_5 ; 84 K_2O	84 P_2O_5
Top dressing Applied at 1-2 weekly dressings	320 N; 32 SO_3	320 N; 190 K_2O; 4MgO

* Control treatments followed the commercial routine of local potato growers. N as ammonium sulfate (AS) and ammonium nitrate (AN); P and K (MOP) as a granular complex compound.

** N, K & Mg as 430 kg x ha^{-1} of Multi-KMg applied by fertigation via center pivots, at 11 5-daily applications, starting at 30 DAP. The balance of N as AN; P as TSP

Table 4: Effect of Multi-KMg on total yields of various cultivars in UK, 1999.

Cultivar	Usage	Total yield		
		Control (MT x ha^{-1})	**Multi-KMg** (MT x ha^{-1})	**Increase** (%)
Romano	Fresh consumption	47.6	52.5	10.3
Marfona	Baking	52.3	64.1	22.6
Russet Burbank	Processing- fries	60.1	64.6	7.3
Maris Piper	Processing- chips	58.8	67.9	15.5
Valor	Processing- chips	60.1	66.9	11.3
Saturna	Processing- crisps	53.9	63.5	17.8
Cara	Pre-packing	61.1	66.9	9.5

Table 5: Effect of Multi-KMg on total yields of various cultivars in Israel, 1999

Cultivar	Usage	Total yield		
		Control (MTx ha^{-1})	**Multi-KMg** (MTx ha^{-1})	**Increase** (%)
Avandale	Fresh consumption	87.8	114.0	29.8
Nicola	Fresh consumption	35.8	42.6	19.0
Santana	Processing- chips	55.0	58.0	5.5
Shepodi	Processing- chips	27.8	32.1	15.5
Hermes	Processing- crisps	46.8	50.9	8.6
Lady Rosetta	Processing- crisps	31.9	34.8	9.0

Table 6: Effect of Multi-KMg treatments on plant and tuber resistance to diseases and on internal parameter of tuber quality.

Cultivar and trial location	Treatment	Powdery Scab incidence (%)	Hollow heart (%)	Phytophthora (%)
Fambo Scotland	Control	21.50 a*		
	Multi-KMg	6.25 b*		
Russet Burbank Scotland	Control		38 a*	
	Multi-KMg		14 b*	
Nieta Egypt	Control			0.24**
	Multi-KMg			0.11**

*Significant at P< 0.01 level. **Significant at P< 0.05 level.

Table 7: Effect of Multi-KMg on of the magnesium content of potato tubers (c.v. *Asterix*).

Treatment	**K_2O at Base dressing (kg x ha^{-1})** as vinasse kali*	**K_2O at Top dressing (kg x ha^{-1})** as Multi-KMg	**Mg content in the tubers** (g x kg^{-1})
Control	400	0	1.10 a**
Multi-KMg	400	100	1.12 b**

* A K-rich organic compound prepared from extracted sugar beets.
** Significant at P<0.10 level