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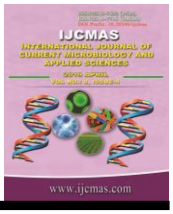

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Effect of Potassium and Magnesium on Productivity of Maize (*Zea mays* L.) under Dryland Conditions

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ABSTRACT

A field experiment was conducted at All India Coordinated Research Project on Dryland Agriculture, Dryland Farming Research Station, Bhilwara, (MPUAT, Udaipur) Rajasthan, for continuous four years on fix site during *Kharif* season of 2014, 2015, 2016 and 2017. The experiment comprised of 4 potassium levels; K_0 (0 kg K_2O ha^{-1}), K_{20} (20kg K_2O ha^{-1}), K_{40} (40 kg K_2O ha^{-1}) and K_{60} (60 kg K_2O ha^{-1}) and 4 magnesium levels; Mg_0 (0 kg $MgSO_4.7H_2O$ha^{-1}), Mg_1 (15 kg $MgSO_4.7H_2O$ ha^{-1}), Mg_2 (30 kg $MgSO_4.7H_2O$ ha^{-1}) and Mg_3 (45 kg $MgSO_4.7H_2O$ ha^{-1}). Total 16 treatment combinations were tested in factorial randomized block design with three replications. Maize variety 'PM-3' was taken as a test crop. The application of K_{60} (60 kg K_2O /ha) resulted in production of maximum grain and stover yields during 2014, 2016 and 2017 with a mean grain yield (2690 kg ha^{-1}) and mean stover yield (6592 kg ha^{-1}), respectively. The mean grain yield 2590 kg ha^{-1} was recorded under the treatment receiving 40 kg K_2O ha^{-1}. Magnesium application also significantly increased grain and stover yields. Application of Mg_{45} (45 kg $MgSO_4$ /ha) produced maximum mean grain (2831 kg ha^{-1}) and stover yield (7000 kg ha^{-1}). Maize yields recorded under Mg_{45} were at par with that recorded under the application of Mg_{30}. The B:C ratio 2.01 was obtained under K_{60} and 2.24 under Mg_{45}.

Keywords

Dryland, potassium, magnesium, maize

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Introduction

Maize (*Zea mays*) the American Indian word for corn means literally "that which sustains life". Maize is emerging as an important world cereal crop after wheat and rice, which is considered as "Queen of Cereals". It serves as basic raw materials for production of starch, oil, alcoholic beverages. It is a good source of carbohydrates, fat, protein and some important vitamins and minerals, but deficient in essential amino acids *viz.*, lysine and tryptophan that reduces its biological value (Jaliya *et al.*, 2008).

Among the modern cultivation practices, sowing method and fertilizer application are imperative for boosting the growth and production of maize, specially under dry land conditions. Considerable work has been reported on these aspects but efforts are still required to improve these techniques for getting maximum yield. Planting technique has a great role to play in increasing maize yield. Our farmers generally use the old broadcast method of sowing that has so many disadvantages, that is, uneven distributions of seeds, depth, and seed lying scattered being picked up by birds. Improved planting method may lead to increased production of maize which will result in attaining self-sufficiency in food and feed (Amin *et al.*, 2006).

Potassium is an essential nutrient and is also the most abundant cation in plants. It plays essential roles in enzyme activation, protein synthesis, photosynthesis, osmoregulation, stomata movement, energy transfer, phloem transport, cation-anion balance, and stress resistance. A major limitation for plant growth and crop production under rainfed condition is soil water availability. Plants that are continuously exposed to drought stress can form reactive oxygen species (ROS), which leads to leaf damage and, ultimately, decreases crop yield. During drought stress, root growth and the rates of K^+ diffusion in the soil towards the roots are both restricted, thus limiting K acquisition. The resulting lower K concentrations can further depress the plant resistance to drought stress, as well as K absorption. Maintaining adequate plant K is, therefore, critical for plant drought resistance. A close relationship between K nutritional status and plant drought resistance has been demonstrated (Bashir, 2012). Magnesium (Mg) is a proportionately important macronutrient essential for plant growth and is the eighth major plentiful mineral element on earth (Maguire and Cowan 2002). Occupying the central location in chlorophyll structure, it is integral to modulating many physiological and biochemical processes including the activation of more than 300 plant growth enzymes such as carboxylases, kinases, phosphatases, ATPases and RNA polymerases (Hawkesford *et al.*, 2012). About three-quarters of leaf Mg content appears to be associated with amino acid and protein synthesis, up to one-fifth with chlorophyll pigments, and the remaining fraction is stored in the vacuole (Karley and White, 2009). More importantly, three major macronutrients (carbon, nitrogen and sulphur) translocated by the roots are further assimilated in the presence of Mg (Marschner and Rengel, 2012).

Magnesium is a component of the chlorophyll molecule. Therefore, it is essential for photosynthesis. As might be expected, plants that are deficient in Mg have an overall light green color. Despite the well-known role of Mg for various critical functions, there is surprisingly little research activity on the role of Mg nutrition in crop production and quality. Hence, Mg is often considered a “forgotten element”. However, Mg deficiency is increasingly becoming an important limiting factor in intensive crop production systems, especially in soils fertilized only with N, P, and K. In particular, Mg depletion in soils is a growing concern for high-productivity agriculture.

In addition to many known critical uses of maize (*Zea mays* L.), such as human food (cereal) and animal food (silage and poultry feed), the crop is being used increasingly for the production of biofuel (ethanol) to reduce carbon footprint intensity in the face of climate change (Munir *et al.*, 2015). Current study was conducted with the objective to study the effect of potassium and magnesium on productivity of maize under dryland condition.

Materials and Methods

A field experiment was conducted at All India Coordinated Research Project on Dryland Agriculture, Dryland Farming Research Station, Bhilwara (Maharana Pratap University of Agriculture and Technology, Udaipur), Rajasthan for continuous 4 years on fix site during *Kharif* season of 2014, 2015, 2016 and 2017. The field experiment comprised of 4 potassium levels, K_0 (0 kg K_2Oha^{-1}), K_{20} (20kg K_2O ha^{-1}), K_{40} (40 kg K_2O ha^{-1}) and K_{60} (60 kg K_2O ha^{-1}) and 4 magnesium levels Mg_0 (0 kg $MgSO_4.7H_2Oha^{-1}$), Mg_1 (15 kg $MgSO_4.7H_2O$ ha^{-1}), Mg_2 (30 kg $MgSO_4.7H_2O$ ha^{-1}) and Mg_3 (45 kg $MgSO_4.7H_2O$ ha^{-1}). Total 16 treatment combinations were tested in factorial randomized block design with three replications. Maize variety 'PM-3' was taken as a test crop. The soil of the experimental field was Sandy clay loam in texture and slightly alkaline in reaction with pH 7.90, EC 0.27 dSm^{-1} and low in organic carbon 0.37%. The soil was low in available nitrogen (210 kg ha^{-1}), medium in available phosphorus (38 kg ha^{-1}) medium in available potash (331 kg ha^{-1}) and low in exchangeable magnesium (0.81 meq/100 gm soil). The annual rainfall of the region is 600 mm.

Treatments of potassium and magnesium was applied as per the plan at the time of sowing as basal application through muraite of potash and $MgSO_4.7H_2O$, respectively. Basal common application of 50Kg N/ha (in two splits) and 30Kg P_2O_5 /ha was applied at the time of sowing to all plots including control. Regular biometric observations were recorded at specific time intervals by selecting randomly five plants in each treatment. Crop was grown completely under rainfed condition. Maize crop could not form grain due to severe drought at the time of grain forming stage during *kharif*, 2015, crop was harvested and produce was dried, threshed, cleaned and weighed. The yield data were subjected to statistical analysis.

Results and Discussion

Effect of potassium

The data presented in Table 1 indicate that the application of potassium significantly affected the grain and stover yields during the year of 2014, 2016 and 2017. The application of K_{60} (60 kg K_2O /ha) recorded maximum grain yield 2415, 2697 and 2959 kg/ha and stover yield 7209, 5467 and 7099 kg/ha during the year of 2014, 2016 and 2017, respectively. This yields increase was significantly higher over control and that recorded with the application of K_{20}. Three years mean of grain and stover yields were observed to be as 2690 kg/ha and 6592 kg/ha respectively under the application of $K_{60.}$ However, the grain and stover yields recorded with the application of K_{60} were found to be at par with the treatment receiving 40 kg K_2O /ha. Further, maize grain and stover yields recorded with the application of K_{40} were significantly higher over that recorded under control during all the years of experimentation. Such a yield increase might be due to the prolific root growth, enhanced water and nutrient absorption. Further, the increase in yields of maize under dryland conditions may be ascribed to positive role of K in maintaining water balance in plants by controlling leaf stomata opening and closing. Positive response of potassium application was also observed by Ramachandrappa, 2013. Increase in stover yield of maize may be attributed to increase in plant height, number of leaves and dry matter production.

Table.1 Effect of potassium and magnesium on grain and stover yields of maize (2014, 2016 and 2017)

Treatments	**Grain yield (kg/ha)**				**Stover yield (kg/ha)**			
	2014	**2016**	**2017**	**Mean**	**2014**	**2016**	**2017**	**Mean**
K_0 (Control)	2003	2128	2328	2153	6111	4271	5587	5323
K_{20} (20 kg K_2O /ha)	2256	2410	2660	2442	6801	4814	6382	5999
K_{40} (40 kg K_2O /ha)	2358	2583	2830	2590	7190	5221	6790	6400
K_{60}(60 kg K_2O /ha)	2415	2697	2959	2690	7209	5467	7099	6592
S. Em±	144	193	232		457	411	558	
C. D. at 5%	**294**	**394**	**474**		**934**	**840**	**1140**	
Mg_0 (Control)	1905	2063	2273	2080	5812	4141	5455	5136
Mg_{15} (15 kg $MgSO_4$ /ha)	2135	2340	2569	2348	6485	4718	6164	5789
Mg_{30} (30 kg $MgSO_4$ /ha)	2400	2598	2851	2616	7320	5213	6838	6457
Mg_{45} (45 kg $MgSO_4$ /ha)	2592	2818	3084	2831	7898	5701	7402	7000
C.D. at 5%	**294**	**394**	**474**		**934**	**840**	**1140**	

Table.2 Effect of potassium and magnesium on economics of maize (Mean of 2014, 2016 and 2017).

Treatments	**CC (Rs/ha)**	**GR (Rs/ha)**	**NR (Rs/ha)**	**B:C Ratio**
Levels of K				
K_0 (Control)	16771	43960	27527	1.68
K_{20} (20 kg K_2O /ha)	17217	49514	32550	1.92
K_{40} (40 kg K_2O /ha)	17662	52571	35076	2.00
K_{60}(60 kg K_2O /ha)	18108	54185	36159	2.01
Levels of Mg				
Mg_0 (Control)	16877	42201	25534	1.53
Mg_{15} (15 kg $MgSo_4$ /ha)	17252	47566	30524	1.79
Mg_{30} (30 kg $MgSo_4$ /ha)	17627	53151	35734	2.05
Mg_{45} (45 kg $MgSo_4$ /ha)	18002	57574	39782	2.24

Increase in dry matter production with increased fertilizer application may also be due to the combined role of NPK with their enhanced use efficiency (Wadsworth, 2002).

Application of potassium was found to increase the shoot dry weight of maize due to selective and adequate potassium uptake in the plant tissue (Kaya *et al.*, 2009). The highest net returns from maize (Rs. 36159 ha^{-1}) was obtained in K_{60} (60 kg K_2O /ha) and the B:C ratio under the treatment K_{40} and K_{60} was recorded as 2.00 and 2.01, respectively.

Effect of magnesium

The data presented in Table 1 reveal that the application of magnesium increased the grain and stover yields of maize under dryland condition during the year of 2014, 2016 and 2017. The application of Mg_{45} (45 kg $MgSO_4$ /ha) recorded maximum grain yield 2592, 2818 and 3084 kgha^{-1} and stover yield 7898, 5701 and 7402 kgha^{-1} during the year of 2014, 2016 and 2017, respectively which were significantly higher in comparison to control but at par with that under Mg_{30} (30 kg $MgSO_4$ /ha). Mean maize grain and stover yields recorded with the application of Mg_{30} (30 kg $MgSO_4$ /ha) was found to be 2616 kg/ha and 6457kg/ha, respectively. This enhancement in grain and stover yields by the application of Mg has also been frequently documented (Sabo *et al.,* 2002). Magnesium plays important role in chlorophyll formation in plants which enhances photosynthesis and thereby improves crop yields. Magnesium plays essential roles in ensuring crop productivity (Senbayram *et al.,* 2015). Further better uptake of phosphorus, improvement in photosynthesis, sugar contents and translocation of starch due to the uptake of Mg play a crucial role in a significant increase of dry biomass and plant height (Marschner and Rengel, 2012). The highest net returns from maize (Rs. 39782 ha^{-1}) and B:C ratio (2.24) were obtained under Mg_{45} (45 kg $MgSO_4$ /ha).

Potassium and magnesium are important essential elements for plants. Further, role of these elements are more important under dryland conditions. It can be inferred from the results of four year experimentation that application of 40 Kg K_2O/ha and application of 30Kg $MgSO_4$/ha can improve the productivity of maize under dryland conditions of sub-humid southern plain of arawali hills.

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