



RESEARCH ARTICLE

## Effect of Graded Levels of Magnesium on Dry Matter Production and Yield of Maize Cultivated in Soils of Maize Growing Tracts in Pudukkottai District of Tamil Nadu

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### ABSTRACT

In order to assess the effect of graded levels of applied magnesium (Mg) (0, 5, 10, 15, 20 and 25 kg ha<sup>-1</sup>) on the soil available major nutrients, field experiments were conducted in 14 farmer's holdings at Pudukkottai district with hybrid maize (NK 6240) as a test crop. Dry matter production (DMP) of the whole plant (above ground) at harvest stage of maize was significantly influenced by the application of 100% NPK + 10 kg Mg ha<sup>-1</sup> and recorded the highest mean as 25620 kg ha<sup>-1</sup> at harvest stage. A noticeable increase in grain and stover yield of maize crop was manifested by applying 100% NPK + 10 kg Mg ha<sup>-1</sup> which recorded the highest mean yield as 11.6 t ha<sup>-1</sup> and 14.0 t ha<sup>-1</sup>, respectively. It reported a 14.31 and 22.25 per cent increase in grain and stover yields, respectively, over control.

Received : 25<sup>th</sup>, May 2021

Revised : 29<sup>th</sup>, May 2021

Revised : 04<sup>th</sup>, June 2021

Accepted : 16<sup>th</sup>, June 2021

**Keywords:** Available magnesium; Graded levels; Critical limit; Maize; Pudukkottai

### INTRODUCTION

Maize is a versatile crop having higher yield potential among cereals and it is cultivated over a wide range of agro climatic zones, hence popularly called as "Queen of Cereals". India is the fifth-largest producer of maize in the world, contributing 3% of global production and cultivated in 9.20 million ha with the production of 23.67 million tonnes and an average yield of 5564 Kg ha<sup>-1</sup>. In Tamil Nadu, it is cultivated in 3.42 lakh ha area with a production of 18.33 lakh tonnes with an average yield of 5359 kg ha<sup>-1</sup> (Anon, 2019). By 2022, the requirement of maize for various sectors is around 100 million tonnes, of which nearly 28 % of maize to be produced is needed for food purpose, 11 %, as livestock feed, 48 % as poultry feed, 12 % for starch in wet milling industry and oil production and one per cent as seed. Maize is the important food grain crop in India and one of the most important cereal crops in the world's agricultural economy, which is gaining popularity among Indian farmers due to its high yielding potential. Magnesium is a component of the chlorophyll molecule and is essential for photosynthesis. It is also a phosphorus carrier in plants. Plants without magnesium would not be able to take up phosphorus. It is essential for phosphate metabolism, plant respiration, and the activation of enzyme systems in plants (Beegle, 2013). The plant, as the Mg<sup>2+</sup> divalent cation takes up magnesium. As magnesium-containing minerals in the soil slowly weather, some magnesium is made available to

plants. The supply of available magnesium can be lost or deleted through leaching, plant uptake, and removal processes. The availability of magnesium to plants is often related to soil pH, with supply decreasing in low and high pH soil.

Magnesium plays an important role in chlorophyll molecules, which is the key plant component responsible for carbon dioxide fixation (Grzebisz *et al.*, 2010). Magnesium is the central core of the chlorophyll molecule in plant tissue. Thus, if magnesium is deficient, the shortage of chlorophyll results in poor and stunted plant growth. Magnesium is also an integral component of large number of enzymes in plants *viz.*, alcohol dehydrogenase, carbonic anhydrase, Cu- magnesium superoxide dismutase, alkaline phosphatase, phospholipases, carboxy peptidases and RNA polymerases. Magnesium serves as a co-factor in most enzymes that activate phosphorylation processes by acting as a bridge between pyrophosphate structures of ATP or ADP, DNA, RNA and the enzyme molecules, essential for amino acid and fat synthesis (Mengel and Kirkby, 2001). Magnesium is absorbed as Mg<sup>2+</sup> and is mobile in plants, moving from the older to the younger leaves. Low cation exchangeable capacity, cation competition and particularly long-term imbalanced fertilization of nitrogen, phosphorus and potassium (NPK) are possible reasons for Mg deficiency in highly weathered, sandy and acidic soils (Gransee and Fuhrs, 2013). Among the cereal crops, maize and wheat are highly susceptible

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to magnesium deficiency. The most distinct magnesium deficiency symptoms are stunted growth and little leaf, which are presumably related to disturbance in the metabolism of auxin and indole acetic acid in particular. The study revealed that the early application of fertilizer could enhance the yield of maize at two weeks after planting. These results are discussed in the light of time of fertilizer application on growth and yield attributes of maize.

Magnesium sulphate fertilizer is designed to easily correct or even ,magnesium deficiencies for all types of crops and soil conditions. It leaches calcium and potassium from the soil. Magnesium is the central atom amid four nitrogen atoms in the chlorophyll molecule, and hence involved in photosynthesis and also as an activator for many enzymes required in plant growth processes and stabilizes the nucleic acids. Plants use magnesium ions to make chlorophyll in their leaves. Like in nitrate deficiency, the plant is limited in terms of its photosynthetic ability and the plant growth is compromised. Magnesium is a limiting factor in healthy plant growth.

Research studies regarding magnesium application has insisted that magnesium supplementation increases magnesium accumulation in the leaf tissue by 34.3 % and concentration of sugar in edible organs by 5.5 % higher as compared to non- magnesium supplemented treatments (Zhengwang *et al.*, 2020). Magnesium deficiency can be overcome with dolomite (a mixed magnesium-calcium carbonate), magnesite (magnesium oxide) or epsom salts (magnesium sulphate).

To know the current status of available magnesium in soil and the impact of graded levels of magnesium fertilizer application on the biomass and yield of grains and stover this study was undertaken Materials and Methods.

The basic survey was undertaken to collect soil samples from major maize growing tracts in Pudukkottai district of TamilNadu. Gandarvakottai, Karambakudi, Pudukkottai, Aranthangi, Kunnandarkoil, Arimalam, Tiruvarankulam and Annavasal blocks were identified as major maize growing block and 256 soil samples were collected randomly. The collected soil were processed and analysed for various parameters such as pH, EC, Mg and Ca The soil were grouped based on Mg status as seven different categories such as ., <25 mg kg<sup>-1</sup>, 25-50 mg kg<sup>-1</sup>, 50-75 mg kg<sup>-1</sup>, 75-100 mg kg<sup>-1</sup>, 100-150 mg kg<sup>-1</sup>, 150-300 mg kg<sup>-1</sup> and >300 mg kg<sup>-1</sup> to conduct the pot and field experiments.

#### **Pot experiment**

Five kilograms of processed soil were weighed and added in the pots which were imitated thrice in

a Completely Randomized Design. Few maize seeds (Hybrid Maize NK 6240 were planted per pot and 10 days after germination, one seedling was kept up in the pot. Suggested levels of NPK (250:75:75 kg ha<sup>-1</sup>) were given consistently in arrangement structure to every one of the pots. Nitrogen was applied in three parts such as., 25 % as basal, 50% on 25 days after sowing and 25 % at 45 days after sowing, full dose of phosphorus and potassium were applied as basal. Graded levels of Mg such as., 0,5, 10, 15, 20 and 25 kg ha<sup>-1</sup> were applied as Mg SO<sub>4</sub>. The crop was raised up to the tasselling stage and the plant tests (over the ground biomass) were drawn and Mg concentration was analysed. The soil samples were also collected at the tasselling stage and analyzed for different parameters.

#### **Soil characteristics**

Representative soil samples collected from the experimental fields were processed and analyzed for various physico-chemical properties. The pH of the initial soil ranged from 6.4 to 8.1 which was acidic to marginally basic. The EC of the soil indicated that they were liberated from saltiness. The soil from various locations showed different textural classes' such as., sandy loam to sandy clay loam. The bulk density and the particle density of the soil ranged from 1.41 to 1.76 Mg m<sup>-3</sup> and 2.40 to 2.66 Mg m<sup>-3</sup>, respectively. The organic carbon content ranged between 0.45 to 0.86 per cent, which is of low to medium status. The soil available Mg status fell under low, medium and high categories respectively.

#### **RESULTS AND DISCUSSION**

Application of 100% NPK + 10 kg Mg ha<sup>-1</sup> recorded the highest mean grain yield of 9075 kg ha<sup>-1</sup> which was on par with 100% NPK + 15 kg Mg ha<sup>-1</sup> with 9000 kg ha<sup>-1</sup>. The lowest mean grain yield of 8002 kg ha<sup>-1</sup> in all the locations was recorded in control. Among all the locations, L<sub>7</sub> (75 to 100 mg kg<sup>-1</sup>) recorded the highest mean grain yield of 10897 kg ha<sup>-1</sup> followed by L<sub>6</sub> (50 to 75 mg kg<sup>-1</sup>) (10587 kg ha<sup>-1</sup>). The locations L<sub>7</sub> (75 to 100 mg kg<sup>-1</sup>) (11604 kg ha<sup>-1</sup>) and L<sub>6</sub> (50 to 75 mg kg<sup>-1</sup>) (11556 kg ha<sup>-1</sup>) recorded the highest grain yield with the application of 100% NPK + 10.0 kg Mg ha<sup>-1</sup>. Application of 100% NPK + 15 kg Mg ha<sup>-1</sup>, recorded the highest grain yield of 11427 kg ha<sup>-1</sup> and 10999 kg ha<sup>-1</sup> were observed in locations L<sub>7</sub> and L<sub>6</sub>. The soil with low to medium levels of initial soil Mg content responded positively to the the Mg application and the highest mean grain yield of 10897 kg ha<sup>-1</sup> and 10587 kg ha<sup>-1</sup> was observed in the location L<sub>7</sub> and L<sub>6</sub> respectively, whereas in the locations L<sub>9</sub> to L<sub>14</sub>, where the initial soil Mg content was high level registered a declining trend of grain yield to the application of Mg was registered the lowest mean grain yield of 7204 kg ha<sup>-1</sup> was recorded in location L<sub>11</sub>. In the control plot, the overall values ranged

from 6311 to 9750 kg ha<sup>-1</sup> across the locations. Crop growth and grain yield were positively correlated with intending at nutrients to the soil. The grain and straw yield of maize crops were significantly increased by the application of Mg fertilizer. The increased yield registered in this field study could be attributed to the effect of Mg on plant growth especially enhanced enzymatic activity. The Mg fertilization improved the synthesis and transport of carbohydrate to grains. The application of Mg established better source link relationship, thus influenced the grain yield. Similar findings were also found in the experiments conducted by Ramanjineyulu *et al.*, 2018, El-Dissoky *et al.* (2017) and Jan Bocianowski *et al.* (2015).

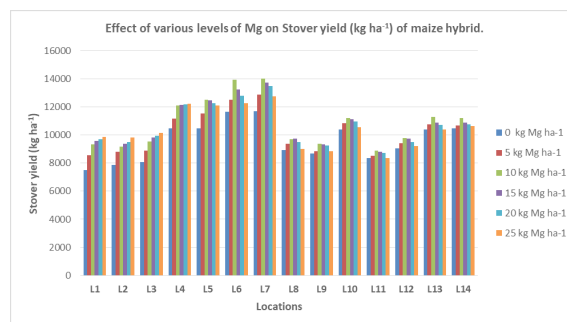


**Figure 1. Effect of various levels of Mg on grain yield (kg ha<sup>-1</sup>) of maize crop.**

The stover yield recorded a positive response with the supplementation of Mg at different levels. The stover yield obtained in various locations showed a positive response to the application of different levels of Mg. Among the different levels of Mg application, application of 100% NPK + 10.0 kg Mg ha<sup>-1</sup> recorded the highest mean stover yield of 10855 kg ha<sup>-1</sup> which was on par with 100% NPK + 15.0 kg Mg ha<sup>-1</sup> (10769 kg ha<sup>-1</sup>) and 100% NPK + 20.0 kg Mg ha<sup>-1</sup> (10652 kg ha<sup>-1</sup>) with the highest per cent stover yield of 13.47 and 12.56 per cent over control. The locations L<sub>1</sub> to L<sub>7</sub> with initial soil Mg content was low to medium status showed a positive response to the application of Mg, whereas the locations L<sub>8</sub> to L<sub>14</sub> (having high soil Mg content was high) showed a decreasing trend in stover yield. Among the different locations, highest mean stover yield of 13090 kg ha<sup>-1</sup> was noted at L<sub>7</sub> (75 to 100 mg kg<sup>-1</sup>) and in location L<sub>11</sub> (150 to 300 mg kg<sup>-1</sup>) the lowest mean stover yield of 8599 kg ha<sup>-1</sup> was recorded. In all the locations, the control plot registered the lowest stover yield, which varied from 7482 to 11705 kg ha<sup>-1</sup>. The stover yield of all the field trials in this study generated positive response with the supplementation of Mg at different levels. The highest mean stover yield of maize crop was recorded in 100% NPK + 10kg Mg ha<sup>-1</sup>. Among the locations, L<sub>1</sub> to L<sub>7</sub> (where the initial soil available Mg content was low to medium) showed positive response whereas as the locations L<sub>8</sub> to L<sub>14</sub> (where the

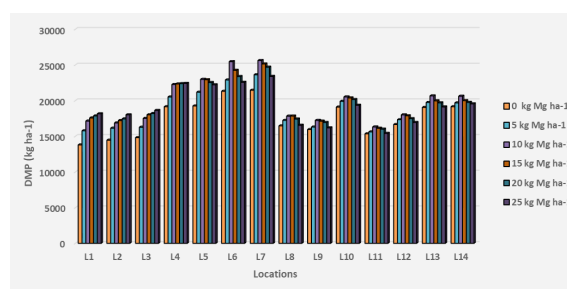
soil available Mg content was high) showed declining trend in stover yield.

It is noticed that the soil with medium levels of initial soil available Mg content in L<sub>7</sub> recorded the highest mean stover yield among the 14 locations and the lowest was observed in the field location L<sub>11</sub> with high levels of initial soil available Mg. The similar finding was recorded by Ei Dissoky *et al.* (2017), Asangi *et al.* (2018), Ramanjineyulu *et al.* (2018) reported that the addition of Mg up to 20 kg ha<sup>-1</sup> enhanced the mean grain and straw yield.



**Figure 2. Effect of various levels of Mg on stover yield (kg ha<sup>-1</sup>) of maize hybrid.**

Application of Mg recorded a significant impact on dry matter production (DMP) of maize crop in a positive way. In locations L<sub>1</sub> to L<sub>4</sub> (soil with low degree of initial soil Mg status), the mean DMP was increasing with the application of Mg fertilizers (the soil with medium to high levels of initial soil Mg content), the mean DMP was inconsistent. The mean biomass yield increased from 17567 kg ha<sup>-1</sup> to 19930 kg ha<sup>-1</sup> and the maximum biomass yield of 19930 kg ha<sup>-1</sup> was noticed with the application of 100 per cent NPK+ 10 kg Mg ha<sup>-1</sup> followed by Mg @ 15 kg ha<sup>-1</sup> with a yield of 19769 kg ha<sup>-1</sup>. Minimum biomass yield of 17567 kg ha<sup>-1</sup> was recorded in the control treatment (100 % RDF).



**Figure 3. Effect of different levels of Mg on the DMP of maize at harvest**

The mean biomass yield ranged from 15804 to 23987 kg ha<sup>-1</sup> in different locations. Application of Mg @ 10 kg ha<sup>-1</sup> significantly increased the biomass yield (25620 kg ha<sup>-1</sup>) in L<sub>7</sub> (75 to 100 mg kg<sup>-1</sup>) followed by L<sub>6</sub> (50 to 75 mg kg<sup>-1</sup>) (25463 kg ha<sup>-1</sup>) and the least DMP was recorded in L<sub>1</sub> (<25 mg kg<sup>-1</sup>) with

17136 kg ha<sup>-1</sup>. The data on dry matter production of the whole plant at harvest was positively correlated with the application of Mg. This might be due to the significant increase in the accumulation of photosynthetic pigments and the total chlorophyll contents increasing the photosynthetic efficiency of maize plants. Chen *et al.* (2017), reported similar findings earlier. Significant difference in biomass yield was recorded over control by the application at different levels of Mg. The minimum biomass yield was recorded in the control. The variation in DMP in different field locations may be due to the availability and application of Mg. The significant increase in DMP in this study might be due to the stimulation and improvement of catalytic, co-catalytic and structural functions of Mg-containing enzymes and also the nutrient uptake. Asangi *et al.* (2018) reported that a similar result in maize was observed due to the application of the distillery spent wash RO reject to soil. The result of this study regarding DMP is in consonance with the findings of Canizella *et al.* (2017).

## CONCLUSION

Dry matter production (DMP) of the whole plant (above ground) at the harvest stage of maize was significantly influenced by the application of 100% NPK + 10 kg Mg ha<sup>-1</sup> and recorded the highest mean as 25620 kg ha<sup>-1</sup> at the harvest stage. A noticeable increase in grain and stover yield of the maize crop was manifested by the application of 100% NPK + 10 kg Mg ha<sup>-1</sup> which recorded the highest mean yield as 11.6 t ha<sup>-1</sup> and 14.0 t ha<sup>-1</sup>, respectively. Therefore, it is concluded that the addition of magnesium fertilizers at the optimal level of 10 kg Mg ha<sup>-1</sup> and the recommended levels of NPK fertilization (100 percent) recorded higher grain yield and enhanced biomass.

## COMPETING INTERESTS

There were no conflict of interest in the publication of this content

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