STATE COMMITTEE ON SCIENCE, TECHNOLOGY AND ENVIRONMENT- KERALA

FINAL REPORT

Broad area : Life science

1. File and GO i. MS.No.35/87/sted/dt.8/12/87

ii. MS.No.73/90/sted/dt.15/11/90

iii. MS.No.7/92/sted/dt.29/1/92

2. Experiment No. AF-05-00-05/89 VKA-STEC

3. Title of the project : Nutritional deficiency symptoms and foliar diagnosis in tree crops.

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5. Institution where project was carried out: College of Forestry

6. Duration of the project: Three years.

7. Date of commencement of the work: 24.8.89

8. Date of completion of work: 15/2/93

9.Budget datails (in rupees)

particulars	1 st year		2nd year		3rd year	
	sanctioned after 5% cut)	Expen-diture	Sanct-ioned	Expen-diture	Sanct-ioned	Expen-diture
TA	1900	1900	2000	2000	2000	338
Recurring contingencies	15675	11982	1650Ø	12576	1650Ø	12671
Total	17575	13882	1850Ø	14576	1850Ø	13009

1Ø.f there is any reappropriation, date and No.

of sanction order: Nil

11.Technical programme:

To develop nutrient deficiency symptoms in cashew and mango seedlings, sand cultutre studies were conducted using Hoaglands nutrient solution. To induce symptoms of deficiency of various macro and micro nutrient, separate solutions were prepared in bulk by eliminating the desired nutrient.The following treatments were imposed for the study.

1.Complete Hoaglands nutrient solution (control)

2. -do- without nitrogen

3. -do- without phosphorus

4. -do- without potassium

5. -do- without calcium

6 -do- without magnesium

7. -do- without zinc

Each treament was replicated five times in randomized block design. The plants showing symptoms of deficiency and toxicity were observed. Biometric observations were recorded for each replication and the plants were sampled after a period of six months. They were processed for chemical analysis.

For foliar diagnosis, tissue samples were collected from different parts of the well grown trees with special reference to growth characteritics. Sampling was done at monthly intervals by giving due considerations for age, position and number. Representative soil samples were also collected. The samples were analysed for N,P,K, Ca,Mg and S and the inter relationship between yield and the nutrient contents were worked out.A prediction equation for yield was also fitted using multiple linear regression.

12.Major results

A.Sand culture studies

i) Nutritional deficiency symptoms in cashew

The seedlings grown in complete Hoaglands nutrient solution were vigorous in vegetative growth with dark green leaves through out the period of investigations. The growth of seedlings in terms of height, girth and number of leaves was satisfactory (Table 1 and Figures 1to3). The concentration of all the nutrients were found to be normal in plants supplied with complete solution.

Table 1. Growth parameters of cashew seedlings grown in sand culture

Sl. No.	Treatments	Height (cm)	Girth (cm)	No. of leaves
1	Complete nutrient solution (control)	28.33	1.70	11.17
2	N - deleted	21.14	1.63	7.91
3	P - deleted	19.97	1.68	8.37
4	K - deleted	22.26	1.79	8.14
5	Ca - deleted	22.10	1.69	7.74
6	Mg - deleted	24.45	1.62	8.14
7	S - deleted	13.47	1.70	8.14
8	Zn - deleted	21.36	1.70	9.80
	F test	*	*	*
	CD (5%)	2.19	0.06	0.89

* Significant at 5 per cent level

Table 2. Foliar nutrient content of cashew seedlings grown in sand culture

Sl. No.	Treatments	N	P	K	Ca	Mg	S	Zn (ppm)
		Per cent						
1	Complete Hoagland's nutrient solution (control)	3.24	0.34	3.17	2.42	1.61	0.23	65.60
2	N - deleted	1.49	0.33	2.80	2.17	1.21	0.22	64.00
3	P - deleted	3.35	0.11	3.13	2.22	1.52	0.23	73.60
4	K - deleted	3.24	0.30	1.06	2.68	1.81	0.24	65.00
5	Ca - deleted	3.25	0.33	2.99	0.74	1.79	0.22	72.00
6	Mg - deleted	3.22	0.26	3.23	2.68	0.28	0.23	65.80
7	S - deleted	3.10	0.28	2.88	2.23	1.44	0.03	65.50
8	Zn - deleted	3.25	0.32	3.12	2.27	1.51	0.22	20.00

Fig.1.Effect of treatments on height of seedlings in cashew

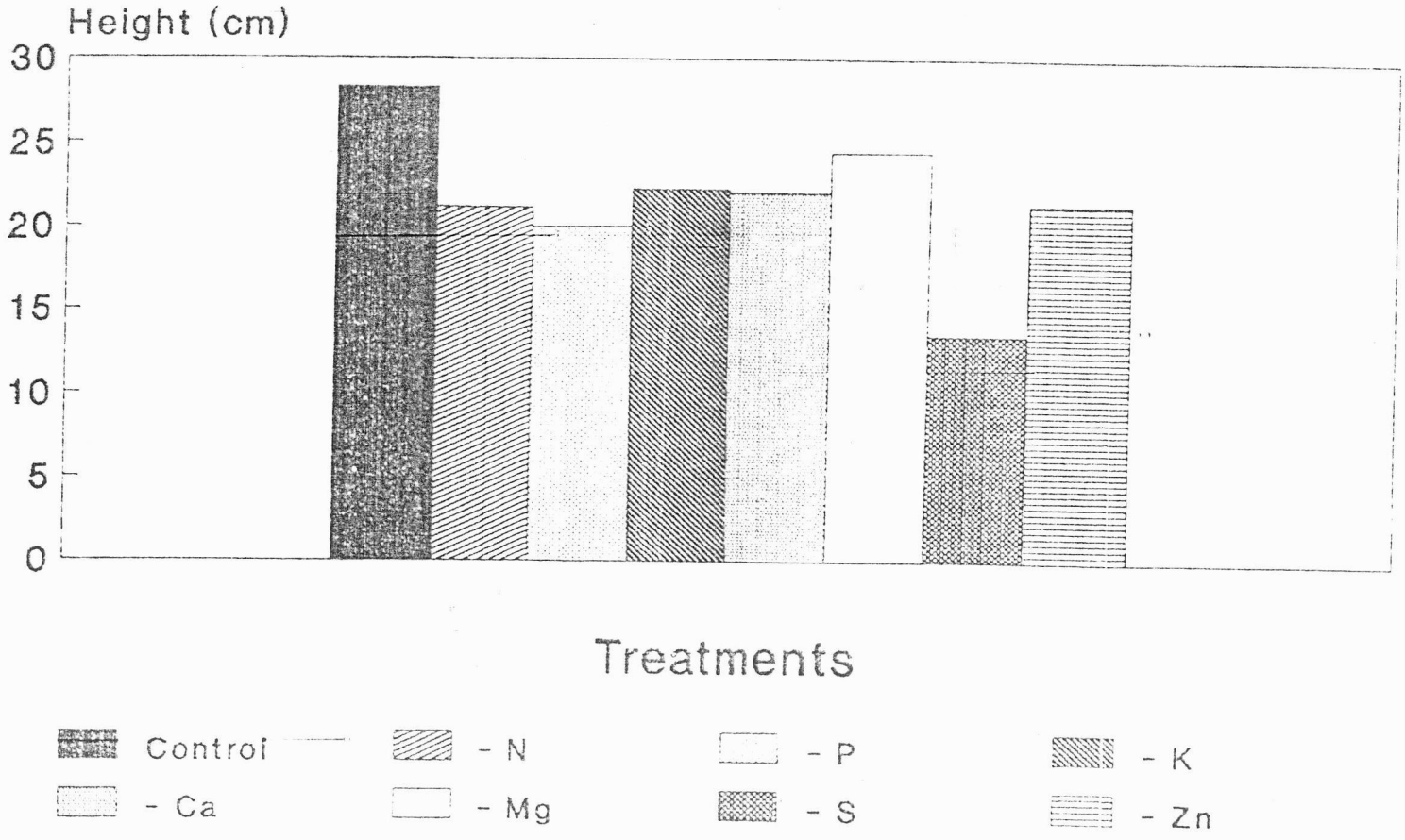


Fig.2.Effect of treatments on girth of seedlings in cashew

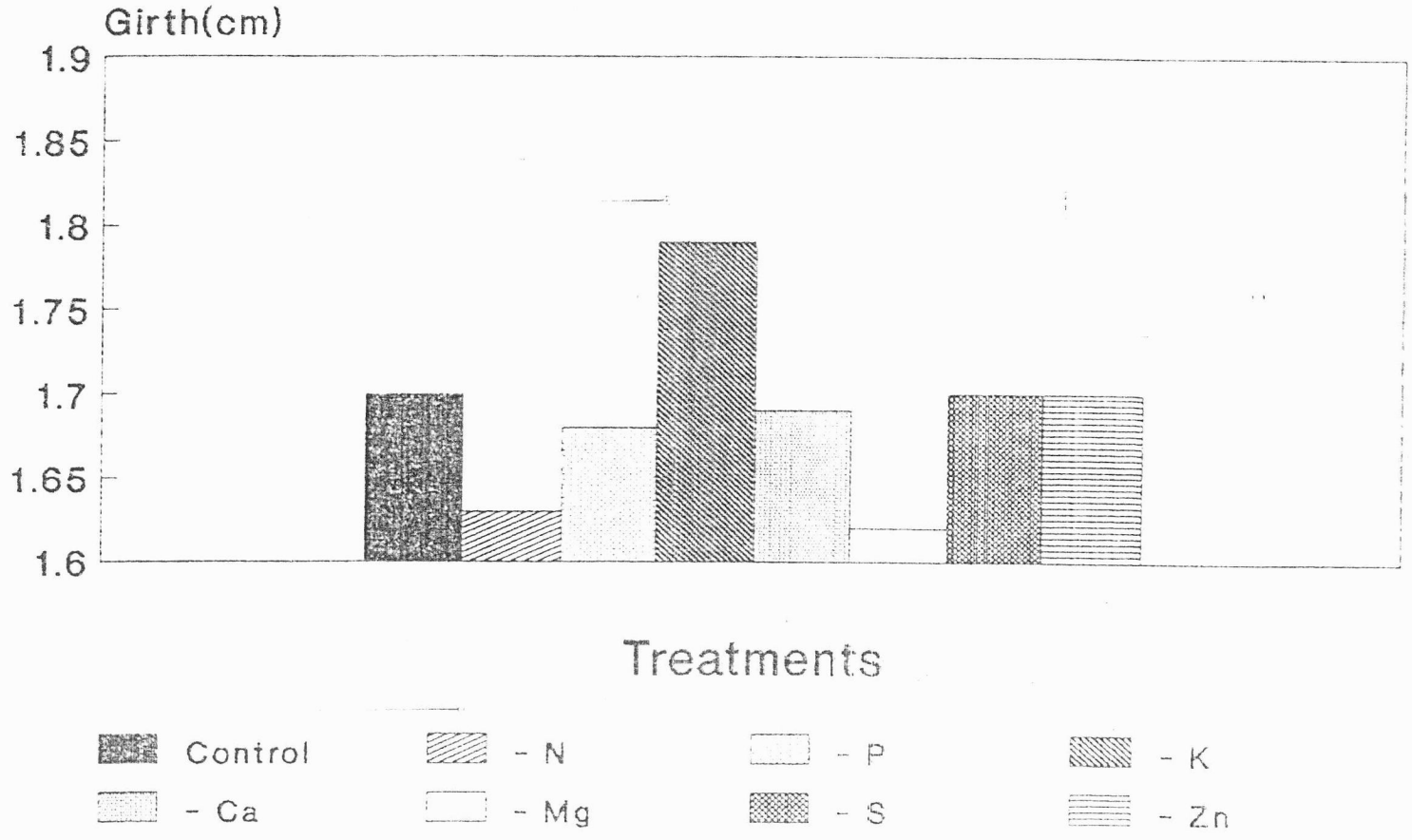
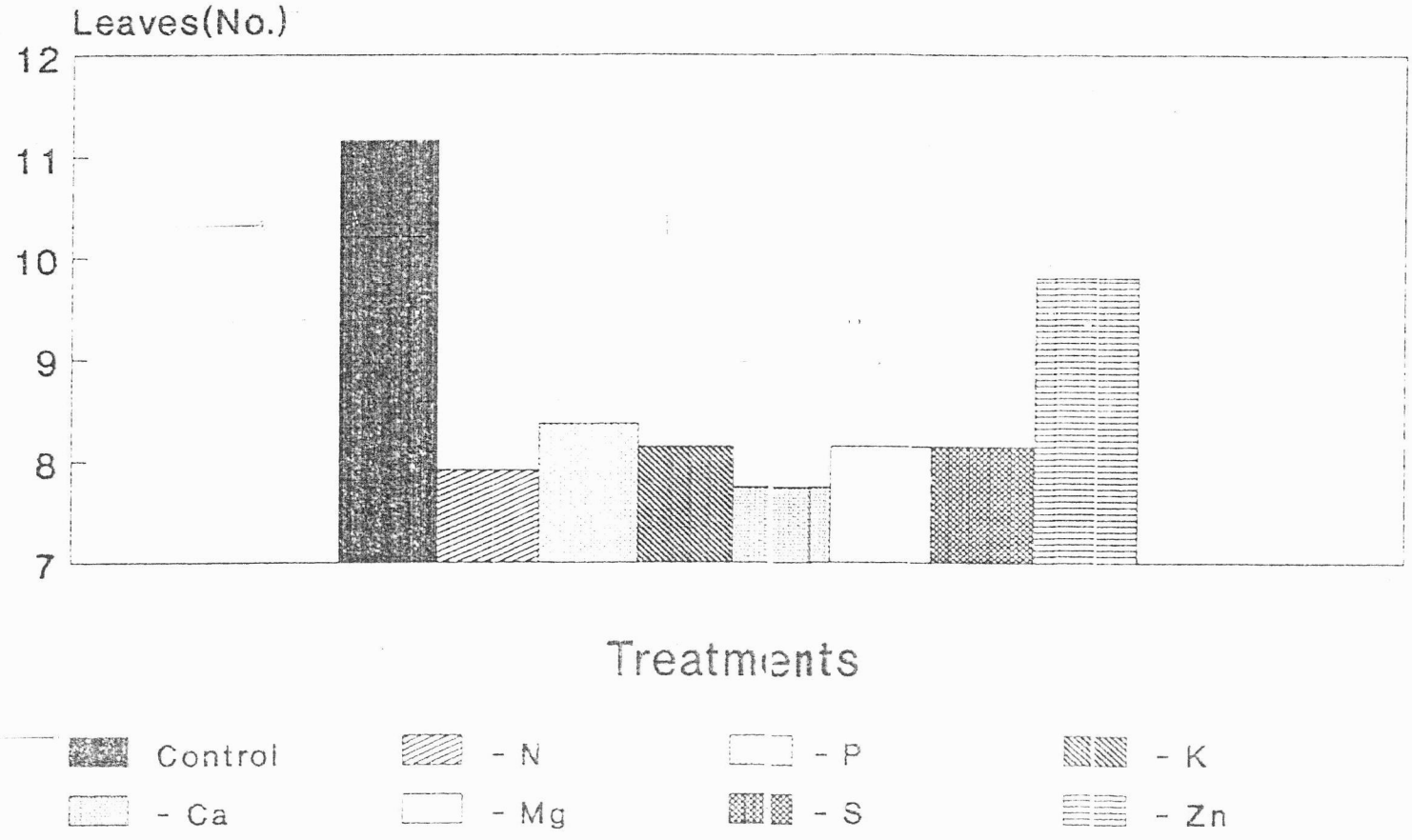


Fig.3.Effect of treatments on leaf production of seedlings in cashew



Nitrogen

Nitrogen deficiency was first manifested as pale green colour of older leaves which later changed to uniform yellow colour. Growth was also stunted considerably (Table 1). The visual symptoms of nitrogen deficincy was found to correlate with leaf content of this element. Here, the N conteant was found to be only 1.49 % compared to control where it was 3.24% (Table 2).

Phosphorus

In the deficiency of phosphorus, the colour of leaves changed very slowly from normal green to dark green. After this stage, there was a gradual transition from dark green to bronze green. Withering of the leaves was also noticed in some cases. phosphorus deficiency was associated with a decrease in foliar content of P(Ø.11%) compared to control (Ø.34%) and is also evident from the study that deletion of P from the nutrient solution did not influence the contents of other elements considerably.

Potassium

Visual symptoms of potassium deficiency was first manifested after 3 -4 months. The lowest leaves turned yellow.The symptom was also characterised by necrosis of older leaf tip. The necrosis spread to other portion of the leaves also. Absence of K adversely affected all the growth parameters except the girth of seedlings. The height and number of leaves produced by

seedlings were 22.26 cm and 8.14 respectively. Visual symptoms of K deficiency were concurred with the significant reduction in foliar content of this element. Interestingly in thsese plants, a slight increase in calcium and magnesium content was noticed due to the antagonism of K with Ca and Mg.

Calcium

No visual symptoms were observed for calcium deficiency. However, the deficiency of Ca resulted in reduction of growth. Results also indicated that in this case, there was an appreciable reduction in foliar content of Ca and an increase in Mg content conmpared to control. Antagonistic effect of Ca and Mg is clearly evident from the table.

Magnesium

In the case of magnesium, the deficiency becomes visible 2-3 months after planting. There was severe interveinal chlorosis and yellowing of lower leaves. Symptoms spread rapidly from lower leaves towards top of plants. The concentration of Mg in the leaves was found to be only Ø.28%, while in control it was 1.61%. A slight accumulation of Ca in these plants is again an evidence for the antagonistic effect of Ca and Mg.

Sulphur

The early symptoms of sulphur deficiency appeared as pale green to greenish yellow discolouration of younger leaves which later turned to uniform yellow. Small necrotic spots appeared on

the affected leaves followed by the development of necrotic arears. Shedding of affected leaves was also noticed. The early symptoms were similar to that of N deficiency except that here the younger leaves were more chlorotic than the older ones. Here the growth was stunted considerably. However, the girth of the seedlings was the same as that of seedlings grown in complete nutrient solutions. Due to S deficiency, there was a reduction in the content of S (Ø.Ø3%).

Zinc

Interveinal chlorosis was observed for zinc deficiency. The new leaves produced were small in size. The young flush also showed chlorotic symptoms. Terminal growth was retarded and the internodal lenght was reduced. In this treatment, the concentration of Zn in leaf tissues were found to be 2Ø ppm while in healthy seedlings the Zn content was found to be 65.6Ø ppm.

ii) Nutritional deficiency symptoms in mango

After a lapse of six months, some treatments started showing differential behaviour in respect of growth of seedlings.Seedlings grown with complete nutrient solution were tall, healthy and vigorous with deep green foliage(Table3 and Figures 4 to6). The content of all nutrients was found to be at satisfactory levels in the leaf tissues of these seedlings (Table 4).

Nitogen

Lack of nitrogen was visible as leaf discolouration. The

Table 3. Growth parameters of mango seedlings grown in sand culture

Sl. No.	Treatments	Height (cm)	Girth (cm)	No. of leaves
1	Complete nutrient solution (control)	26.48	1.89	16.05
2	N - deleted	16.55	1.54	13.55
3	P - deleted	19.68	1.56	11.60
4	K - deleted	20.48	1.35	14.43
5	Ca - deleted	19.78	1.78	15.48
6	Mg - deleted	20.45	1.86	13.88
7	S - deleted	18.83	1.59	12.93
8	Zn - deleted	22.38	1.81	13.50
	F test	*	*	*
	CD (5%)	1.31	0.09	0.78

* Significant at 5 per cent level

Table 4. Foliar nutrient content of mango seedlings grown in sand culture

Sl. No.	Treatments	N	P	K	Ca	Mg	S	Zn (ppm)
		Per cent						
1	Complete Hoagland's nutrient solution (control)	3.20	0.30	3.18	2.49	1.71	0.20	63.00
2	N - deleted	1.19	0.32	3.19	2.50	1.81	0.21	54.00
3	P - deleted	3.11	0.09	3.18	2.11	1.09	0.21	50.00
4	K - deleted	2.11	0.29	0.91	2.31	1.11	0.28	79.00
5	Ca - deleted	3.10	0.31	3.18	0.61	1.89	0.29	81.00
6	Mg - deleted	2.18	0.31	3.12	2.16	0.12	0.26	79.00
7	S - deleted	3.10	0.29	2.91	2.30	1.17	0.09	69.00
8	Zn - deleted	2.19	0.27	3.10	2.19	1.19	0.29	21.00

Fig.4.Effect of treatments on height of seedlings in mango

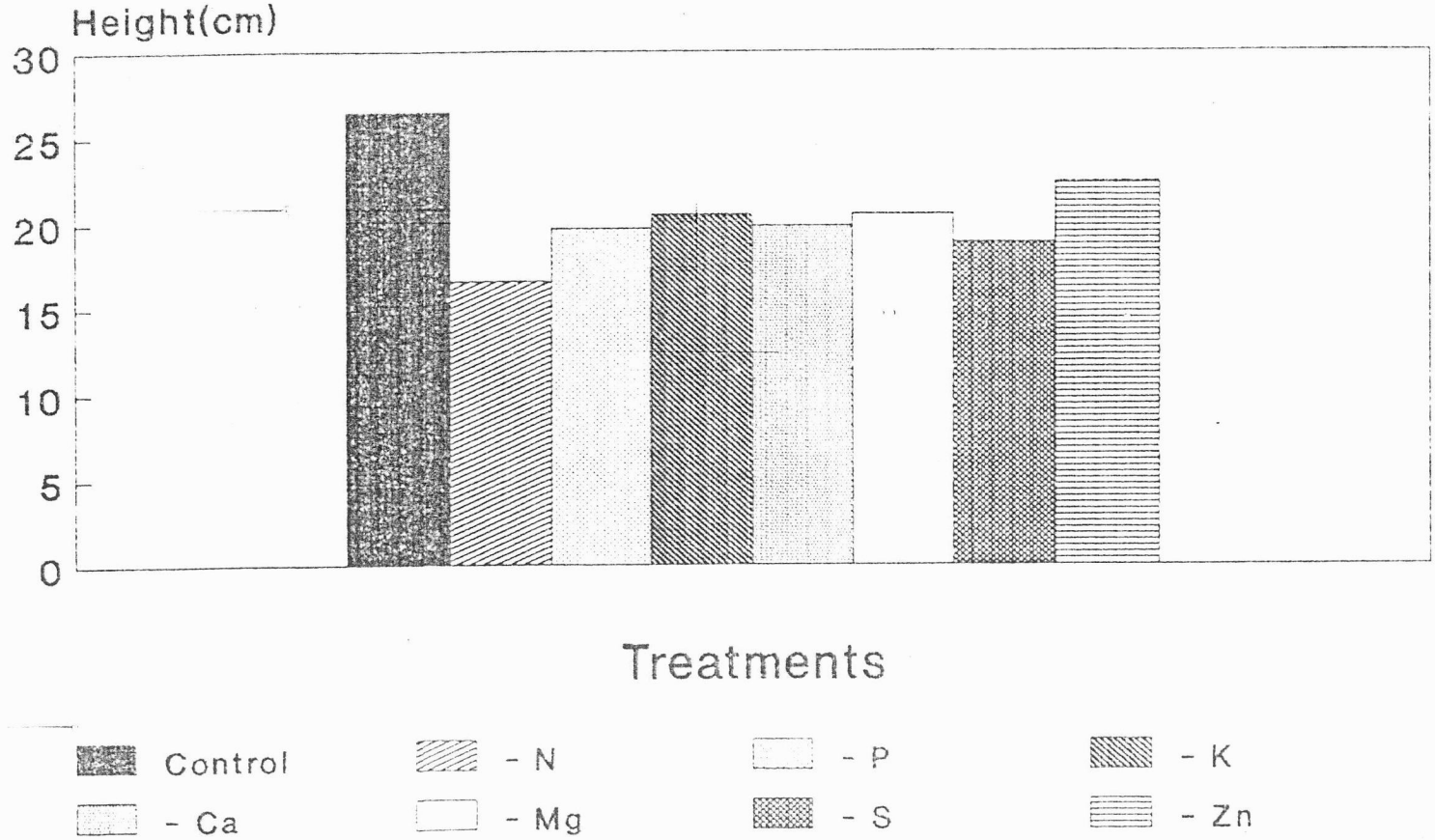


Fig.5.Effect of treatments on girth of seedlings in mango

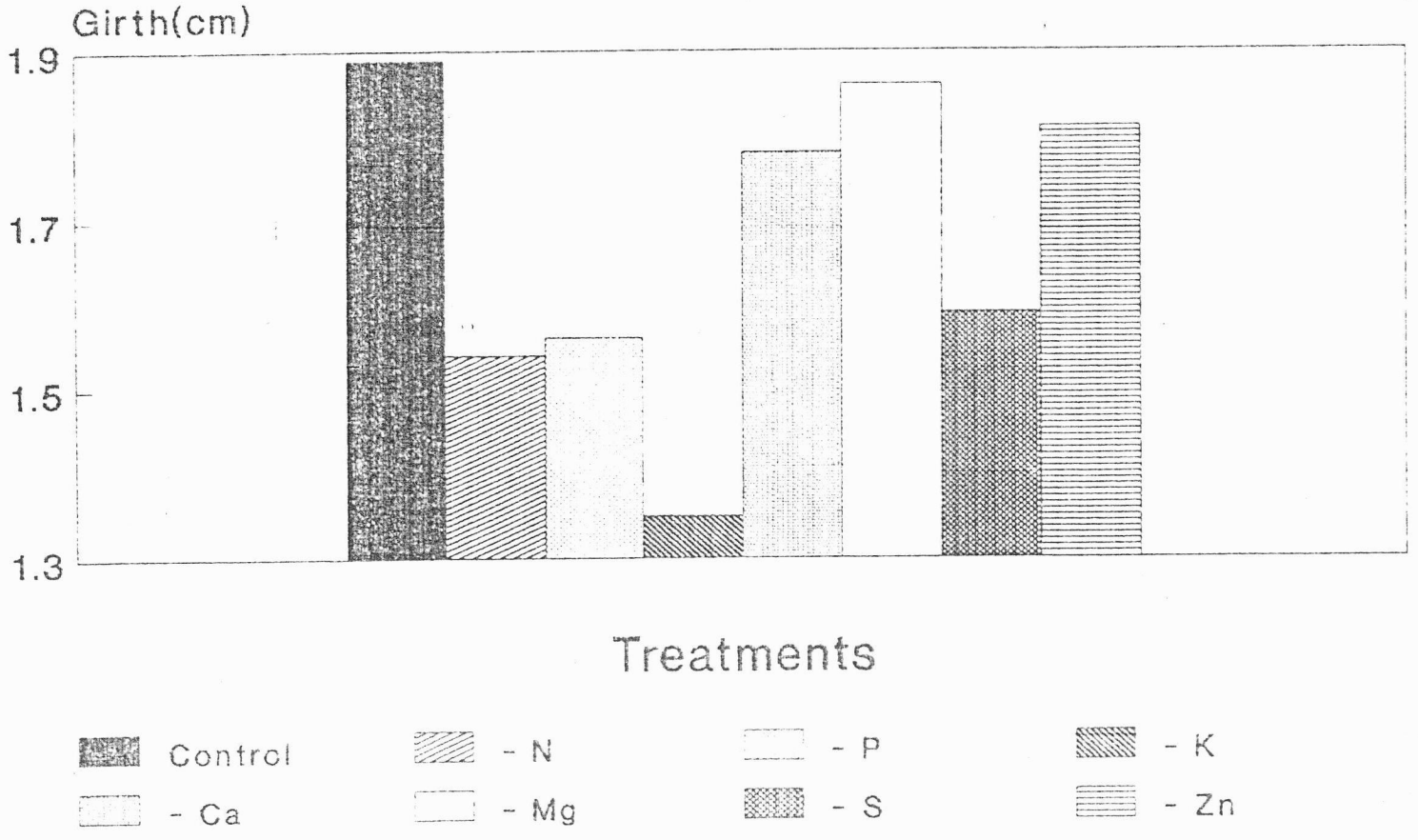
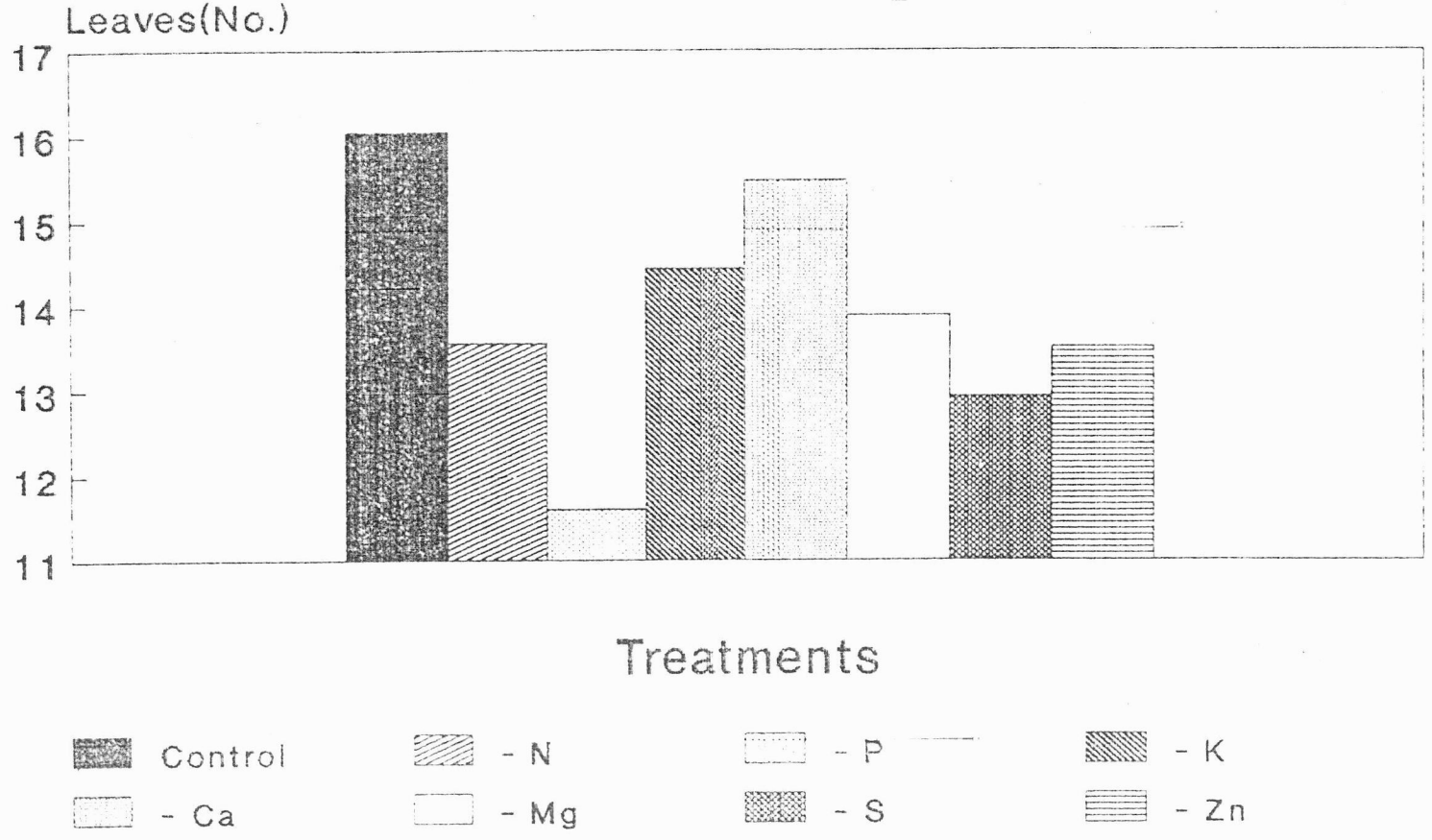


Fig.6.Effect of treatments on leaf production of seedlings in mango



deficiency symptoms were manifested as pale green colour of the leaves which gradually changed to uniform yellow. Symptoms spread from lower leaves to upwards. Development of symptoms coincided with growth stagnation. The mean height of plants were only 16.55 cm compared to 26.48 cm in control. Here also the visual symptoms of N deficiency was found to influence the leaf content of this element. The nitrogen content in these seedlings was found to be only 1.19 % compared to control where it was 3.20%. A slight increase in Mg content was observed in these seedlings compared to control. This is due to the antagonism of N and Mg.

Phosphorus

The phosphorus deficiency resulted a slow change in leaf colour from normal green to dark green. In some leaves the colour changed to purple to bronze. Premature drying and withering of lower leaves were also noticed. Deficiency also resulted a significant reduction in height, girth and leaf production. Moreover, the deletion of P resulted a drastic reduction in foiar P content (0.09%). Zinc content was relatively low in these seedlings (50ppm) compared to control (63ppm). The synergic relation of P and Zn is evident from this study.

Potassium

No visual symptoms were observed for patassium and calcium deficiency. However, the deficiency resulted reduction in growth. Absence of K adversely affected the growth parameters of seedlings particularly the girth. The girth of seedlings in K

deficient plants was 1.35 cm while in control it was 1.89 cm. Significant reduction in foliar content of this element was noticed. Interestingly in these seedlings, the Zn content was found to be relatively high (79ppm) compared to healthy seedlings.

Calcium

Results indicated that in the case of Ca deficiency also, there was an appreciable reduction in foliar content of this element. A slight increase in Mg content (1.89%) was noticed in these seedlings. This may be because of the antagonistic effect of Ca and Mg as observed in the case of cashew. No visual symptoms were observed.

Magnesium

Deficiency of magnesium was visible 3-4 months after planting. Severe interveinal chlorosis and yellowing of younger leaves were noticed. Development of leaf was poor. Since, mg constitutes 27% weight of chlorophyll, chlorotic symptoms are generally observed in Mg deficient plants. The leaf production was also relatively low in this treatment. The concentartion of Mg in the leaves was found to be Ø.12 % compared to healthy seedlings where it was 1.71%.

Sulphur

The initial symptoms of sulphur deficiency was similar to that of nitrogen deficiency. However, the younger leaves were

more chlorotic than older ones. Some leaves showed a reddish discolouration of petioles. Leaf size was also reduced. The height and girth of seedlings were rspectively 18.83 cm and 1.59 cm while in control it was 26.48 cm and 1.89 cm respectively. The content of sulphur in sulphur deficient plants was only Ø.Ø9 per cent.

Zinc

Zinc deficiency was initially manifested as mild interveinal chlorosis of younger leaves. Leaf size was found to be reduced considerably. Curling of leaf tip and reduction in internodal length was also noticed. In some cases abscission of leaves was observed. Youngest leaves remained small and clustered resulting a rossetting condition. The foliar content of zinc was found to be 2Ø ppm while in control it was 63 ppm.

B. Studies on foliar diagnosis

i) Foliar diagnosis in cashew

Nitrogen

The coefficients of simple correlation between yield and nitrogen content of leaf in relation to different leaf positions and months of sampling showed that the N content in the leaf gave a significant positive correlation only for the leaf at second position which was taken for sampling during September. The correlation coefficient and mean N content associated with this leaf was Ø.9158 and 2.Ø84 per cent respectively (Table 5 and 6)

Table 5. Mean foliar nutrient content of cashew leaves with regard to months of sampling and positions

Nutrient elements (%)	Leaf positions	Months of sampling											
		March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
N	1	2.698	2.374	2.179	1.933	1.993	2 068	2.110	2.105	2.017	2.122	1.826	1.987
	2	2.589	2.188	2.106	2.113	1.979	2.005	2.084	2.044	2.004	2.008	1.818	2.202
	3	2.535	2.077	2.000	1.900	2.108	2.037	1.842	2.210	1.919	1.949	2.015	2.221
	4	2.352	2.226	2.089	2.119	2.142	2.062	2.131	2.137	2.094	2.003	1.991	2.118
P	1	0.228	0.210	0.176	0.187	0.180	0.193	0.206	0.207	0.178	0.164	0.137	0.162
	2	0.226	0.212	0.170	0.176	0.193	0.217	0.172	0.199	0.181	0.177	0.131	0.153
	3	0.215	0.233	0.188	0.195	0.188	0.206	0.181	0.214	0.159	0.180	0.176	0.165
	4	0.231	0.226	0.201	0.187	0.192	0.196	0.170	0.193	0.163	0.152	0.163	0.181
K	1	1.420	1.434	1.271	1.262	1.250	1.310	1.329	1.331	1.350	1.361	1.328	1.368
	2	1.432	1.381	1.225	1.260	1.267	1.339	1.422	1.390	1.403	1.307	1.306	1.381
	3	1.424	1.284	1.345	1.247	1.271	1.218	1.510	1.390	1.438	1.384	1.299	1.340
	4	1.301	1.403	1.313	1.168	1.253	1.253	1.394	1.400	1.417	1.391	1.304	1.362
Ca	1	1.672	1.600	1.631	1.611	1.483	1.502	1.513	1.542	1.491	1.464	1.521	1.574
	2	1.763	1.667	1.588	1.607	1.463	1.446	1.562	1.472	1.540	1.647	1.219	1.596
	3	1.724	1.703	1.554	1.619	1.466	1.540	1.541	1.514	1.495	1.644	1.540	1.586
	4	1.732	1.693	1.544	1.619	1.473	1.542	1.514	1.594	1.535	1.643	1.512	1.624
Mg	1	0.551	0.665	0.589	0.559	0.673	0.550	0.627	0.650	0.496	0.537	0.516	0.572
	2	0.587	0.501	0.562	0.518	0.664	0.563	0.587	0.575	0.541	0.523	0.493	0.556
	3	0.579	0.537	0.634	0.570	0.653	0.549	0.542	0.580	0.515	0.557	0.503	0.540
	4	0.565	0.565	0.548	0.557	0.639	0.591	0.510	0.583	0.488	0.534	0.511	0.497
S	1	0.153	0.167	0.177	0.184	0.197	0.157	0.189	0.192	0.170	0.183	0.164	0.184
	2	0.188	0.184	0.187	0.170	0.191	0.171	0.182	0.207	0.187	0.190	0.177	0.195
	3	0.196	0.189	0.198	0.204	0.212	0.194	0.201	0.194	0.196	0.198	0.183	0.201
	4	0.233	0.205	0.206	0.206	0.201	0.191	0.199	0.185	0.204	0.212	0.192	0.186

Table 6. Correlation coefficients between foliar nutrient content and yield in cashew

Nutrient elements (%)	Leaf position	Months of sampling											
		March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
N	1	0.5416	-0.0605	0.6052	0.0307	0.3606	0.4861	0.4901	-0.0938	-0.3128	-0.1816	-0.0522	0.5899
	2	0.4867	-0.2087	0.3596	0.0158	0.5836	0.4688	0.9158*	-0.1751	-0.1548	0.0134	-0.5954	0 4674
	3	-0.1545	-0.2815	-0.1081	0.3936	0.1921	0.0840	0.3767	0.3568	0.1875	-0.1680	-0.4978	0.5938
	4	-0.2541	0.2614	0.1982	0.5814	-0.0085	0.3236	0.3746	0.6430	0.3552	0.0009	-0.3104	0.4150
P	1	0.2678	0.1826	0.2075	0.6271*	0.2352	0.1395	0.5307	0.3262	0.6516	0.1434	0.3434	0.5906
	2	0.2779	0.7165*	0.4251	0.6862*	0.1382	0.4564	0.5705	0.3589	0.3924	0.0283	0.4948	0.4178
	3	0.3555	0.5211	0.2723	0.4102	0.1808	0.4172	0.3214	0.0137	0.3571	0.0151	0.2061	0.7532*
	4	0.4574	0.5131	0.3651	0.4633	0.1440	0.3394	0.4297	0.1980	0.3678	0.1322	0.4192	0.5282
K	1	0.6127	0.4533	0.4247	0.3924	0.5877	0.4088	0.2884	0.3420	0.2084	0.4931	0.4008	0.3700
	2	0.5795	0.5665	0.4966	0.4047	0.6189	0.4220	0.2584	0.3552	0.3485	0.5906	0.4852	0.3384
	3	0.5306	0.6504*	0.4344	0.2754	0.5510	0.4775	0.3286	0.1719	0.2964	0.4586	0.5029	0.1834
	4	0.4336	0.6265	0.4455	0.4500	0.5958	0.4825	0.3318	0.1947	0.3198	0.4492	0.4503	0.2376
Ca	1	0.2366	0.1104	0.3195	0.3265	0.3171	0.1835	0.3442	0.2610	0.1513	-0.0288	0.0888	0.1473
	2	0.1672	0.2419	0.3434	0.1991	0.3808	-0.2617	0.3431	0.3010	0.1533	-0.1500	0.0732	-0.0262
	3	0.0036	0.1608	0.4251	0.4018	0.3596	-0.2889	0.3322	0.1668	0.1319	0.0776	0.2023	0.1366
	4	0.0869	0.2932	0.3458	0.3893	0.2204	-0.1626	0.3796	0.0195	0.1361	-0.1465	0.1891	0.0721
Mg	1	0.5659	0.6262	0.7585*	0.5544	0.6784*	0.5138	0.3915	0.4278	0.5740	0.6152	0.6955*	0.3359
	2	0.5990	0.5310	0.6927*	0.3360	0.5832	0.5804	0.3402	0.6261	0.6249	0.6320	0.5251	0.5537
	3	0.6420	0.5547	0.5782	0.3519	0.5297	0.4615	0.5187	0.4883	0.5688	0.5118	0.4955	0.5585
	4	0.4903	0.4667	0.6777*	0.2752	0.2868	0.5046	0.5384	0.5825	0.7148*	0.5791	0.5651	0.6380
S	1	-0.0553	0.3757	-0.5768	-0.3590	0.0087	-0.3952	-0.4905	-0.2172	-0.1063	-0.4491	-0.2286	-0.4381
	2	-0.5839	0.5228	-0.0135	-0.2517	-0.5913	-0.1688	0.1211	0.2383	0.3073	-0.1915	-0.1612	-0.1232
	3	-0.6090	-0.0702	-0.2838	-0.1608	-0.1048	-0.1846	-0.0376	-0.3618	0.6012	-0.0981	-0.4166	0.5522
	4	0.0690	-0.2833	-0.4367	-0.1798	-0.3655	0.0646	0.2234	-0.2294	0.4819	-0.4685	-0.3526	0.3141

* Significant at 5 per cent level

Phosphorus

Considering the simple correlation coefficients between P content of leaf at different sampling positions and months of sampling, it was observed that there was a positive correlation between yield and P content of leaves. However, this correlation was significant only for the leaves at second position taken during April and June and third position taken during February. The highest positive correlation (r = Ø.7532) was observed with the latter case. The mean P content of this leaf was estimated as Ø.165 per cent.

Potassium

Similar to P, the yield of cashew was found to be positively correlated with the leaf K content at different leaf positions and months of sampling. In spite, correlation between yield and K content in leaf was not significant at any leaf position or sampling season.

Calcium

None of the correlation coefficients between cashew yield and leaf Ca content were significant indicating that Ca content of the leaves had no specific role to influence the yield of cashew.

Magnesium

There was a positive correlation between the yield and Mg

content of cashew leaves as evidenced from the data. The Mg content of the leaves, when taken from the first position during May and July and January gave significant correlation coefficiets with yield. Leaves collected during May from second and fourth positions and in November from fourth position also recorded a significant correlation with yield. The maximum value of correlatin coefficient (r =Ø.7585), was obtained from leaves of first position when plucked during May and these leaves registered an average Mg content of Ø.589 per cent.

Sulphur

When the coefficients of simple correlation were considered, it was seen that the yield was not significantly correlated with yield. No relationship could be seen between soil test values and leaf nutrient contents.

ii) Prediction of yield of cashew based on leaf nutrient levels

Based on the nature of relationship, the foliar content N, Pand K were considered for formulating the prediction equation. Adopting the multiple regression models and using the highest correlation coefficient values for N, P and K the following equation was laid out for predicting the yield of cashew,

Y = -54.8636 + 17.5328X1 +8.58ØØX2 +3.8787X3 ,

where,

X1 = N content of the leaf at second position and sampled during September

X2 = P content of the leaf at third position and sampled during February

X3 = K content of the leaf at third position and sampled during April

iii) Foliar diagnosis in mango

Nitrogen

Studying the simple correlation coefficients between yield and leaf N content of mango it was revealed that a significant negative correlaiton existed between these two aspects when the leaf samples were taken from the first leaf position during March and April. In contrast to these findings, a high positive correlation was also noticed with the mango leaves of first, second and third positions sampled during June and fourth position sampled during October. The highest value for correlation coefficient, Ø.9572 was computed in the case of third leaf sampled duringJune. The mean N content of this leaf was read as 1.385 per cent (Tables 7 and 8).

Phosphorus

The statistical analysis to correlate the yield and leaf P content of mango revealed that there is generally a significant negative correlation between yield of mango and leaf P content, though the leaves at first position sampled during June showed a significant positive correlation, the value being, Ø.7Ø46 and mean P content being, Ø.137 per cent.

Table 7. Mean foliar nutrient content of mango leaves with regard to months of sampling and positions

Nutrient elements (%)	Leaf positions	Months of sampling											
		March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
N	1	1.310	1.351	1.352	1.442	1.385	1.469	1.418	1.397	1.315	1.466	1.494	1.422
	2	1.230	1.329	1.360	1.425	1.375	1.354	1.262	1.386	1.253	1.410	1.435	2.376
	3	1.212	1.268	1.281	1.385	1.303	1.329	1.520	1.320	1.264	1.341	1.396	1.382
	4	1.200	1.198	1.232	1.375	1.257	1.271	1.243	1.317	1.218	1.385	1.329	1.308
P	1	0.105	0.103	0.091	0.137	0.070	0.087	0.098	0.164	0.116	0.114	0.139	0.113
	2	0.106	0.098	0.086	0.072	0.062	0.084	0.100	0.108	0.115	0.113	0.133	0.112
	3	0.100	0.084	0.094	0.070	0.066	0.094	0.102	0.089	0.110	0.101	0.119	0.105
	4	0.096	0.071	0.101	0.091	0.060	0.095	0.089	0.114	0.080	0.085	0.092	0.094
K	1	1.323	1.355	1.359	1.275	1.301	1.252	1.382	1.422	1.775	1.731	1.658	1.696
	2	1.100	1.393	1.264	1.262	1.299	1.285	1.378	1.251	1.673	1.639	1.661	1.676
	3	1.147	1.304	1.310	1.280	1.289	1.243	1.292	1.206	1.583	1.513	1.642	1.625
	4	0.900	1.193	1.155	1.150	1.310	1.168	1.261	1.189	1.600	1.503	1.629	1.543
Ca	1	2.070	1.982	2.038	1.902	2.140	2.143	2.087	1.917	2.210	2.175	2.308	2.243
	2	2.017	1.893	2.038	1.865	2.103	2.135	2.043	1.965	2.122	2.218	2.253	2.222
	3	1.978	1.862	2.050	1.828	2.112	2.112	2.035	1.852	2.142	2.012	2.103	2.210
	4	1.993	1.753	2.038	1.818	2.005	2.052	1.985	1.810	2.160	2.050	1.980	2.153
Mg	1	1.505	1.302	1.308	1.770	1.653	1.555	1.563	1.460	1.433	1.792	1.793	1.863
	2	1.488	1.215	1.300	1.762	1.623	1.515	1.562	1.445	1.430	1.769	1.780	1.820
	3	1.413	1.163	1.253	1.730	1.568	1.453	1.582	1.405	1.415	1.708	1.787	1.745
	4	1.343	1.178	1.238	1.737	1.543	1.467	1.532	1.368	1.362	1.655	1.758	1.690
S	1	0.268	0.310	0.287	0.277	0.310	0.260	0.243	0.275	0.240	0.198	0.275	0.245
	2	0.208	0.302	0.268	0.223	0.288	0.280	0.238	0.245	0.278	0.207	0.275	0.285
	3	0.210	0.297	0.248	0.223	0.315	0.263	0.208	0.263	0.227	0.198	0.243	0.276
	4	0.180	0.288	0.265	0.188	0.305	0.232	0.222	0.213	0.220	0.198	0.218	0.232

Table 8. Correlation coefficients between foliar nutrient content and yield in mango

Nutrient elements (%)	Leaf position	Months of sampling											
		March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
N	1	-0.8956*	-0.6901*	0.2601	0.7974*	-0.0469	0.2841	0.2083	0.1090	-0.1265	0.1519	0.1898	0.2645
	2	-0.2045	-0.1131	-0.1717	0.7407*	-0.2746	0.2523	-0.0118	0.1173	0.2377	0.2229	0.0653	0.1709
	3	-0.4369	-0.2377	0.1731	0.9572*	-0.1119	0.4220	-0.2978	0.0010	0.0777	0.1680	0.0905	0.0796
	4	-0.2640	0.5193	0.1355	0.2220	-0.1002	0.4370	0.0290	0.8726*	0.2682	-0.4180	-0.0684	-0.1747
P	1	0.4471	-0.5234	-0.2928	0.7046*	-0.4117	-0.5821	-0.6998*	0.6230	-0.6423	0.0907	-0.6900*	-0.4193
	2	0.0273	-0.5064	-0.2975	-0.5531	-0.2324	0.3334	-0.3875	-0.3504	-0.4235	0.0745	0.0071	-0.4970
	3	0.3802	-0.6553*	-0.5746	-0.3379	-0.2521	0.4799	-0.2665	-0.7607*	-0.7279*	-0.4824	0.2338	-0.6388
	4	0.1774	-0.2994	-0.5880	-0.4740	-0.1306	-0.5028	-0.3089	-0.1650	0.2328	0.5523	0.0217	-0.7203*
K	1	-0.2080	0.4865	0.7002*	-0.3724	0.6660*	0.6658*	0.1865	0.1013	-0.0712	0.1521	-0.0205	-0.0572
	2	0.4875	0.7859*	0.9115*	-0.3916	0.5226	0.1778	0.1430	0.8845*	0.3338	0.2199	0.0870	0.1086
	3	0.0263	0.5166	0.3090	0.4889	-0.6660*	-0.3510	-0.3293	0.5196	0.0474	0.1887	-0.0350	0.1193
	4	-0.1515	0.2179	0.0811	0.2270	0.3217	-0.5031	-0.3217	-0.2271	0.1610	0.3048	0.0625	0.1020
Ca	1	0.6048	-0.6543*	-0.4962	0.7999*	-0.8954*	-0.0176	0.0821	-0.2615	-0.1173	0.3835	-0.2560	0.4316
	2	0.7326	0.6930*	0.4282	-0.9083*	-0.9548*	0.1605	0.0685	0.5331	-0.3427	0.1601	-0.3196	-0.0851
	3	-0.3612	0.1342	0.0470	0.5535	-0.9070*	0.1197	-0.1547	-0.4261	0.4850	-0.4129	0.5424	-0.1445
	4	-0.7734*	-0.0091	-0.4234	0.4219	-0.8486*	-0.8433*	-0.1048	0.1015	0.6096	-0.3295	-0.3413	-0.2657
Mg	1	0.2527	-0.0436	-0.4379	-0.8835*	0.0305	-0.1922	0.3112	0.0599	0.8920*	0.6052	0.4647	-0.5380
	2	0.6374	0.7620*	0.2614	0.6778*	-0.6698*	-0.1279	-0.3445	0.4519	0.8821*	0.6755*	0.9285*	-0.5981
	3	-0.5570	-0.2566	0.0342	0.0834	0.1111	0.6131	-0.0227	0.2075	0.8627*	0.5727	-0.2987	0.2648
	4	0.0196	-0.1404	0.6614*	0.4919	0.4750	0.0136	0.1452	0.6320	0.8149*	0.5288	-0.3978	0.1814
S	1	0.4061	-0.2053	-0.6207	0.0967	0.3170	-0.4029	-0.5266	0.5063	-0.4445	0.0894	-0.6278	0.3313
	2	0.1459	0.5837	0.4334	-0.1738	0.3021	0.2075	-0.8257*	0.1937	0.1547	0.1043	-0.3403	0.2075
	3	-0.2658	-0.7717*	-0.0223	0.1259	-0.1153	-0.3707	-0.3188	-0.5772	0.3340	-0.7874*	0.0522	-0.7054*
	4	0.0189	-0.5023	-0.1844	0.2755	0.3251	-0.3493	-0.4996	0.1547	-0.0847	0.6063	0.6539*	0.2961

*. Significant at 5 per cent level

Potassium

The analysis of the data revealed the existance of a significant positive corelation between the yield and K levels of leaf though there was a significant negative correlation between the yield and leaf K content when the leaf was sampled during July from the third position. A highly significant positive correlation existed between the yield and leaf K content when the samples were taken from the first leaf position during May, July and August and from the second leaf position during April May and October. It was observed that the maximum correlation coefficient value, r =Ø.9115, related the yield of mango and K content of the leaf at second position taken during May and the corresponding K content of the sample was estimated as 1.264 per cent.

Calcium

When the leaves were taken from the first position during June and from the second position during April and correlation coefficients were worked out, it was found that there was a positive correlation between yield and Ca content of leaves. However, when the overal picture of simple correlation coefficients between the yield and leaf Ca content was taken into consideration,it could be generalised that mango leaves showed generally negative correlation in this respect.The value representing the highest negative correlation (r =-Ø.9548) was resulted from the leaves sampled from the second position during

July, the corresponding Ca content of which was estimated as 2.1Ø3 per cent. The Ca content of the leaves sampled from the fourth position during March July and August and second position during June was also found to be negatively related with yield. Interestingly, the Ca content of leaves sampled from all positions during July was found to be negatively related with yield.

Magnesium

On contrary to the case of Ca, Mg content of mango leaves showed a positive correlation with yield though two sets of leaves showed a significant negative correlation. The leaves taken from the second position during January gave the highest correlation value, r =Ø.9285, while its Mg content was estimated to be 1.78 percent.

Sulphur

Examining the simple correlation coefficients it was found that all the significant correlation values were negative except one indicating the existance of a negative correlation between the yield and S content of the leaves. The value showing the highest negative correlation (r =-Ø.8257) was obtained for the leaves sampled from the second position during September. The foliar nutrient content of S in the sample was Ø.238 per cent. The foliar content was not found to be related with soil nutrient status.

iv) Prediction of yield of mango based on leaf nutrient levels

Similar to the case of cashew, in mango also, a yield

prediction equation was formulated as shown below:

$$Y = -46.5949 + 37.1725X1 - 63.4920X2 + 21.1931X3,$$

where,

X1 =N content of the leaf at third position taken during June

X2 = P content of the leaf at first position and taken during June

X3 = K content of the leaf at second position taken during May

13. Conclusions

The deletion of various nutrient elements from complete Hoagland's nutrient solution resulted in differential growth behaviour of cashew and mango seedlings. The visual symptoms were also manifested as various types of discolouration of leaves and retardation of growth. The deficiency was concurred with marked reduction in foliar level of concerned elements. The antagonistic relation of calcium and magnesium is also evident from the studies. The visual symptoms of deficiency illustrated in the report may provide guidelines to understand nutrient deficiencies under field conditions.

Based on the correlation between leaf nutrient content and yield, a multiple regression model was fitted. By making use of the leaf nutrient levels, the yield of cashew and mango could be predicted using these models.