Effect of graded levels of magnesium on the yield of hybrid maize in soils of Pudukkottai District, Tamil Nadu, India

Sankaralingam P and Malarvizhi P

DOI: https://doi.org/10.22271/chemi.2020.v8.i2e.8790

Abstract
Field experiments were conducted in the farmer’s holdings with hybrid maize as a test crop during Kharif and Rabi season of 2016-2017 to evaluate the response of maize to soil application of graded levels of magnesium in Pudukkottai district of Tamil Nadu. The experiment was conducted with six treatments replicated five times in a randomized block design. The texture of experimental soil was sandy loam to sandy clay loam. The soil available NPK status fell under low-medium, low to high and low to high categories respectively. The available Mg status was also low to high. The results of the present study revealed that the application of 10 kg Mg ha⁻¹ along with the RDF was found to record the highest grain and stover yield, uptake of Mg and also the available Mg in soil.

Keywords: Maize, magnesium, response, yield, soil application

Introduction
Maize (Zea mays L.) is the most significant food grain crop next just to rice and wheat in World and India. It is one of the most important cereal crops on the world’s agrarian economy, both as a food and feed crop. Maize is gaining up prevalence among the Indian farmers. It is known as the "Queen of Cereals" because of its high yielding potential. In India, it is grown in an area of 8.55 Million hectares with a production of 21.73 Million tonnes and an average productivity of 2540 kg ha⁻¹. In Tamil Nadu, it is cultivated in an area of 3.15 lakh hectares with a production of 9.50 lakh tonnes and productivity of 4554 kg ha⁻¹. High yield of maize crops require large quantities of soil nutrients for its growth and development. Most of the farmers apply only fertilizers that supply major nutrients of N, P and K and less attention is paid to secondary and micro nutrients which led to rapid depletion of secondary and micro nutrients necessity periodic or yearly supply of these nutrients. Although the requirement of secondary and micronutrients is small compared to macronutrients, nevertheless their deficiency can limit the crop growth and production. This shows the immense gap between the potential yield and targeted yield, which warns us to concentrate on achieving the targeted yield and to boost up the productivity level. The optimization of mineral nutrition is the important tool to improve the production of maize. The stumpy productivity of maize is mainly attributed to improper mineral nutrition, unscientific irrigation, adopting the local varieties and improper crop management awareness among farmers. Most of the maize growing farmers in the semi-arid regions of India are not aware of the proper nutrient application and uses only one or two nutrients which lead to the imbalance and inadequate use of nutrients which is the main reason for yield reduction and nutritional disorder in maize.

From the nutrition point of view, among the cereal crops, Maize and Wheat are highly susceptible to Mg deficiency. Magnesium is absorbed as the Mg²⁺ ion and is mobile in plants, moving from the older to the younger leaves. Magnesium is an integral component of large number of enzymes viz., alcohol dehydrogenase, carbonic anhydrase, Cu-Mg superoxide dismutase, alkaline phosphatase, phospholipases, carboxy peptidases and RNA polymerases. In the enzymes, Mg has three main functions as catalytic, co-catalytic and structural functions. Magnesium plays an important role in DNA and RNA metabolism, cell division and protein synthesis.
The most distinct Mg deficiency symptoms are stunted growth and little leaf which are presumably related to disturbance in the metabolism of auxin and indoleacetic acid in particular. It is also required for maintaining the integrity of biomembranes in the plants (Hafeez et al., 2013) [9]. Thus, it is peak time to concentrate on mineral nutrition aspect of maize in order to attain high yield and promote the suitable dosage for optimizing the maize yield.

**Materials and Methods**

Field experiments were conducted in the farmer’s holdings with maize as a test crop during Kharif and Rabi season of 2016-2017 with an aim to evaluate the response of hybrid maize (NK 6240) to soil application of graded levels of magnesium in the soils of Pudukkottai district with six treatments replicated five times in a randomized block design. The details of soil initial properties are given in the (Table 1).

The treatments imposed in the present study were T1- 100% RDF (250:75:75 kg/ha) control, T2-100% RDF+5 kg Mg/ha, T3- 100% RDF+10 kg Mg/ha, T4- 100% RDF+15 kg Mg/ha, T5- 100% RDF+20 kg Mg/ha, T6- 100% RDF+25 kg Mg/ha. From the experimental plots, 10 plants were selected randomly, tagged and growth and yield were observed. The yield data were recorded at physiological maturity stage and after the harvest of the crop. The yield obtained in the study were subjected to statistical scrutiny by analysis of variance (ANOVA) as outlined by Panse and Sukhatme (1967) [9].

**Results and Discussion**

The soils of the experimental field were neutral in reaction and non saline. The texture of the soils revealed that soils were coarse textured to moderately fine textured.

**Grain yield**

The application of Mg influenced the grain yield significantly and the data pertaining to that were presented in the Table 2. The application of 100% NPK +10 kg Zn ha⁻¹ recorded the highest pooled mean grain yield of 9.15 t ha⁻¹ followed by application of 100% NPK + 15 kg Mg ha⁻¹ (T3). There observed 14.31 per cent and 13.10 per cent increase in yield respectively over control. Control recorded the lowest mean grain yield of 8.00 t ha⁻¹ in all the locations. Among the locations, L7 recorded the highest mean grain yield of 10.89 t ha⁻¹ followed by L4 (10.63 t ha⁻¹), L11 (9.06 t ha⁻¹), L14 (14.96 t ha⁻¹) and L13 (9.0 t ha⁻¹). The locations L1 and L6 recorded the highest grain yield of 11.60 and 11.55 t ha⁻¹ respectively by the application of 100% NPK +10.0 kg Mg ha⁻¹ (T3). The soils with low to medium level of initial soil Mg content responded positively to the Mg application and the highest mean grain yield of 10.89 t ha⁻¹ and 10.63 t ha⁻¹ was observed in the location L7 and L4 respectively, whereas the locations L9 to L13, where the initial soil Mg content was high level registered a declining trend of grain yield to the application of Mg and the lowest mean grain yield of 7.20 t ha⁻¹ was recorded in the location L11. The lowest mean grain yield was found in the control plots which ranged from 6.31 to 9.75 t ha⁻¹ in different locations. The increased yield registered in this field study could be attributed due to the effect of Mg on plant growth especially enhanced enzymatic activity. The Mg fertilization improved the synthesis and transport of carbohydrates to grains. The application Mg established better source link relationship, thus influenced the grain yield. The similar findings were also found in the experiments conducted by Ramanjineyulu et al., (2018) [10], Chiezy (2014) [6], Altarugio et al., (2017) [11] Bocenawo sky et al., (2015) [12], Szulc et al., (2008) [13], Noor et al., (2015), Abunewa et al., (2017) [5], El-Dissooky et al., (2017) [11] and Jan Bocianski et al., (2015) [13].

**Table 2:** Effect of Mg on grain yield per hectare of Maize crop

| Mg Level (kg ha⁻¹) | L1 | L2 | L3 | L4 | L5 | L6 | L7 | L8 | L9 | L10 | L11 | L12 | L13 | L14 | Pooled Mean | Percent increase over control |
|-------------------|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-------------|-------------------------------|
| 0                 | 6311| 6601| 6744| 8678| 8789| 9682| 9750| 7527| 7269| 8963| 7016| 7607| 6860| 6878| 8012       | -                              |
| 5                 | 7196| 7346| 7397| 9356| 9645| 10383| 10750| 7878| 7452| 9064| 7120| 7911| 8706| 8989| 8534       | 6.26                          |
| 10                | 8119| 8904| 8272| 10153| 10477| 11556| 11604| 8121| 7873| 9331| 7416| 8227| 9394| 9413| 9146       | 14.31                         |
| 15                | 8218| 8149| 8939| 10192| 10456| 10999| 11247| 8111| 7787| 9275| 7337| 8131| 9109| 9119| 9050       | 13.10                         |
| 20                | 8245| 8162| 8473| 10185| 10285| 10601| 11219| 7949| 7710| 9183| 7292| 7971| 8994| 9019| 8949       | 11.84                         |
| 25                | 8285| 8190| 8488| 10210| 10110| 10600| 10630| 7554| 7366| 8816| 7047| 7713| 8720| 8898| 8759       | 9.46                          |
| Mean              | 7729| 7557| 7981| 9796| 9960| 10637| 10097| 7856| 7576| 9063| 7204| 7926| 8979| 9019| 8949       | -                              |
| SED               | 20.74| 71.30| 62.17| 43.44| 80.13| 39.64| 99.71| 166.56| 104.23| 61.77| 53.23| 53.28| 53.66| 54.62| -          | -                             |
| CD (P=0.05)       | 43.27| 148.7| 129.6| 90.61| 167.1| 82.0| 205.9| 347.4| 217.4| 128.8| 111.0| 111.1| 111.9| 113.9| -          | -                             |
Stover yield

The stover yield presented in the Table 3 showed a positive response to the application of Mg doses. Among the different doses of Mg application, the application of 100% NPK + 10.0 kg Mg ha⁻¹ (T₅) recorded the highest mean stover yield of 14.61 t ha⁻¹ followed by T₄ (14.46), T₃ (14.29), T₆ (13.98), T₂ (13.65) and T₁ (11.95). The treatment T₃ recorded the highest per cent stover yield increase of 22.25 over control followed by treatment T₄ which was 20.96 and was on par with each other. The locations L₁ to L₅ (where the initial soil Mg content was low to medium) showed a positive response to the application of Mg whereas the locations L₆ to L₁₄ (where the soil Mg content was high) showed a decreasing trend of stover yield. Among different locations, the L₇ had the highest mean stover yield of 17.29 t ha⁻¹ and the location L₁₁ recorded the lowest mean stover yield of 11.39 t ha⁻¹. In all the locations the control plots registered the lowest stover yield which ranged from 10.09 to 14.63 t ha⁻¹. The application of 100% NPK + 10 kg Mg ha⁻¹ (T₅) resulted in the highest stover yield in the locations L₁ to L₈ (low to medium level of initial soil Mg content) in the order of L₈ (18.56), L₇ (18.47), L₅ (16.73) and L₄ (16.25). In the locations the application of 100% NPK + 10.0 kg Mg ha⁻¹ (T₅) registered the highest stover yield of 15.06, 15.01, 14.93, 13.16, 12.59, and 11.86 t ha⁻¹ in L₁₄, L₁₃, L₁₀, L₁₂, L₉ and L₁₁ respectively. The application of 100% NPK + 10.0 kg Mg ha⁻¹ (T₃) recorded the highest stover yield of 18.55 and 18.48 t ha⁻¹ in the locations L₇ and L₆ respectively. The application of 100% NPK + 10.0 kg Mg ha⁻¹ (T₃) registered a 22.25 per cent increase of straw yield over control. It is noticed that the L₇ recorded the highest mean stover yield among the 14 locations and the lowest was observed in the field location L₁₁. The similar finding was recorded by Ei Dissoky et al., (2017) [7], Asangi et al., (2018) [4], Ramanjineyulu et al. (2018) [10], Rao and Rajput (2011) [11].

Table 3: Effect of Mg on Stover yield per hectare of Maize crop

| Mg Level (kg ha⁻¹) | L₁ | L₂ | L₃ | L₄ | L₅ | L₆ | L₇ | L₈ | L₉ | L₁₀ | L₁₁ | L₁₂ | L₁₃ | L₁₄ | Pooled Mean | Percent Over control |
|-------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-------------|--------------------|
| 0                 | 10099| 10278| 10082| 12167| 13511| 14627| 14787| 11793| 10751| 12749| 10482| 10930| 12936| 12167| 11953     |
| 5                 | 11511| 11753| 11841| 14962| 15423| 16613| 17191| 12591| 11918| 14530| 11315| 12661| 14358| 14384| 13646     |
| 10                | 12984| 12838| 13233| 16248| 16732| 18477| 18556| 12888| 12593| 14933| 11861| 13163| 15018| 15060| 14613     |
| 15                | 13140| 13039| 13436| 16294| 16451| 17590| 18280| 12972| 12457| 14841| 11747| 13016| 14571| 14588| 14459     |
| 20                | 13198| 13063| 13553| 16297| 16173| 16960| 17949| 12719| 12338| 14694| 11663| 12751| 14393| 14436| 14299     |
| 25                | 13262| 13108| 13587| 16331| 16358| 16952| 16995| 12804| 11780| 14102| 11278| 12334| 13954| 14230| 13983     |
| Mean              | 12364| 12346| 12622| 15383| 15675| 16870| 17292| 12508| 11973| 14380| 11391| 12476| 14205| 14144     |
| SED               | 40.75| 20.10| 10.80| 70.87| 32.70| 65.37| 59.49| 266.11| 67.47| 104.83| 85.66| 85.55| 84.55| 79.73    |
| CD(P=0.05)        | 85.01| 250.52| 225.50| 447.84| 376.82| 136.36| 322.70| 555.11| 349.35| 210.68| 78.69| 80.54| 76.37| 166.32   |

Conclusions

The results of the present study revealed that the soils with low to medium level of available Mg responded positively to the Mg application. Application of 100% NPK + 10.0 kg Mg ha⁻¹ may be the viable practice in the low Mg status soils to achieve the highest grain and stover yield of hybrid maize and also for maintaining the fertility of soil.

Acknowledgements

We sincerely acknowledge the input and support provided by field staffs during trial management, sampling and analysis. We are very thankful to farmers from Pudukkottai district for providing experimental field and TN Au hosting analytical laboratory.

Disclosure statement

No potential conflict of interest was reported by the author.

References

1. Abd El Sayed M, Mansour S. Effect of irrigation rates and potassium fertilization on growth and chemical composition of Moghat (Glossostemon bruguieri, Desf) grown in sandy soil. Journal of Productivity and Development. 2018; 23(2):261-286.
2. Abunyewa AA, Ferguson RB, Wortmann CS, Mason SC. Grain sorghum nitrogen use as affected by planting practice and nitrogen rate. Journal of soil science and plant nutrition, 2017; 17(1):155-166.
3. Altarugio LM, Loman MH, Nirschl MG, Silvano RG, Zavaschi E, Carneiro LMS et al. Yield performance of soybean and corn subjected to magnesium foliar spray. Pesquisa Agropecuária Brasileira. 2017; 52(12):1185-1191. https://doi.org/10.1590/s0100-02442017001200007
4. Asangi AM, Srinivasamurthy CA. Nutrient status of Soil as influenced by application of distillery spentwash Rot. IJCS, 2018; 6(1):2003-2007.
5. Bocianowski J, Szulc P, Nowosad K. Parallel coordinate plots of maize traits under different magnesium applications. Journal of Integrative Agriculture, 2015; 14(3):593-597.
6. Chiezy UF. Field Performance of Quality Protein Maize with Zinc and Magnesium Fertilizers in the Sub-Humid Savanna of Nigeria. Journal of Agricultural Science. 2014; 6(3):84.
7. El-Dissoky RA, Al-Kamar FA, Derar RM. Impact of magnesium fertilization on yield and nutrients uptake by maize grown on two different soils. Egyptian Journal of Soil Science. 2017; 57(4):455-466.
8. Hafeez BYM, Khanif AW, Samsuri O, Radziah W, Zakaria, Saleem M. Direct and Residual Effects of Zinc on Zinc-Efficient and Zinc-Inefficient Rice Genotypes Grown under Low-Zinc-Content Submerged Acidic Conditions, Communications in Soil Science and Plant Analysis. 2013; 44(15):2233-2252. DOI: 10.1080/00103624.2013.803558.
9. Pans VE, Sukhatme PV. Statistical Methods for Agricultural Workers. 2nd Edition, Indian Council of Agricultural Research, New Delhi, 1967.
10. Ramanjineyulu AV, Madhavi A, Neelima TL, Naresh P, Indudhar Reddy K, Srinivas A. Effect of row spacing and sowing time on seed yield, quality parameters and nutrient uptake of guar [Cymopsis tetragonoloba (L.)..
11. Rao BR, Rajput DK. Response of palmarosa \{Cymbopogon martini\ (Roxb.) Wats. var. motia Burk.\} to foliar application of magnesium and micronutrients. Industrial crops and products. 2011; 33(2):277-281.

12. Szulc P, Kiel DP, Delmas PD. Calcifications in the abdominal aorta predict fractures in men: MINOS study. Journal of Bone and Mineral Research. 2008; 23(1):95-102.