

Effects of applying magnesium fertilizer on Chinese cabbage's yield, nutrient elements' uptake and soil's fertility*

Dong-Feng Huang, Li-Min Wang, Xiao-Qin Wei and Tao Luo
Institute of Soil and Fertilizer, Fujian Academy of Agricultural Sciences,
Fuzhou, 350013, China
E-mail: huangdf@189.cn

Magnesium deficiency is a common item in red-soil vegetable field in the south of China, and it has few studies about effects of applying magnesium fertilizers on vegetable's growth this region. So, a field trial, with applying different rates of magnesium fertilizers on the basis of farmer routine fertilization, was conducted to test the effects on vegetable's yield, nutrient elements' uptake and soil's basic fertility in a red-soil vegetable field. Results showed that, with the application of magnesium fertilizer (magnesium sulfate, 112.5~450 kg/hm²), Chinese cabbage's yield, and the amount of nitrogen, phosphorus, potassium and magnesium absorbed by vegetable were increased obviously. Moreover, the contents of total magnesium and exchange magnesium in vegetable-field soil after harvest were enhanced greatly.

Keywords: Red Soil; Vegetable Field; Magnesium; Yield; Nutrient Elements; Uptake; Soil Fertility.

1. Introduction

Magnesium is an important component of chlorophyll and a great impact factor for green plant's photosynthesis, thereby green plant's photosynthesis would be held back and crop's yield and quality would be decreased while soil's magnesium is deficient[1-4]. Many studies have pointed out that magnesium deficient is a common item in red-soil vegetable field in South China for its individual climate and soil property [5-7]. In the red soil region of Southern China, vegetable cropping index are increasing continuously for its rich water & heat resources and high economic benefits. For high vegetable output, farmers widely use excess amount chemical fertilizers of nitrogen, phosphorus and potassium, but ignore the application of organic manure and magnesium fertilizers. The content of magnesium in soils is decreasing gradually while

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amount of magnesium has been taken out from vegetable field with vegetable products harvested. Therefore, magnesium deficiency is becoming more and more common in vegetable production in red soil region of Southern China [8].

Presently, there are few studies about effects of applying magnesium fertilizers on vegetable, in especial, that is less in red-soil region vegetable field of Southern China [8-10]. Thus, a field trial was conducted to test effects of applying different doses of magnesium fertilizers on the basis of farmer routine fertilization on yield, uptake of mineral nutrients by vegetable and soil's basic fertility after harvest. Results from this study would provide some scientific basis for the application of magnesium fertilizers in vegetable production in the red soil region of Southern China.

2. Materials and Methods

Trial field was located at Sixi village, Guanqiao town, Nanan city of Fujian province, Southern China. Five treatments were designed, namely:(1) Chemical fertilizers (i.e., farmer conventional fertilization, N 180 kg/hm², P₂O₅ 72 kg/hm² and K₂O 90 kg/hm², the same below);(2) Chemical fertilizers + Magnesium sulfate(112.5 kg/hm²);(3) Chemical fertilizers + Magnesium sulfate (225 kg/hm²); (4) Chemical fertilizers + Magnesium sulfate (337.5 kg/hm²); (5) Chemical fertilizers + Magnesium sulfate (450 kg/hm²). Those five treatments were stood for by Mg₀, Mg₁, Mg₂, Mg₃ and Mg₄, respectively. Each treatment had 3 replicates, and the area of each plot was 20 m², and those plots were arranged randomly. Fertilizers used were as follows: Urea (N46%), Ammonium phosphate (N10%, P₂O₅50%), and Potassium chloride (K₂O 60%), Magnesium sulfate (including magnesium 15%). And all fertilizers of each plot were applied as basal fertilizers, combining with soil preparation.

Chinese cabbage (Qingjiang cabbage, *Brassica campestris* L. ssp.) was selected as tested vegetable breed, seeded on March 30, 2014, and harvested on May 14, 2014. On harvest season, vegetable yield of each plot was measured, and vegetable's edible part was sampled.

Routine analytical methods were used for the determination of nutrient elements in vegetable samples [14]. Trial data were processed by Excel-2007 of Microsoft, and statistically analyzed by using SPSS11.0.

3. Results and Analysis

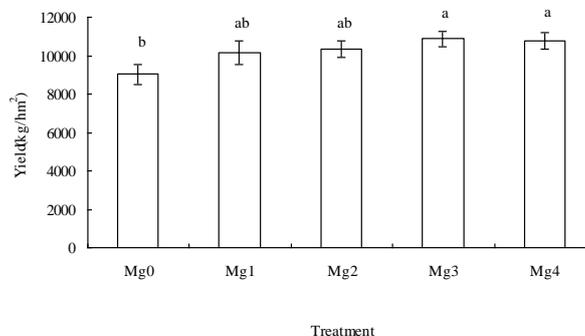
3.1. Effect of applying magnesium fertilizer on yield of vegetable

Results (Figure 1) showed that, compared with the control treatment (Mg₀), applying magnesium fertilizer treatments (Mg₁, Mg₂, Mg₃ and Mg₄) could increase vegetable's yield by 12.4%~20.4%. Among them, vegetable's yield of

the treatment Mg₄ reached at the highest.

Results of variance analysis showed that treatments of Mg₃ and Mg₄ could significantly ($P < 0.05$) increase vegetable's yield compared with Mg₀, and the difference between treatments of Mg₁ and Mg₂ was not significant. And the difference was not significant among Mg₁, Mg₂ and Mg₀.

Results of linear regression analysis between Vegetable yield (y , kg/hm²) and Use rate of magnesium sulfate (x , kg/hm²) showed that the relationship between those two factors could be well fit by quadratic equation with one unknown, $y = -0.53x^2 + 60.61x + 9093$ ($R^2 = 0.961^{**}$). And results could be concluded by above equation that, vegetable's yield would reach at the highest (10825.81 kg/hm²) while applying the amount of Magnesium Sulfate 381.2 kg/hm².



Note: Different capital and small letters indicate the difference is significant at 0.05 and 0.01 levels, respectively (inspect by LSD). The same below.

Fig. 1. Effect of using magnesium fertilizer on the yield of Chinese cabbage.

3.2. Effects of applying magnesium fertilizer on uptake of nitrogen, phosphorus, potassium and magnesium by vegetables

Results (Table 1) showed that, compared with the control treatment (Mg₀), applying magnesium fertilizer treatments (Mg₁, Mg₂, Mg₃ and Mg₄) could significantly improve the uptake of nutrient elements of nitrogen, phosphorus, potassium and magnesium by vegetable, and the improving amplitudes were 27.7%~42.5%, 30.1%~84.9%, 38.0%~80.3% and 53.2%~131.9%, respectively. Among them, vegetable's yield of the treatment Mg₄ reached at the highest. Among them, the effect of Mg₃ treatment on nitrogen uptake of vegetables was the best, and the effect of Mg₄ treatment on P, K and Mg uptake was the best.

Results of variance analysis showed that, compared with Mg₀, all applying magnesium fertilizer treatments (Mg₁, Mg₂, Mg₃ and Mg₄) could extreme-significantly ($P < 0.01$) improve the uptake of nitrogen by vegetable; and

the uptakes of nitrogen for treatments of Mg₂, Mg₃ and Mg₄ were significantly ($P < 0.05$) higher than treatment Mg₁. On the uptake of phosphorus by vegetable, treatments of Mg₃ and Mg₄ were significantly ($P < 0.05$) better than others, and treatments of Mg₁ and Mg₂ were significantly ($P < 0.05$) better than Mg₀. On the uptake of potassium by vegetable, all applying magnesium fertilizer treatments (Mg₁, Mg₂, Mg₃ and Mg₄) were extreme-significantly ($P < 0.01$) better than Mg₀; Treatments of Mg₃ and Mg₄ were extreme-significantly ($P < 0.01$) better than Mg₂; and treatment of Mg₂ was extreme-significantly ($P < 0.01$) better than Mg₁, too. On the uptake of magnesium by vegetable, treatments of Mg₃ and Mg₄ were extreme-significantly ($P < 0.01$) better than others, and treatments of Mg₁ and Mg₂ were extreme-significantly ($P < 0.01$) better than Mg₀, too.

Table 1. Effect of using magnesium fertilizer on the uptake of nitrogen, phosphorus, potassium and magnesium by vegetable.

Treatment	Nitrogen		Phosphorus		Potassium		Magnesium	
	(kg·hm ⁻²)	± (%)						
Mg ₀	18.9Bc	\	1.83c	\	38.0Dd	\	1.82Cd	\
Mg ₁	24.1Ab	27.7	2.39b	30.1	52.3Cc	37.6	2.78Bc	53.2
Mg ₂	25.8Aa	36.5	2.62b	42.7	60.4Bb	59.1	3.38Bb	86.2
Mg ₃	26.9Aa	42.5	3.01a	64.3	74.7 Aa	96.7	4.16Aa	128.9
Mg ₄	25.8Aa	37.0	3.39a	84.9	80.3Aa	111.3	4.21Aa	131.9

3.3. Effects of applying magnesium fertilizer on soil's basic fertility

Results (Table 2) showed that, compared with the control treatment (Mg₀), all applying magnesium fertilizer treatments (Mg₁, Mg₂, Mg₃ and Mg₄) could increase vegetable-field soil's total magnesium and exchangeable magnesium by 15.8%~68.4% and 29.0%~119.0%, respectively. And soil pH and the contents of organic matter, total nitrogen and available potassium were decreased a little; the content of soil's total potassium was increased a little; and the contents of total phosphorus, available nitrogen and phosphorus were increased or decreased a little.

Results of variance analysis showed that: (1) On the effect of increasing soil's total magnesium content, treatment of Mg₄ was significantly ($P < 0.05$) better than Mg₀ and Mg₁; but the difference was not significant among Mg₀, Mg₁, Mg₂ and Mg₃. (2) On the effect of increasing soil's exchangeable magnesium content, treatments of Mg₃ and Mg₄ was significantly ($P < 0.05$) better than Mg₀, Mg₁ and Mg₂; but the difference was not significant between Mg₄ and Mg₃ or among Mg₀, Mg₁ and Mg₂. (3) On effects of other soil's basic fertility indices, such as pH, organic matter, total nitrogen, total phosphorus, available nitrogen, available phosphorus, available potassium, and so on, the difference was not significant among Mg₀, Mg₁, Mg₂, Mg₃ and

Mg₄.

Table 2. Effects of applying magnesium fertilizer on soil basic fertility.

Treatments	pH	Organic matter (g/kg)	Total nitrogen (g/kg)	Total phosphorus (g/kg)	Total potassium (g/kg)
Mg ₀	5.42a	46.6a	2.9a	0.91a	25.9a
Mg ₁	5.41a	44.5a	2.6a	0.92a	26.1a
Mg ₂	5.38a	45.5a	2.8a	0.91a	26.9a
Mg ₃	5.33a	45.4a	2.7a	0.89a	28.2a
Mg ₄	5.25a	44.9a	2.8a	0.89a	27.2a

Treatments	Total magnesium (g/kg)	Available nitrogen (mg/kg)	Available phosphorus (mg/kg)	Available potassium (mg/kg)	Exchangeable magnesium (mg/kg)
Mg ₀	0.19b	16.3a	37.4a	326.5a	25.2b
Mg ₁	0.22b	15.8a	36.5a	319.6a	32.5b
Mg ₂	0.27ab	16.6a	36.8a	318.5a	40.3b
Mg ₃	0.31ab	16.7a	37.1a	315.1a	52.5a
Mg ₄	0.32a	17.1a	37.5a	323.2a	55.2a

4. Conclusion

Results concluded from our field trial showed that, with the application of magnesium fertilizer (magnesium sulfate, 112.5~450 kg/hm²), Chinese cabbage's yield increased by 12.4%~20.4%; The amount of nitrogen, phosphorus, potassium and magnesium absorbed by vegetable increased by 27.7%~42.5%, 30.1%~84.9%, 38.0%~80.3% and 53.2%~131.9%, respectively. Moreover, the contents of total magnesium and exchange magnesium in vegetable-field soil after harvest were enhanced by 15.8%~68.4% and 29.0%~119.0%, respectively. Among them, treatment of Mg₃ (Magnesium Sulfate, 337.5 kg/hm²) had the best effect to improve the uptake of nitrogen absorption by vegetable, and Mg₄ (Magnesium Sulfate, 450 kg/hm²) had the best effect to improve the uptakes of phosphorus, potassium and magnesium by vegetable. Presently, it has few studies about effects of applying magnesium fertilizer on soil basic fertility of vegetable field, which need to be further strengthened in the future.

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