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Delineation of Leaf Nutrient Status of Maize Crop Grown in Alfisols, Inceptisols and Vertisols in Chittoor District of Andhra Pradesh

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ABSTRACT

A survey was undertaken to delineate the leaf nutrient status of maize crop grown in Alfisols, Inceptisols and Vertisols in Chittoor district of Andhra Pradesh. The analysis of the index leaf samples revealed that the nitrogen, phosphorous, potassium, calcium, magnesium and sulphur contents were in sufficient range. Further, iron, manganese, copper and boron contents in the index leaf samples were also found to be sufficient whereas zinc content was found to be low to sufficient.

Key words : Correlation, Leaf nutrients, Maize grown soils, Soil orders.

Maize (*Zea mays* L.) is one of the important cereal crops next only to wheat and rice in the world. In India, it ranks fourth after rice, wheat and sorghum. In the world, it is grown over an area of 131 (m.ha.) with an annual production of 506 (m t) with a productivity of 3890 kg ha^{-1}. In India, it is cultivated over an area of 6.10 m ha with an annual production of 10 m t and productivity of 1639 kg ha^{-1}. The area is mostly concentrated in Rajasthan, Uttar Pradesh, Madhya Pradesh, Karnataka, Andhra Pradesh, Bihar, Gujarat and also grown in a small area in almost all the states.

Maize crop producing 62.7 quintals grain yield per hectare is estimated to consume 168 kg N, 57 kg P_2O_5, 135 kg K_2O and 30 kg Zn. Hence there is a need to get acquainted with N, P, K and Zn nutrition and their management as they are not replenished in sufficient quantities to produce optimum corn yields.

MATERIAL AND METHODS

The survey area in Chittoor district of Andhra Pradesh is located at the East longitudes of 76° 58' and 79° 34' and North latitudes of 14° 54' and 16° 18' and lies on the eastern side of peninsular India.

Based on the status report of Southern Zone (2001), maize is grown in three predominant soil orders namely Alfisols, Inceptisols and Vertisols. From each of the three orders 30 holdings totaling to 90 holdings were selected. Plant samples were collected at flowering stage (60 DAS) from these 90 holdings, by counting 3^{rd} leaf from top. The procedure which was followed by Munshi *et al.* (1979) was adopted for preparation of leaf samples for analysis. The nitrogen content of foliar tissue was estimated by microkjeldahl distillation method (A.O.A.C., 1970). The phosphorus content of foliar tissue was determined by vanado-molybdo phosphoric yellow colour method and the concentration of potassium was determined by using flame photometer (Jackson, 1973). Ca and Mg contents were determined by versenate method while sulphur content was determined by turbidimetric method (Vogel, 1978). The leaf diacid extract was fed to atomic absorption spectrophotometer and the concentration of Fe, Mn, Zn and Cu were determined (Vogel, 1978). The boron in plant sample was determined colorimetrically by curcumin determinative procedure (Mulford and Martens, 1970).

All the major (N, P and K), secondary (Ca, Mg and S) and micro (Fe, Mn, Zn, Cu and B) nutrients in the leaf samples were rated as low, sufficient and high categories as per the limit suggested by Tandon (2005) (Table 1). The data were subjected to statistical analysis by adopting the simple correlations to find out the extent of relationship between soil characteristics and leaf nutrient status, as per the procedure described by Gomez and Gomez (1984).

Table 1. Low, sufficiency and high limits of nutrients for maize crop.

Element*	Low	Sufficient	High
Nitrogen (%)	<3.5	3.5-5.0	>5.0
Phosphorus (%)	<0.3	0.3-0.50	>0.5
Potassium (%)	<2.5	2.5-4.00	>4.00
Calcium (%)	<0.3	0.3-0.70	>0.70
Magnesium (%)	<0.15	0.15-0.45	>0.45
Sulphur (%)	<0.15	0.15-0.50	>0.50
Iron (mg kg^{-1})	<50	50-250	>250
Manganese (mg kg^{-1})	<20	20-300	>300
Zinc (mg kg^{-1})	<20	20-60	>60
Copper (mg kg^{-1})	<5	5-20	>20
Boron (mg kg^{-1})	<5	5-25	>25

* Concentrations less than the low category denote the deficiency

RESULTS AND DISCUSSION

Major nutrient (N, P and K) concentration in index leaf

The results of the index leaf analysis revealed that mean nitrogen, phosphorus and potassium contents in Alfisols, Inceptisols and Vertisols were 3.95, 0.37 and 3.05, 3.90, 0.34 and 3.24 and 4.06, 0.35 and 2.98 per cent, respectively (Table 2). Among the three soil orders, the index leaf samples collected from Vertisols recorded the highest leaf concentration of N as compared to other orders. This could be due to high level of available nitrogen in Vertisols as compared to other orders. As per the limits of Tandon (2005) all the index leaf samples were within the sufficient range with respect to N, P and K in all the three orders.

Secondary nutrient (Ca, Mg and S) concentration in index leaf

The mean leaf Ca concentration in Alfisols, Inceptisols and Vertisols was 0.75, 0.61 and 0.59 per cent, respectively whereas mean leaf Mg concentration in Alfisols, Inceptisols and Vertisols was 0.29, 0.36 and 0.34 per cent, respectively. Further, mean leaf S concentration in Alfisols, Inceptisols and Vertisols was 0.34, 0.31 and 0.30 per cent, respectively (Table 3). As per the limits of Tandon (2005) all the index leaf samples were within the sufficient range with respect to Ca, Mg and S in all the three orders.

Micro nutrient (Fe, Mn, Zn, Cu and B) concentration in index leaf

The mean Fe concentration in the index leaf of maize grown on Alfisols, Inceptisols and Vertisols were 252, 149 and 216 mg kg^{-1}, respectively. All the index leaf samples were in the sufficiency range of more than 44.2 mg kg^{-1} as proposed by Mehra *et al*., (2005). As per the limits of Tandon (2005) all the maize index leaf samples were within the sufficient range with respect to Fe in all the three orders. This might be due to better nutrient availability in soil and also favourable physical conditions existing in soil. The leaf Fe was high in crop grown on Alfisols followed by Vertisols and Inceptisols. The mean Mn concentration in index leaf of maize grown on Alfisols, Inceptisols and Vertisols were 79, 76 and 100 mg kg^{-1}, respectively. The critical limit for Mn in maize index leaf was given as 15 mg kg^{-1} by Hoeft and Peck (1991) and also as per the limits of Tandon (2005) all the maize index leaf samples were within the sufficient range with respect to Mn in all the three orders. Accordingly, none of the leaf samples were rated as deficient in leaf Mn. Better uptake of Mn might be attributed due to availability of the nutrient in soil in sufficient amounts supported by favorable soil physico-chemical properties.

The Zn concentration in index leaf of maize grown on Alfisols, Inceptisols and Vertisols ranged from 15 to 72, 30 to 49 and 41 to 104 mg kg^{-1},

Table 2. Nitrogen, phosphorus and potassium status in maize leaf at flowering stage grown in different soil orders

Sl. No.	Soil orders	Number of samples	Major nutrients concentration (%)					
			N		P		K	
			Range	Mean	Range	Mean	Range	Mean
1	Alfisols	30	3.52-4.38	3.95	0.31-0.41	0.37	2.78-3.52	3.05
2	Inceptisols	30	3.60-4.24	3.90	0.30-0.37	0.34	2.85-3.64	3.24
3	Vertisols	30	3.68-4.41	4.06	0.30-0.41	0.35	2.72-3.48	2.98

Table 3. Calcium, magnesium and sulphur status in maize leaf at flowering stage grown in different soil orders.

Sl. No.	Soil orders	Number of samples	Secondary nutrients concentration (%)					
			Ca		Mg		S	
			Range	Mean	Range	Mean	Range	Mean
1	Alfisols	30	0.57-0.83	0.75	0.25-0.43	0.29	0.26-038	0.34
2	Inceptisols	30	0.52-0.72	0.61	0.27-0.52	0.36	0.24-0.35	0.31
3	Vertisols	30	0.46-0.68	0.59	0.25-0.38	0.28	0.23-0.34	0.30

Table 4. Iron, Manganese, Zinc, Copper and Boron status in maize leaf at flowering stage in maize grown soil orders

Sl. No.	Soil orders	Number of samples	Micronutrients concentration (%)									
			Fe		Mn		Zn		Cu		B	
			Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	Alfisols	30	132-399	252	25-119	79	15-72	38	53-126	85	16.10-21.21	18.11
2	Inceptisols	30	105-234	149	23-148	76	30-49	41	29-101	59	15.08-21.10	17.33
3	Vertisols	30	145-398	216	53-144	100	41-104	56	31-70	49	16.24-22.12	19.52

Table 5. Correlation coefficients between soil physico-chemical characteristics and leaf nutrients in Alfisols

Physico-chemical characteristics	Leaf Nutrients										
	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B
pH	0.2300	-0.3063	-0.2443	-0.1485	0.0644	0.1730	0.1346	0.0909	-0.2084	-0.0530	0.0500
EC	-0.2601	-0.4693*	0.1060	-0.3552	0.0133	0.3816*	-0.1584	0.0440	-0.2423	0.1513	-0.0489
OC	0.2570	-0.0525	-0.1244	-0.0054	0.0393	-0.0568	0.1784	-0.0755	-0.0928	0.0322	-0.1060
$CaCO_3$	0.1815	0.0472	0.0465	0.0241	-0.0054	0.0075	-0.3157	-0.7750**	-0.0371	0.3932*	-0.1437

* * At 1% level of significance

* At 5% level of significance

Table 6. Correlation coefficients between soil physico-chemical characteristics and leaf nutrients in Inceptisols

Physico-chemical characteristics	Leaf Nutrients										
	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B
pH	0.2359	-0.2781	-0.3156	-0.1318	0.0348	0.2358	0.0432	-0.0429	-0.0145	-0.0232	0.2142
EC	0.1509	-0.0928	0.0062	-0.0526	-0.1154	0.3385	-0.1627	-0.1348	0.0085	0.1420	0.0307
OC	0.3099	0.2746	0.0468	-0.3147	-0.0879	0.1440	-0.0691	-0.2092	-0.2108	0.4662**	-0.1372
$CaCO_3$	-0.1369	-0.2856	-0.2376	-0.1460	0.1150	-0.2181	-0.1748	0.2108	0.1476	-0.0665	0.0925

* * At 1% level of significance
* At 5% level of significance

Table 7. Correlation coefficients between soil physico-chemical characteristics and leaf nutrients in Vertisols

Physico-chemical characteristics	Leaf Nutrients										
	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B
pH	0.0168	-0.1319	0.1722	0.1729	0.1015	0.1918	0.0373	0.3739*	0.3443	0.0782	0.0897
EC	-0.2866	0.0038	0.3314	-0.2892	-0.3999*	0.2884	-0.0458	-0.2106	-0.0277	-0.2318	-0.2846
OC	0.0038	-0.0658	0.4425*	0.1326	-0.1998	0.1241	0.1396	0.2493	0.3817*	-0.0382	0.2320
$CaCO_3$	-0.0282	0.2419	0.1061	0.2289	0.2115	-0.0864	-0.2813	-0.0486	0.0454	0.1012	0.2857

* * At 1% level of significance
* At 5% level of significance

respectively. As per the limits of Tandon (2005) all the maize index leaf samples were in low (< 20 mg kg^{-1}) to sufficient (20 to 60 mg kg^{-1}) range with respect to Zn in all the three orders. All the index leaf samples were in sufficiency level except 23.33 per cent samples in Alfisols were in low range with regard to Zn concentration. This sufficiency might be due to favourable soil physico-chemical conditions and also due to availability of Zn in the soil.

The mean Cu concentration in index leaf of maize grown on Alfisols, Inceptisols and Vertisols was 85, 59 and 49 mg kg^{-1}, respectively. As per the limits of Tandon (2005) all the maize index leaf samples were within the sufficient range (5 to 20 mg kg^{-1}) with respect to Cu in all the three orders. From this an inference can be drawn that none of the index leaf samples were deficient in Cu. The mean B concentration in the maize index leaf samples under present investigation varied from 15.08 to 22.12 mg kg^{-1} in different soil orders (Table 4). As per the limits of Tandon (2005) all the maize index leaf samples were within the sufficient range (5 to 25 mg kg^{-1}) with respect to B in all the three orders.

Correlation coefficients between soil physico-chemical characteristics and foliar nutrients in Alfisols

There was no significant correlation between leaf nutrients and soil pH and Organic carbon. Leaf sulphur was positively and significantly correlated with soil electrical conductivity whereas leaf phosphorous was negatively and significantly correlated with soil electrical conductivity. Further, Leaf copper was positively and significantly correlated with soil calcium carbonate whereas leaf manganese was negatively and significantly correlated with calcium carbonate (Table 5).

Correlation coefficients between soil physico-chemical characteristics and foliar nutrients in Inceptisols

There was no significant correlation between leaf nutrients and soil pH, soil EC and soil calcium carbonate content. Further, leaf copper was positively and significantly correlated with soil organic matter content (Table 6).

Correlation coefficients between soil physico-chemical characteristics and foliar nutrients in Vertisols

Leaf manganese was positively and significantly correlated with soil pH. Leaf magnesium was negatively and significantly correlated with soil electrical conductivity. Leaf potassium and zinc were positively and significantly correlated with soil organic carbon. Calcium carbonate did not show any significant correlation with all the leaf nutrients tested (Table 7).

The analysis of the index leaf revealed that the nitrogen, phosphorous, potassium, calcium, magnesium and sulphur contents were in sufficient range. Further, iron, manganese, copper and boron contents in the index leaf samples were found to be sufficient whereas zinc content was found to be low to sufficient. The leaf Mn concentration was positively and significantly correlated with soil pH. Leaf P and Mg concentrations were negatively and significantly correlated with EC whereas leaf S was positively and significantly correlated with EC. The leaf K, Cu and Zn were positively and significantly correlated with OC. The leaf Cu concentration was positively and significantly correlated with $CaCO_3$ whereas Mn concentration was negatively and significantly correlated with $CaCO_3$.

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