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Influence of Iron and Arbuscular Mycorrhiza Inoculation on Growth and Yield of Hybrid Maize in Calcareous Soil

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Field experiment was conducted at the Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore during *Kharif* 2010 to study the influence of iron and arbuscular mycorrhiza (AM) inoculation on growth and yield of hybrid maize in calcareous soil. The experiment was laid out in factorial randomized block design with three replications. The treatments included were inoculation of arbuscular mycorrhiza (M^+) and control (without inoculation of mycorrhiza, M^-) under factor A and T_1 - 25 kg $FeSO_4$ ha^{-1}, T_2 - 50 kg $FeSO_4$ ha^{-1},T_3 - 0.5% $FeSO_4$ foliar spray, T_4 - 25 kg $FeSO_4$ ha^{-1} + 0.5 % $FeSO_4$ foliar spray, T_5 - 50 kg $FeSO_4$ ha^{-1} + 0.5 % $FeSO_4$ foliar spray and T_6 – Control under factor B. The results revealed that among the iron treatments, 50 kg $FeSO_4$ + 0.5% $FeSO_4$ foliar spray showed the highest grain yield and it was comparable with 25 kg $FeSO_4$ + 0.5% $FeSO_4$ foliar spray. Regarding the mycorrhizal treatments, AM inoculated plants recorded the best results. Regarding the interaction, the treatment combination of 25 kg $FeSO_4$ + 0.5% $FeSO_4$ foliar spray along with AM recorded the highest grain yield. All the growth attributes showed the similar trend.

Keywords: Hybrid maize, arbuscular mycorrhiza, calcarerus soil iron, foliar spray, growth, yield.

Maize (*Zea mays* L.) is the third most important cereal next to rice and wheat, in the world and in India. It is also known as “Queen of cereals”. It has got immense potential and hence called a “Miracle crop”. Maize is cultivated both in tropical and temperate regions. It is one of the world’s leading crops cultivated over an area of about 157.1 million hectares with a production of about 770.0 million tonnes and productivity of 4.71 tonnes of grain ha^{-1}. In India, maize was cultivated over an area of 8.26 million hectares with a production of 19.30 million tonnes and the average productivity is 2337 kg ha^{-1} in 2006. In Tamil Nadu, in 2005, maize was cultivated in an area of 0.20 million hectares with a production of 0.24 million tonnes and productivity of 1189 kg ha^{-1} (Crop Report, 2006- 07).

Maize has high yield potential and responds greatly to nutrient application. Apart from major nutrients, despite being needed in small quantities, micronutrients are also essential for the overall performance and health of the maize crop. They include iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo) and boron (B). Among the micronutrients, Fe and Zn are more important to maize.

Iron deficiencies are found mainly on calcareous (high pH) soils which reduces iron uptake by plants causing iron chlorosis. Foliar applications of iron used for corn, sorghum have been more effective on hybrids/varieties relatively tolerant of iron chlorosis.

Mycorrhiza is an association or symbiosis between the roots of most land plants and many soil fungi that colonize the cortical tissue of roots during periods of active plant growth, from which both partners benefit; *arbuscular mycorrhiza* (AM) is the most common and universal mycorrhiza. Arbuscular mycorrhizal fungi are widespread and agronomically important plant symbiont and often stimulate plant uptake of nutrients such as P, Zn, Cu, and Fe in deficient soils (Liu *et al.,* 2000). The micronutrient improvement in mycorrhizal plants is always associated with rhizosphere acidification (Dodd *et al*., 1987), more external mycelium in the soil (Jakobsen *et al*., 1992) and soil biochemical changes.

The AM isolates improve Fe acquisition in maize grown under severe Fe deficiency conditions. Improved host plant, root development, morphology and acquisition of P may have been involved in enhanced Fe acquisition by AM plants. *Glomus mosseae* inoculated corn plants display better growth responses than no mycorrhizal plants at relatively low iron concentration while at high concentrations there was no pronounced effects. High mycorrhizal colonization allows mycorrhizal plants to transport more nutrients beyond the rhizospheric zone. Iron concentrations and contents generally increased in AM plants grown on the alkaline soils. With these ideas in view, the present investigation was carried out to study the influence of iron application and AM inoculation on growth and yield of hybrid maize in calcareous soil.

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Materials and Methods

A field experiment was conducted during *Kharif* 2010 at Tamil Nadu Agricultural University, Coimbatore. The experimental soil was sandy clay loam in texture having a pH of 7.58. The fertility status was low in available N (220.4 Kg ha^{-1}), medium in available P (13.1 Kg ha^{-1}) and high in available K (457.5 Kg ha^{-1}). The available Fe (DTPA- extractable) content was 2.24 ppm. The experiment was laid out in factorial randomized block design with three replications.

The treatments included were AM inoculation viz., inoculation of arbuscular mycorrhiza (M^+) and control (without inoculation of mycorrhiza, M^-) under factor A and iron treatments viz., T_1 - 25 kg $FeSO_4$ ha^{-1}, T_2 - 50 kg $FeSO_4$ ha^{-1},T_3 - 0.5% $FeSO_4$ foliar spray (FS), T_4 - 25 kg $FeSO_4$ ha^{-1} + 0.5 % $FeSO_4$ foliar spray, T_5 - 50 kg $FeSO_4$ ha^{-1} + 0.5 % $FeSO_4$ foliar spray and T_6 – Control under factor B.

Hybrid maize (CO H(M)5) was used as test crop and it was sown by adopting a spacing of 60 x 25 cm. Seeds of maize hybrids under AM inoculation treatments were sown with vermiculite based mycorrhizal inoculum at a depth of 5 cm below the seeds. An uniform fertilizer schedule was followed at the rate of 150: 75: 75 Kg NPK ha^{-1}. Nitrogen was applied in three splits as 25: 50: 25 per cent as basal, at 25 and 45 days after sowing, respectively. The entire dose of phosphorus was applied basally. The potassium was applied in two equal split doses *viz*., basal and at 45 days after sowing. Iron was applied basally and as foliar spray of 0.5% $FeSO_4$. Foliar spray was given twice at 35 and 45 days after sowing. During the course of investigation, plant height leaf area index, dry matter production and yield were recorded. The data collected were statistically scrutinized and results presented.

Results and Discussion

Plant height

Among the iron treatments, the tallest plants were recorded with application of 25 kg $FeSO_4$ + 0.5% $FeSO_4$ foliar spray and was comparable with 50 kg $FeSO_4$ + 0.5% $FeSO_4$ foliar spray (Table 1). This might be due to increased availability and uptake of iron which might have resulted in the increased uptake of N which in turn might have increased the plant height. Amanullah *et al.* (2007) in sorghum and Ramu and Reddy (2007) in maize hybrid reported that addition of iron enhanced the growth parameters. With regard to mycorrhiza, AM inoculation significantly increased plant height. This might be due to the formation of external mycelium around the roots by AMF fungi and that resulted in better uptake of nutrients. Similar result was obtained by Khaliq and Sanders (1997).

Leaf area index

Leaf area index estimated at 60 days showed that application of 25 kg $FeSO_4$ + 0.5% $FeSO_4$ foliar spray recorded the highest leaf area index (7.92) which was comparable with 50 kg $FeSO_4$ + 0.5% $FeSO_4$ foliar spray (Table 1). The increased leaf area index might be due to the production of more number of leaves per plant due to iron application. Amanullah *et al.* (2007) reported an increase in LAI of sorghum due to foliar spray of iron which might have caused fast and speedy entry of iron. AM inoculation significantly increased leaf area index, which might be due to the increase in the number of leaves and the leaf enlargement by virtue of better nutrient uptake. Similar results were reported by Ananthi (2010) in hybrid maize.

Table 1. Effect of iron application and AM inoculation on growth parameters of hybrid maize

Treatment	Plant height (cm)						Leaf area index			Dry matter production (kg ha^{-1})					
	60 DAS			90 DAS			60 DAS			60 DAS			90 DAS		
	M-	M+	Mean	M-	M+	Mean	M-	M+	Mean	M-	M+	Mean	M-	M+	Mean
T_1 - 25 kg $FeSO_4$	210.4	217.5	213.9	218.0	232.2	225.1	4.36	5.06	4.71	7025	7419	7222	12583	13833	13208
T_2 - 50 kg $FeSO_4$	225.8	230.8	228.2	232.9	234.3	233.6	4.98	5.24	5.11	7431	7514	7472	13417	14417	13917
T_3 - 0.5% $FeSO_4$ FS	213.2	229.5	221.4	222.2	238.1	230.1	4.48	5.64	5.06	7167	7597	7382	12833	15111	13972
T_4 - 25 kg $FeSO_4$ + 0.5% $FeSO_4$ FS	221.2	236.7	229.8	226.9	248.0	237.4	4.74	7.92	6.33	7292	8103	7697	13333	16278	14805
T_5 - 50 kg $FeSO_4$ + 0.5% $FeSO_4$ FS	232.2	234.0	233.1	234.1	243.9	238.9	5.31	6.02	5.66	7506	7869	7687	13861	15194	14528
T_6 – Control	206.3	216.1	211.2	209.5	231.5	220.5	3.74	4.88	4.31	6797	7344	7071	11944	13472	12708
Mean	218.2	227.4		223.9	238.5		4.60	5.79		7023	7641		12995	14718	
CD. (P= 0.05)															
	SEd	CD		SEd	CD		SEd	CD		SEd	CD		SEd	CD	
T	5.7	12.0		6.4	13.3		0.1	0.3		195	405		303	629	
M	3.3	6.9		3.7	7.7		0.0	0.1		113	234		175	363	
T X M	8.1	17.0		8.1	15.9		0.2	0.4		276	573		429	889	

NS: Not Significant FS – Foliar Spray

Drymatter production

The highest DMP was obtained under iron treatment 25 kg $FeSO_4$ + 0.5% $FeSO_4$ FS which was comparable with 50 kg $FeSO_4$ + 0.5% $FeSO_4$ FS, 50 kg $FeSO_4$ alone and 0.5% $FeSO_4$ FS alone (Table 1). It might be due to the application of Fe which accentuated the availability in the soil favourably which contributed towards the better uptake and nullifying the deficiency that might have helped in increasing dry matter accumulation. The results are in conformity with the findings of Amanullah *et al.* (2007). Inoculation of mycorrhiza significantly increased dry matter at 60 and 90 days after sowing. The higher uptake of nutrients due to the formation of external mycelium around the roots by AM fungi might be the reason for the higher DMP. Similar results were reported by Ananthi (2010) and Wang *et al.* (2006) in maize.

Grain yield

Application of 50 kg $FeSO_4$ + 0.5% $FeSO_4$ FS recorded the highest grain yield of 5752 kg ha^{-1} followed by 25 kg $FeSO_4$ + 0.5% $FeSO_4$ FS and 50 kg $FeSO_4$ and both were comparable with each other (Table 2). This increase in yield was due to effective utilization of applied nutrients. The positive and significant improvement in LAI and DMP noticed at different stages, increased yield attributes and nutrient uptake. Both soil and foliar application of $FeSO_4$ would have resulted in enhanced grain yield. The results are in conformity with the findings of Amanullah *et al.,* (2007) in sorghum and Ramu and Reddy (2007) in maize. Inoculation of mycorrhiza significantly influenced grain yield (5820 kg ha^{-1}). This yield increase under treatment might be due to mycorrhizal inoculation cause the intense flow of minerals and metabolites from the leaf to the developing kernel. A higher yield of maize due to mycorrhizal inoculation has been reported previously by Solaiman and Harita (1998).

Stover yield

Iron application either through soil or foliar had influenced significantly registering higher stover yield (Table 2). The treatment 25 kg $FeSO_4$ + 0.5% $FeSO_4$ FS recorded the highest yield (8937 kg ha^{-1}) followed by 50 kg $FeSO_4$ + 0.5% $FeSO_4$ FS and 50 kg $FeSO_4$ and both were comparable with each other.

Table 2. Effect of iron application and AM inoculation on yield of hybrid maize

	Grain yield			Stover yield		
	M-	M+	Mean	M-	M+	Mean
T_1 - 25 kg $FeSO_4$	4501	5407	4954	7581	8705	8143
T_2 - 50 kg $FeSO_4$	5208	5764	5486	8346	9206	8776
T_3 - 0.5% $FeSO_4$ FS	4919	5868	5394	7917	9248	8583
T_4 - 25 kg $FeSO_4$ + 0.5% $FeSO_4$ FS	5023	6470	5747	8313	9561	8937
T_5 - 50 kg $FeSO_4$ + 0.5% $FeSO_4$ FS	5451	6053	5752	8547	9088	8817
T_6 – Control	4468	5357	4912	7646	8651	8148
Mean	4928	5820		8058	9076	
CD (P=0.05)						
	SEd	CD		SEd	CD	
T	164	337		161	323	
M	94	196		110	221	
T X M	221	467		232	465	

Application of $FeSO_4$ either soil or foliar would help to recover the crop from chlorosis and yield well especially in calcareous soil. AM inoculation significantly influenced the stover yield. AM inoculated plants recorded significantly higher stover yield (9076 kg ha^{-1}). It is due to increase in growth parameters as evidenced in the present investigation. Similar results of increase in stover yield due to mycorrhizal inoculation were also reported earlier by Lauzon and Miller (1997) and Ananthi (2010) in maize.

The study revealed that, application of 50 kg $FeSO_4$ + 0.5% $FeSO_4$ FS among iron treatments and AM inoculation recorded better growth and yield. Among the treatment combinations, 25 kg $FeSO_4$ + 0.5% $FeSO_4$ FS along with AM inoculation recorded better growth and yield attributes and grain yield and it was comparable with 50 kg $FeSO_4$ + 0.5% $FeSO_4$ FS along with AM inoculation.

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