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

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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 Mg^{2+} 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) [8]. 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).

Table 1: Field experiment locations based upon available Mg status

SL. No	Mg Status	Name of the Farmer	Name of the village	Name of the Block
L_1	<25 ppm	Mr. Ramamoorthy	Pallathividuthi	Tiruvarankulam
L_2		Mr. chinnaiah	Vembankudi	Tiruvarankulam
L_3	25-50 ppm	Mr. Veeraiah	Vamban	Tiruvarankulam
L_4		Mr. Meganathan	Melakottai	Tiruvarankulam
L_5	50-75 ppm	Mr. Tamilarasan	Pallathividuthi	Tiruvarankulam
L_6		Mr. Velysamy	Thatchinapuram	Tiruvarankulam
L_7	75-100 ppm	Mr. Pilavendran	Mikelpatty	Tiruvarankulam
L_8		Mr. Arumugam	Visalur	Annavasal
L_9	100-150 ppm	Mr. Rengaraj	Adhanakottai	Pudukottai
L_{10}		Mr. Raghupathi	Melur	Annavasal
L_{11}	150-300 ppm	Mrs. Lakshmi	Thudaiyur	Annavasal
L_{12}		Mr. Elamurugu	Thudaiyur	Annavasal
L_{13}	>300 ppm	Mr. Kumar	Kudumianmalai	Annavasal
L_{14}		Annafarm	Kudumianmalai	Annavasal

The treatments imposed in the present study were T_1- 100% RDF (250:75:75 kg/ha) control, T_2-100% RDF+5 kg Mg/ha, T_3- 100% RDF+10 kg Mg/ha, T_4- 100% RDF+15 kg Mg/ha, T_5- 100% RDF+20 kg Mg/ha, T_6- 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} (T_4). 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, L_7 recorded the highest mean grain yield of 10.89 t ha^{-1} followed by L_6 (10.63 t ha^{-1}), L_{10} (9.06 t ha^{-1}), L_{14} (14.96 t ha^{-1}) and L_{13} (9.0 t ha^{-1}). The locations L_7 and L_6 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} (T_3). 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 L_7 and L_6 respectively, whereas the locations L_9 to L_{14}, 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 L_{11}. 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], Chiezey (2014) [6] Altarugio *et al.*, (2017) [3] Boceannow sky *et al.*, (2015) [5], Szulc *et al.*, (2008) [12], Noor *et al.*, (2015), Abunyewa *et al.*, (2017) [2], El-Dissoky *et al.*, (2017) [7] and Jan Bocianowski *et al.*, (2015) [5].

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

	Grain Yield (kg ha^{-1})															
Mg Level (kg ha^{-1})	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}	L_{13}	L_{14}	Pooled Mean	Percent increase over control
0	6311	6601	6744	8678	8789	9682	9750	7527	7269	8693	7016	7607	8680	8678	8002	-
5	7196	7346	7397	9356	9645	10383	10750	7878	7452	9084	7120	7911	8976	8989	8534	6.66
10	8119	8094	8272	10153	10477	11556	11604	8121	7873	9331	7416	8227	9394	9413	9146	14.31
15	8218	8149	8393	10192	10456	10999	11427	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	7757	7961	9796	9960	10637	10897	7856	7576	9063	7204	7926	8979	9019		
SED	20.74	71.30	62.17	43.44	80.13	39.34	98.71	166.56	104.23	61.77	53.21	53.28	53.68	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		
Impact	S	S	S	S	S	S	S	S	S	S	S	S	S	S		

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 of100% NPK + 10.0 kg Mg ha^{-1} (T_3) recorded the highest mean stover yield of 14.61 t ha^{-1}followed by T_4 (14.46), T_5 (14.29), T_6 (13.98), T_2 (13.65) and T_1(11.95). The treatment T_3 recorded the highest per cent stover yield increase of 22.25 over control followed by treatment T_4 which was 20.96 and was on par with each other. The locations L_1 to L_8 (where the initial soil Mg content was low to medium) showed a positive response to the application of applied Mg whereas the locations $L_9$to L_{14} (where the soil Mg content was high) showed a decreasing trend of stover yield. Among different locations, the L_7 had the highest mean stover yield of 17.29 t ha^{-1}and the location L_{11} 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 from10.09 to 14.63 t ha^{-1}.The application of 100% NPK + 10 kg Mg ha^{-1} (T_3) resulted in the highest stover yield in the locations L_1 to L8 (low to medium level of initial soil Mg content) in the order of L_7(18.56), L_6 (18.47), L_5(16.73 1) and L_4 (16.25). In the locations the application of 100% NPK + 10.0 kg Mg ha^{-1} (T_3) registered the highest stover yield of 15.06, 15.01, 14.93, 13.16, 12.59, and 11.86 t ha^{-1}in L_{14}, L_{13}, L_{10}, L_{12}, L_9 and L_{11} respectively. The application of 100% NPK + 10.0 kg Mg ha^{-1} (T_3) recorded the highest stover yield of 18.55 and 18.48 t ha^{-1} in the locations L_7 and L_6 respectively. The application of 100% NPK + 10.0 kg Mg ha^{-1} (T_3) 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

	Stover Yield (kg ha $^{-1}$)															
Mg Level (kg ha^{-1})	**L_1**	**L_2**	**L_3**	**L_4**	**L_5**	**L_6**	**L_7**	**L_8**	**L_9**	**L_{10}**	**L_{11}**	**L_{12}**	**L_{13}**	**L_{14}**	**Pooled Mean**	**Percent Over control**
0	10090	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	14.16
10	12984	12838	13233	16248	16732	18477	18556	12888	12593	14933	11861	13163	15018	15060	14613	22.25
15	13140	13039	13436	16294	16451	17590	18280	12972	12457	14841	11747	13016	14571	14588	14459	20.96
20	13198	13063	13553	16297	16173	16960	17949	12719	12338	14694	11663	12751	14393	14436	14299	19.62
25	13262	13108	13587	16331	15758	16952	16995	12084	11780	14102	11278	12334	13954	14230	13983	16.98
Mean	12364	12346	12622	15383	15675	16870	17293	12508	11973	14308	11391	12476	14205	14144		
SED	40.75	120.10	108.10	70.87	132.70	65.37	159.49	266.11	167.47	104.83	85.66	86.55	84.55	79.73		
CD(P=0.05)	85.01	250.52	225.50	147.84	276.82	136.36	332.70	555.11	349.35	218.68	178.69	180.53	176.37	166.32		
Impact	S	S	S	S	S	S	S	S	S	S	S	S	S	S		

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.

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Disclosure statement

No potential conflict of interest was reported by the author.

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