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STUDIES ON
THE EFFECT OF PLANT NUTRIENTS ON INSECT INFESTATION
ON
Abelmoschus esculentus MOENCH

BY

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THESIS

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1967

CERTIFICATE

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Shri Viswanath, B.N., under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

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INTRODUCTION

INTRODUCTION

Many variations in the abundance of insects and the injury done by them to cultivated crops have been attributed to soil conditions, particularly to fertility levels or to deficiencies of certain major and minor nutrient elements. This correlation was first recognised as early as 1913 by Hoffman. Subsequently various workers assessed the influence of fertilizer application on the pests of crops like plum trees, coffee, cotton, beans, tea, apple, citrus, grape, jute, potato and maize. Very little information is available on the influence of fertilizer applications on the insects injuring the major crops in India. Das (1945) showed that superphosphate and lime as well as superphosphate, ammonium sulphate and potash combinations reduced the attack of Apion corchori Marshall on jute significantly, whereas nitrogenous manures increased it. Abraham (1957) found that the incidence of Nilaparvata lugens was highest in plants treated with higher doses of nitrogen. Jayaraj and Venugopal (1964) also reported that the application of nitrogen gave significant increase in the incidence of cotton jassid and cotton aphid. Waghray and Singh (1965) observed that the fecundity of Aphis craccivora koch a serious pest of groundnut showed an increase with the application of a higher doses of nitrogen to the host plant. Apart from these, no work has been carried out in these lines in India.

In the present investigations the effect of four important plant nutrients and their various combinations on pests of bhindi (Abelmoschus esculentus) was ascertained by a field experiment. A review of literature on the influence of fertilizer application to the various insect pests also is presented in this thesis.

REVIEW OF LITERATURE

Review of literature

One of the earliest publications on the effect of fertilizers on insect infestation is that of Hoffman (1913). He studied the effect of manuring plum trees on their susceptibility to the bark boring beetles Scolytus pruni, S. rugulosus and Xyleborus dispar. In plots treated with stable manure, potassium nitrate and nitrophosphate, all trees were found free from infestation. The damage caused to trees grown in plots treated with potassium phosphate alone was 8 1/3%, while the trees which received lime suffered 16 2/3% loss. Nearly 1/3 of the trees grown in untreated plots were destroyed by the pest. The greater resistance of the manured trees was attributed to the rapid growth of the woody tissues in such trees, leading to the gradual closure of the insect tunnels in the bark. Theobald (1914) reported similar results on plum trees in Germany.

Vuillet (1924) observed that the cotton crop grown in manured ground remained healthy and resisted infestation by Chlorita facialis and indicated that the damage was more severe on plots grown in soils rich in mineral fertilizers particularly potash.

Wilkinson (1924) showed that the coffee plants grown in solutions of high potassium/phosphorous ratio were infested more by the bug Antestia lineaticollis.

Davidson (1925) reported that beans grown in soils treated with complete mineral fertilizers became more susceptible to pest infestation than those grown in unmanured soils. Beans supplied with increased potash indicated higher infestation while with less potash a decrease in infestation was obtained. When grown in sand watered with culture solution containing magnesium sulphate, the plants showed a marked increase in infestation.

Jepson (1925) conducted experiments for the control of shot hole borer of tea, Xyleborus fornicatus using fertilizers. The results revealed that the healing of the entrance holes was promoted to a marked degree by nitrogenous fertilizers and to a lesser extent by potash on phosphoric acid manures. Lime had no influence on infestation by the pest. From another experiment it was concluded that manuring with complete fertilizers accelerated the rate of healing of entry holes, increased the number of empty gallaries and caused small broods to be raised. Manuring did not have any influence on the degree to which bushes were attacked by the borer pest.

He (Jepson, 1926) further reported that manuring the tea bushes gave no immunity from attack, but infestation was less when bushes were treated with potash manures and lime. When complete fertilizer mixture was used, slightly smaller broods were produced and the number of vacated galleries increased. It was also observed that (Jepson and Gadd 1926) though attack was somewhat lighter in the plots treated with potassic manures, the extent of reduction in attack was small to be of much practical value. In every case the percentage of gallery entrances which healed up was higher in treated than in the control plots.

Dusserre (1927) observed that chemical fertilizers had considerable value in destroying cockchafer larvae of Melolontha sp. in the soils. When animal or vegetable manures were used in conjunction, they were found to favour development of the various insects.

Shchepkina (1930) investigated the effect of artificial manures such as nitrogen and phosphorous pentoxide on infestation by Oscinella frit L. The extent of damage caused by them depended on the age of the plant and infestation of the older plants had a favourable effect on their ultimate yield. Though the manures did not protect the plants, the damage caused by the pest was considerably reduced.

Jancke (1933) reported that potash manures had no effect on infestation of apple trees by wooly aphis, Eriosoma lanigerum or Aphis pomi.

Schone (1941) noted that in the case of Pseudococcus comstocki, a pest of apple in Virginia, the injury was most severe in orchards treated with nitrogenous fertilizers continuously for a number of years. No damage was observed on the trees grown in untreated orchards if the young trees had received complete fertilizers.

Thompson (1941) from Florida, made some observations on the the effect of soil fertilizers on the population of the purple scale Lepidosaphes beckii Newm., a pest on citrus. Application of magnesium in the form of dolomite resulted in an increase in the percentage of green leaves, the density of foliage and number of coccids. Observation on grape showed that scale infestation was lightest in plots receiving an acid inorganic fertilizer containing nitrogen, phosphorous and potassium, and heaviest in those trees receiving zinc, copper and magnesium. Apparently any fertilizer programme that maintained vigorous growth indirectly influenced the scale development owing to the high percentage of green leaves and the shaded conditions in well foliated trees.

Observations made by Mc Garr (1942) indicated that the use of nitrogenous fertilizers on cotton stimulated the development of Aphis gossypii on it.

Studies made by Das (1945) on jute stem weevil Apion corchori indicated that the plots manured with superphosphate and lime or with superphosphate with ammonium sulphate and potash reduced the attack, whereas nitrogenous manures increased it.

According to Gadd (1947) manuring with nitrogen, potash and phosphoric acid was found to promote the healing of galleries formed by the shot hole borer of tea, but did not diminish the damage as assessed by the number of branches broken. The number of broken branches was greater in plants giving minimum yields. This was probably because nitrogen caused an increase in yield as well as in insect damage.

Maltais (1951) found that the content of amino nitrogen in lucern plants was the most important factor governing susceptibility of the plants to infestation by the aphid Macrosiphum onobrychis. This was attributed to the fact that aphids required solid food in plants which was being provided by solutes in plants comprising mainly of aminoacids and sugars.

Arant and Jones (1951) studied the effect of lime and nitrogenous fertilizers on the population of Toxoptera graminum (Rond.) on oats in Alabama. Counts of the aphids on selected leaves were considerably less on plants which received nitrogen than on plants which did not receive nitrogen. In general the population was found to vary inversely with the amount of nitrogen applied. The addition of lime decreased the population and the reduction due to this factor was greatest where no nitrogen was used.

Barker and Tauber (1951) studied the influence of nitrogen, phosphorous, potassium, calcium and magnesium supplied to nasturtium plants on the developmental period of Myzus persicae breeding on it. No significant differences were observed. They found that the plants subjected to deficiency conditions were more vulnerable to infestation than those receiving all the nutrients and the fecundity of aphids on them was less. Plants deficient in nitrogen and phosphorous had the shortest life when infested. The increased injury to deficient plants and an associated decrease in the survival period of aphids on such plants were considered to be largely responsible for the reduction in aphid population.

Volk et al (1952) reported that the use of potassium chloride as a fertilizer increased the incidence of leaf roll disease on potato but significant differences were not detected in the population of the commonest potential vectors, Myzus persicae and Aphis rhamni Boy.

According to Tylor et al. (1952) no significant differences existed in the reduction capacity of Macrosiphum solanifolii (Ashm), breeding on potato plants grown at high and low levels of the nutrients, nitrogen, phosphorous and potassium. No significant differences could be found in the reproductive capacity of M. pisum (Harriss.) feeding on pea plants grown at high levels of nitrogen, phosphorous and potassium. The larvae of European corn borer Pyrausta nubilalis showed slightly faster growth on maize plants grown in a balanced nutrient solution than on plants subjected to deficiency of nitrogen, potassium and phosphorous. In field conditions when the plants were infested artificially, the percentage of survival of Pyrausta nubilalis was higher on vigorous plants than on plants subjected to nutrient deficiency.

Areny and Schroppel (1952) showed that calcium cyanamide when applied as a fertilizer reduced infestation by potato beetle Leptinotarsa decemlineata on potato. The cyanamide was absorbed by the roots and subsequently translocated to the leaves which were rendered temporarily toxic.

Broadbent et al. (1952) found that aphid population was highest on potatoes planted early in the season and that there was an increase in the population by the application of dung, ammonium sulphate and superphosphate while potassium chloride reduced the aphid population.

Eden (1953) observed that nitrogen when applied at 50-200 lbs, caused no significant difference in damage by rice weevil on corn before harvest. When nitrogen was applied at 48-120 lbs/acre there was significant positive correlation between rate of nitrogen application and damage caused. The average percentage of injured grains increased from 47.9 to 78.7 as the dosage of nitrogen increased. No significant difference in infestation resulted from treatments with either phosphate or potash fertilizers.

Douglas and Eckhardt (1953) could not detect any difference in damage to corn in plots treated with 0 - 80 lbs of nitrogen/acre. But the percentage infestation and the damage were greater in plots receiving no nitrogen, the plants producing only small and poorly developed ears. Those plants which received nitrogen at 60-160 lbs/acre did not reveal any significant effect on the degree of damage from pest infestation. It was also found that the damage was greater in maize receiving no nitrogen and the highest (120 lbs/acre) rate of nitrogen, than in those receiving medium dose (60 lbs/acre) of nitrogen.

In investigations in Missouri, Adkinson (1957) found that on cotton, infestation by Psallus seriatus (Rent.) Adelphocoris rapidus (Say.) and Lygus cincolaris were more in irrigated and fertilized plots than in non-irrigated counterparts.

Abraham (1957) found from his experiments that the incidence of the fulgorid Nilaparvata lugens increased rapidly after lodging and the population was highest in plots treated with 60 lbs of nitrogen in combination with 30, 45 and 60 lbs of phosphorous, on account of early lodging of the crop. Plots treated with higher doses (45 and 60 lbs/acre) of nitrogen alone harboured spectacularly larger population of the fulgorids than plots treated with, phosphorous, lime, potash and plots receiving no treatment.

Daniels (1958) found fewer insects per unit weight of foliage, less plant damage and greater plant weight, in plots of winter wheat treated with nitrogen, except in cases where this was applied in conjunction with calcium sulphate, phosphorous and potassium.

Ishii and Hirano (1958) observed in Japan that nitrogenous fertilizers applied to rice favoured the growth of the larvae of Chilo suppressalis Wlk. Hirano and Ishii (1959) showed that the use of fertilizers containing phosphorous had little or no effect on the growth of the larvae of Chilo suppressalis Wlk.

Jayaraj and Venugopal (1964) showed from experiments that nitrogen in the mineral form at 22.4 lbs/acre gave significant increase in the incidence of the leaf hopper Empoasca devastens on cotton and that none of the other nutrients had influenced the incidence of either cotton jassid or cotton aphid.

According to Schindler and Baule (1964) the application of soil fertilizers on newly established pine stands in N.W. Germany had no effect on infestation by Rhyacionia bouliana for the first five years after treatment. But in the 6th and 7th years the insect population suffered a marked and progressive reduction ranging from 43-56% in plots receiving the fertilizer treatments.

Experiments on the effect of nitrogen, phosphorous and potassium on the fecundity of the groundnut aphid Aphis craccivora (Koch), conducted by Waghray and Singh (1965) in India showed that groundnut plants grown in solutions containing different levels of nitrogen, phosphorous and potassium influenced fecundity of the pest; low and high rates of fecundity were associated with plants containing low and high levels of nitrogen respectively.

Cram (1965) observed that under field conditions in Columbia, nitrogen, phosphorous and potassium fertilizers had no significant influence on fecundity of Sciopithes obscurus Horn., a pest on strawberry. But when plants were raised in sand cultures devoid of nitrogen there was a significant reduction in the fecundity of Otiorhynchus sulcatus F. Low levels of nitrogen had no effect on the fecundity of Sciopithes obscurus. Further, it was found that fecundity of Otiorhynchus sulcatus did not differ significantly when the nitrogen was supplied at either high or low concentrations as nitrate or as ammonium.

Terry et al. (1966) observed that more than twice as many of the aphid, Rhopalosiphum maidis were found on corn plants receiving nitrogen than on those which came up under nitrogen deficient conditions. A reduction was noticed in the fecundity of aphids breeding in plants grown under nitrogen deficient condition. This was attributed to a crowding response rather than to the effect of nitrogen deficient condition. The percentage of alate aphids on nitrogen, deficient plants was twice that on plants which were not deficient. The higher percentage of alate aphids was due to nitrogen deficiency and not due to over crowding.

MATERIALS AND METHODS

MATERIALS AND METHODS

A. Materials

Bhindi seeds: The bhindi seeds used for raising the crop under the experiments were of the variety, pusa sawani. These were obtained from the Agricultural College Farm, Vellayani.

Fertilizers: The following fertilizers were used to supply the different nutrients.

(a) Ammonium Sulphate: The material used was the one manufactured by the FACT, Alwaye, Kerala State. It contained 20% nitrogen.

(b) Lime: A material containing 52% calcium was used to supply the calcium to the plants.

(c) Magnesium carbonate: The substance used contained 24.6% of magnesium.

(d) Zinc sulphate and Copper sulphate: These materials were used to supply zinc and copper to plants. Zinc sulphate was supplied by the British Drug Houses (India) Private Limited Bombay. It contained 22.47% of Zinc. Copper sulphate contained 25.45% of copper.

B. Methods

1. Raising the bhindi crop for the experiment: The land selected for the experiment was ploughed well and the grass and other weeds were removed. The clods were then broken with hand to get a fin tilth. The soil was of red loam. After preparing the land thus, the field was then divided into

rectangular plots according to the fixed design by raising low ridges all around. Shallow rectangular pits measuring 20 cm x 20 cm were dug at the rate of 16 pits per plot to receive the seeds. Farm yard manure was applied equally to all the pits. The seeds were dibbled in these pits at the rate of 3 seeds per pit. After a week of sowing a single healthy plant alone was allowed to remain in each pit and others were removed. The pits were watered daily. Weeding of the field was done regularly at fortnightly intervals.

2. Application of fertilisers: Lime was mixed with the soil in the plots which had to receive it a week before sowing. The rest of the fertilizers were weighed, mixed and applied 2 days before sowing. Only half the dose of ammonium sulphate and muriate of potash was applied in the beginning, the rest of the fertilizers being applied in full dose. The remaining half dose of ammonium sulphate and muriate of potash was again split into two doses, the 1st dose applied after about 20 days and the 2nd dose after another 20 days.

3. Assessment of results: The results of the experiments were assessed in two ways.

(1) By determining the degree of infestation by various pests on the plants under the various treatments. For this the number of the different insects found on all the leaves and other parts of the plants were counted. These counts were taken at weekly intervals.

(2) By determining the total yield of fruits. For this purpose, the fruits were pluked at intervals of 3-4 days. On the whole

10 pluckings were done. The fruits at each time were sorted out into those damaged by fruit borers and those undamaged.

All the above observations were made on the plants in the net plots, numbering four each. A row of plots all round the net plots were left to eliminate border effect. The data obtained were statistically analysed using Chi-square method. The analysis was made only on the effects of the four individual nutrients and their possible two factor interactions.

LAYOUT – RANDOMISED BLOCK DESIGN

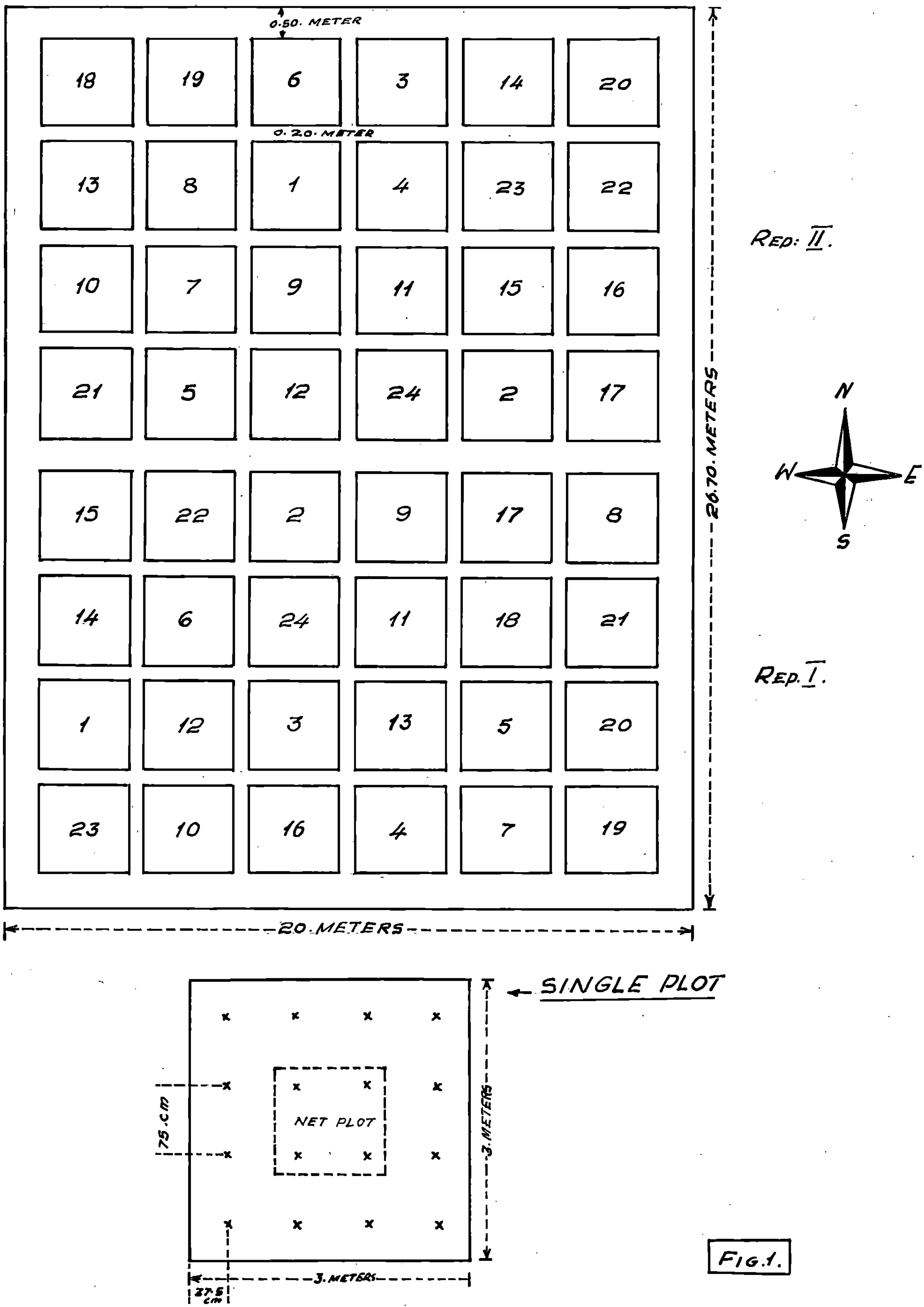

FIG. 1.

DETAILS OF EXPERIMENT AND RESULTS

Details of experiments and results

Effect of four important plant nutrients and their various combinations on pests of Bhindi was ascertained by a field experiment. The details of this experiment and its results are given below.

Experimental details

Design and layout of the experiment: A randomised block design was adopted for the experiment. There were twenty four treatment combinations including control and these were distributed at random in plots in a block and such a block was replicated twice. Each plot was square in shape measuring 2.25m x 2.25 m. There were sixteen pits in each plot, each pit measuring 20 cm x 20 cm. Each pit had one plant in it. The net plot size was 45 cm x 45 cms which contained four plants. The remaining twleve plants in each plot served as border rows to eliminate border effect. The randomised distribution of the combinations in forty eight plots is shown in Figure.1

Treatments:

1) N_0 Ca_0 Mg_0 Zn Cu_0
2) N_0 Ca_0 Mg_0 Zn Cu_1
3) N_0 Ca_0 Mg_1 Zn Cu_0
4) N_0 Ca_0 Mg_1 Zn Cu_1
5) N_0 Ca_1 Mg_0 Zn Cu_0
6) N_0 Ca_1 Mg_0 Zn Cu_1

7) N_0 Ca_1 Mg_1 Zn Cu_0

8) N_0 Ca_1 Mg_1 Zn Cu_1

9) N_1 Ca_0 Mg_0 Zn Cu_0

10) N_1 Ca_0 Mg_0 Zn Cu_1

11) N_1 Ca_0 Mg_1 Zn Cu_0

12) N_1 Ca_0 Mg_1 Zn Cu_1

13) N_1 Ca_1 Mg_0 Zn Cu_0

14) N_1 Ca_1 Mg_0 Zn Cu_1

15) N_1 Ca_1 Mg_1 Zn Cu_0

16) N_1 Ca_1 Mg_1 Zn Cu_1

17) N_2 Ca_0 Mg_0 Zn Cu_0

18) N_2 Ca_0 Mg_0 Zn Cu_1

19) N_2 Ca_0 Mg_1 Zn Cu_0

20) N_2 Ca_0 Mg_1 Zn Cu_1

21) N_2 Ca_1 Mg_0 Zn Cu_0

22) N_2 Ca_1 Mg_0 Zn Cu_1

23) N_2 Ca_1 Mg_1 Zn Cu_0

24) N_2 Ca_1 Mg_1 Zn Cu_1

Wherein:

N_0	=	No nitrogen
N_1	=	125 Kg nitrogen/Hectare
N_2	=	250 Kg/Hectare
Ca_0	=	No calcium
Ca_1	=	625 Kg calcium/Hectare

Mg_0	=	No magnesium
Mg_1	=	625 Kg magnesium/Hectare
$Zn\ Cu_0$	=	No zinc and copper
$Zn\ Cu_1$	=	25 Kg zinc and 25 Kg copper/Hectare

Besides the different nutrient combinations given above each plot received phosphorous and potash at 50 kg/Hectare each.

Amounts of different commercial fertilizers used per plot to give the required nutrients:

1) Lime	1.05 kg	
2) Ammonium sulphate	N_0	Nil
	N_1	0.5625 Kg
	N_2	1.1250 Kg
3) Magnesium carbonate	Mg_1	1.25 Kg
4) Zinc sulphate + copper sulphate	$Zn\ Cu_1$	23 gms + 23 gms
5) Super phosphate		0.73 Kg
6) Muriate of potash		0.188 Kg

Date of sowing 25th October 1966

Dates of counts of insects:

1st observation		9--11--1966
2nd	"	16--11--1966
3rd	"	23--11--1966
4th	"	30--11--1966
5th	"	7--12--1966
6th	"	14--12--1966
7th	"	21--12--1966
8th	"	28--12--1966

Dates of plucking fruits:

1st plucking	7—12—1966
2nd "	11—12—1966
3rd "	15—12—1966
4th "	18—12—1966
5th "	22—12—1966
6th "	24—12—1966
7th "	29—12—1966
8th "	2—1—1967
9th "	5—1—1967
10th "	10—1—1967

Temperature, humidity and rain fall during the experiment: Data on the minimum and maximum temperature and rainfall during the period of the experiment are given in Appendix I.

Procedure: The laying out of the experiment, the application of fertilizers and the assessment of results were done as described under 'Methods'. To assess the extent of infestation, counts were made on four plants in each plot (net plot). During the first four weeks, counts of jassids and aphids were made on all the leaves of the four plants and for subsequent counts aphids on the upper five leaves alone were counted and jassids on all the leaves except the bottom 3 leaves which had become soiled by soil particles. Infestation by borers was assessed by counting the number of fruits damaged by the boring caterpillars.

Results: Result of the experiment are given in Appendices II to IV. Appendices II and III give detailed counts of the aphid *Aphis gossypii* and the jassid *Empoasca devastens* respectively which were observed on the plants on various occasions. Appendix IV gives the data of the bhindi fruits damaged by the fruit borer *Earias fabia*. All these data were analysed statistically, the details of which are presented below.

Effect of different fertilizers on the incidence of *Aphis gossypii*

Table 1 gives a consolidated statement of the total counts of *Aphis gossypii* taken at the various intervals. Table 2 gives the mean number of aphids corresponding to the different treatment combinations. Table 3 summarises the analysis of the data.

The x^2 value for all main effects and all two factor interactions are significant except the interaction between magnesium and zinc copper.

Thus there is a significant positive correlation between the aphid population and the doses of nitrogen and magnesium and a negative correlation between the aphid population and the doses of calcium and zinc copper. There is also significant positive correlation between aphid population and the nutrient combinations nitrogen + calcium, nitrogen + magnesium, calcium + magnesium and nitrogen + zinc copper. The calcium zinc copper combination shows significant positive correlation at .05 level.

Table 1

Consolidated data of the counts of *Aphis gossypii* in the various treatments

Treatment number	R I	R II	Total
T_1	778	1178	1956
T_2	298	2497	2795
T_3	365	700	1065
T_4	248	334	582
T_5	229	351	580
T_6	267	166	433
T_7	930	504	1434
T_8	792	456	1248
T_9	1451	532	1983
T_{10}	437	412	849
T_{11}	840	924	1764
T_{12}	812	773	1585
T_{13}	1042	498	1540
T_{14}	690	785	1475
T_{15}	636	987	1623
T_{16}	550	801	1351
T_{17}	1244	876	2120
T_{18}	1073	608	1681
T_{19}	456	1349	1805
T_{20}	1695	918	2613
T_{21}	816	518	1334
T_{22}	667	1247	1914
T_{23}	1290	838	2128
T_{24}	731	1403	2134

Table 2

Mean number of aphids corresponding to different treatments

	N_0	N_1	N_2	Mean
Ca_0	799.75	772.63	1027.38	866.59
Ca_1	461.88	748.63	938.75	716.42
Mean	630.82	760.63	983.07	791.51

	N_0	N_1	N_2	Mean
Mg_0	720.50	730.88	881.13	777.51
Mg_1	541.13	790.38	1085.00	805.50
Mean	630.82	760.63	983.07	791.51

	N_0	N_1	N_2	Mean
Zn Cu_0	629.38	863.75	923.38	805.50
Zn Cu_1	632.25	657.50	1042.75	777.50
Mean	630.82	760.63	983.07	791.51

	Ca_0	Ca_1	Mean
Mg_0	948.67	606.33	777.51
Mg_1	784.50	826.50	805.50
Mean	866.59	716.42	791.51

	Ca_0	Ca_1	Mean
Zn Cu_0	891.08	719.93	805.51
Zn Cu_1	842.08	712.92	777.50
Mean	866.59	716.42	791.51

	Mg_0	Mg_1	Mean
Zn Cu_0	792.75	818.26	805.51
Zn Cu_1	762.25	792.75	777.50
Mean	777.50	805.50	791.51

Table 3

Chi-square values of the aphid population corresponding to different treatments

Comparisons	df	X^2 value	
Between levels of N	2	1283.03^+	* *
,, ,, Ca	1	170.94^-	* *
,, ,, Mg	1	11.87^+	* *
,, ,, Zn Cu	1	11.87^-	* *
Association between NCa	2	420.95^+	* *
,, ,, N Mg	2	379.99^+	* *
,, ,, N Zn Cu	2	269.98^+	* *
,, ,, Ca Mg	1	580.93^+	* *
,, ,, Ca Zn Cu	1	5.13^+	*
,, ,, Mg Zn Cu	1	0.13	

X_1^2 (.01) 6.635 X_2^2 (.01) 9.210
(.05) 3.841 (.05) 5.991

* * Significant at .01 level
  * Significant only at.05 level

Effect of different fertilizers on the incidence of *Empoasca devastens* on bhindi plants at different stages of growth

(a) On seven day old plants

The data on the counts of the jassids and the results of their analysis are given in Tables 4, 5 and 6. It may be seen that the chi-square values for the effect of the individual nutrients and their combinations are not significant. This shows that the plant nutrients do not influence the jassid infestation in any way at this stage.

Table 4

Counts of E. devastens on bhindi plants and the treatments observed seven days after sowing (First count)

Treatment number	R_I	R_{II}	Total
T_1	1	..	1
T_2	..	1	1
T_3	3	..	3
T_4	1	1	2
T_5	1	..	1
T_6	..	1	1
T_7	..	..	..
T_8	..	..	..
T_9	1	..	1
T_{10}	1	..	1
T_{11}	..	..	..
T_{12}	1	..	1
T_{13}	..	..	..
T_{14}	1	..	1
T_{15}	3	..	3
T_{16}	2	1	3
T_{17}	..	1	1
T_{18}	2	..	2
T_{19}	3	..	3
T_{20}	1	2	3
T_{21}	2	1	3
T_{22}	..	..	..
T_{23}	..	..	..
T_{24}	1	..	1

Table 5

Mean number of jassids corresponding to first count

	N_0	N_1	N_2	Mean
Ca_0	0.88	0.38	1.13	0.80
Ca_1	0.25	0.88	0.50	0.54
Mean	0.57	0.63	0.82	0.67

	N_0	N_1	N_2	Mean
Mg_0	0.50	0.38	0.75	0.54
Mg_1	0.63	0.88	0.88	0.80
Mean	0.57	0.63	0.82	0.67

	N_0	N_1	N_2	Mean
Zn Cu_0	0.63	0.50	0.88	0.67
Zn Cu_1	0.50	0.75	0.75	0.67
Mean	0.57	0.63	0.82	0.67

	Ca_0	Ca_1	Mean
Mg_0	0.58	0.50	0.54
Mg_1	1.00	0.58	0.80
Mean	0.80	0.54	0.67

	Ca_0	Ca_1	Mean
Zn Cu_0	0.75	0.58	0.67
Zn Cu_1	0.83	0.50	0.67
Mean	0.80	0.54	0.67

	Mg_0	Mg_1	Mean
Zn Cu_0	0.58	0.75	0.67
Zn Cu_1	0.50	0.83	0.67
Mean	0.54	0.89	0.67

Table 6

Chi-square values of the jassids corresponding to different treatments in the first count

Comparisons			df	χ^2 value
Between levels of N			2	0.58
"	"	Ca	1	1.58
"	"	Mg	1	0.81
"	"	Zn Cu	1	0.32
Association between N Ca			2	5.35
"	"	N Mg	2	0.70
"	"	N Zn Cu	2	0.60
"	"	Ca Mg	1	0.55
"	"	Ca Zn Cu	1	0.52
"	"	Mg Zn Cu	1	0.00

χ^2_1 (.01) = 6.635 χ^2_2 (.01) = 9.210

(.05) = 3.841 (.05) = 5.991

(b) On fourteen day old plants

Tables 7, 8 and 9 give the results of the counts and their analysis.

The Chi-square values for the effects of nitrogen and calcium and the combination nitrogen + calcium are significant. The rest are not significant. There is significant positive correlation between the jassid population and the doses of nitrogen and a negative correlation between jassids and the doses of calcium at 0.05 level. The correlation between jassid and nitrogen + calcium combination at 0.05 level is positive and significant.

(c) <u>On twenty one day old plants</u>

Tables 10, 11 and 12 give the results and their analysis. The chi-square value of the effects of nitrogen, magnesium and zinc copper and the combination nitrogen+calcium are significant. The rest are not significant.

The correlations between the jassid population and the doses of nitrogen magnesium (.05 level only) and zinc copper are positive and significant. There is also significant positive correlation between the jassids and the nitrogen + calcium combination.

(d) <u>On twenty eight day old plants</u>

The counts of the jassids and their analysis are given in Tables 13, 14 and 15.

The chi-square values of the effects of nitrogen, magnesium, zinc copper and their combinations nitrogen + calcium, nitrogen + zinc copper and calcium + zinc copper are significant. Thus their exists significant

Table 7

Counts of *E. devastens* on bhindi plants under the various treatments observed fourteen days after sowing (second count)

Treatments	R_I	R_{II}	Total
T_1	2	1	3
T_2	-	4	4
T_3	-	3	3
T_4	1	2	3
T_5	-	-	-
T_6	-	-	-
T_7	-	1	1
T_8	1	-	1
T_9	4	1	5
T_{10}	2	2	4
T_{11}	-	2	2
T_{12}	2	2	4
T_{13}	2	-	2
T_{14}	-	1	1
T_{15}	-	2	2
T_{16}	1	-	1
T_{17}	1	3	4
T_{18}	4	4	8
T_{19}	1	-	1
T_{20}	1	4	5
T_{21}	1	2	3
T_{22}	2	2	4
T_{23}	3	-	3
T_{24}	3	6	9

Table 8

Mean number of jassids corresponding to second count

	N_0	N_1	N_2	Mean
Ca_0	1.63	1.88	2.25	1.92
Ca_1	0.25	0.75	2.38	1.13
Mean	0.94	1.32	1.53	1.53

	N_0	N_1	N_2	Mean
Mg_0	0.88	1.50	2.38	1.59
Mg_1	1.00	1.13	2.25	1.46
Mean	0.94	1.32	2.32	1.53

	N_0	N_1	N_2	Mean
Zn Cu_0	0.88	1.38	1.38	1.21
Zn Cu_1	1.00	1.25	3.25	1.46
Mean	0.94	1.32	2.32	1.53

	Ca_0	Ca_1	Mean
Mg_0	2.33	0.83	1.59
Mg_1	1.50	1.42	1.46
Mean	1.92	1.13	1.53

	Ca_0	Ca_1	Mean
Zn Cu_0	1.50	0.92	1.21
Zn Cu_1	2.33	1.33	1.83
Mean	1.92	1.13	1.53

	Mg_0	Mg_1	Mean
Zn Cu_0	1.42	1.00	1.21
Zn Cu_1	1.75	1.92	1.83
Mean	1.59	1.46	1.53

positive correlation between the jassid population and the doses of nitrogen, magnesium and zinc copper and their mixtures of nitrogen + calcium, nitrogen + zinc copper and calcium + zinc copper (.05).

Table 9

Chi-square values of the jassids corresponding to different treatments in second count

Comparisons			df	X^2 value
Between levels of N			2	10.63$^+$ * *
,,	,,	Ca	1	4.95$^-$ *
,,	,,	Mg	1	0.12
,,	,,	Zn Cu	1	1.54
Association between N Ca			2	8.14$^+$ *
,,	,,	N Mg	2	0.46
,,	,,	N Zn Cu	2	3.85
,,	,,	Ca Mg	1	3.77
,,	,,	Ca Zn Cu	1	0.00
,,	,,	Mg Zn Cu	1	0.92

X_1^2 (.01) = 6.635 X_2^2 (.01) = 9.210
(.05) = 3.841 (.05) = 5.991

* * Significant at both .01 and .05 levels

* Significant only at .05 level

Table 10

Counts of E. devastens on bhindi plants under the various treatments observed twenty one days after sowing (Third count)

Treatments	R_I	R_{II}	Total
T_1	2	-	2
T_2	2	16	18
T_3	2	2	4
T_4	2	15	17
T_5	5	4	9
T_6	2	2	4
T_7	10	3	13
T_8	11	2	13
T_9	9	8	17
T_{10}	8	7	15
T_{11}	6	8	14
T_{12}	15	15	30
T_{13}	12	2	14
T_{14}	3	7	10
T_{15}	6	3	9
T_{16}	4	9	13
T_{17}	16	8	24
T_{18}	9	3	12
T_{19}	16	2	18
T_{20}	10	10	20
T_{21}	7	1	8
T_{22}	18	12	30
T_{23}	2	15	17
T_{24}	10	31	41

Table 11

Mean number of jassids corresponding to Third count.

	N_0	N_1	N_2	mean
Ca_0	5.12	9.50	9.25	7.96
Ca_1	4.87	5.75	12.00	7.54
mean	5.00	7.63	10.63	7.75

	N_0	N_1	N_2	mean
Mg_0	4.12	7.00	9.25	6.79
Mg_1	5.87	8.25	12.00	8.71
mean	5.00	7.63	10.63	7.75

	N_0	N_1	N_2	mean
Zn Cu_0	3.50	6.75	8.38	6.21
Zn Cu_1	6.50	8.50	12.85	9.28
mean	5.00	7.63	10.63	7.75

	Ca_0	Ca_1	mean
Mg_0	7.33	6.25	6.79
Mg_1	8.58	8.83	8.71
mean	7.96	7.54	7.75

	Ca_0	Ca_1	mean
Zn Cu_0	6.58	5.83	6.21
Zn Cu_1	9.33	9.25	9.28
mean	7.96	7.54	7.75

	Mg_0	Mg_1	mean
Zn Cu_0	6.71	6.25	6.21
Zn Cu_1	7.41	11.17	9.28
mean	6.79	8.71	7.75

Table 12

Chi-square values of the jassids corresponding to different treatments in third count

Comparisons		df	χ^2 value
Between levels of N		2	32.71+ * *
,, ,,	Ca	1	0.27
,, ,,	Mg	1	5.67+ *
,, ,,	Zn Cu	1	14.72+ * *
Association between	N Ca	2	9.52+ * *
,, ,,	N Mg	2	0.50
,, ,,	N Zn Cu	2	1.70
,, ,,	Ca Mg	1	0.70
,, ,,	Ca Zn Cu	1	0.19
,, ,,	Mg Zn Cu	1	3.69

χ^2_1 (.01) = 6.635 χ^2_2 (.01) = 9.210
(.05) = 3.841 (.05) = 5.991

* * Significant at both .01 and .05 levels
* Significant only at .05 level.

(e) On thirty five day old plants

Results are given in Tables 16, 17 and 18.

The chi-square values of the effects of nitrogen, magnesium and the combination nitrogen + calcium, nitrogen + magnesium, calcium + magnesium, nitrogen + zinc copper, calcium + zinc copper and magnesium + zinc copper are significant. There is significant positive correlation

Table 13

Counts of *E. devastens* on bhindi plants under the various treatments observed twenty eight days after sowing (Fourth count)

Treatments	R_I	R_{II}	Total
T_1	10	7	17
T_2	10	24	34
T_3	5	14	19
T_4	7	34	41
T_5	6	8	14
T_6	9	13	22
T_7	7	9	16
T_8	6	15	21
T_9	18	32	50
T_{10}	9	14	23
T_{11}	27	30	57
T_{12}	22	34	56
T_{13}	19	9	28
T_{14}	14	35	49
T_{15}	7	35	42
T_{16}	6	37	43
T_{17}	35	21	56
T_{18}	19	20	39
T_{19}	15	17	32
T_{20}	13	49	62
T_{21}	24	5	29
T_{22}	28	33	61
T_{23}	5	54	59
T_{24}	27	55	82

Table 14

Mean number of jassids corresponding to fourth count.

	N_0	N_1	N_2	mean
Ca_0	13.87	23.25	23.63	20.25
Ca_1	9.13	20.25	28.87	19.42
mean	11.50	21.75	26.24	19.83

	N_0	N_1	N_2	mean
Mg_0	10.87	18.75	23.13	17.58
Mg_1	12.13	24.75	29.37	22.08
mean	11.50	21.75	26.24	19.83

	N_0	N_1	N_2	mean
Zn Cu_0	8.25	22.12	22.00	17.46
Zn Cu_1	14.75	21.38	30.50	22.21
mean	11.50	21.75	26.24	19.83

	Ca_0	Ca_1	mean
Mg_0	18.25	16.92	17.58
Mg_1	22.25	21.92	22.08
mean	20.25	19.42	19.83

	Ca_0	Ca_1	mean
Zn Cu_0	19.25	15.66	17.46
Zn Cu_1	21.25	23.17	22.21
mean	20.25	19.42	19.83

	Mg_0	Mg_1	mean
Zn Cu_0	16.17	18.75	17.46
Zn Cu_1	19.00	25.42	22.21
mean	17.58	22.08	19.83

between jassids and the effects of nitrogen, magnesium and the combinations nitrogen + calcium, calcium + magnesium, nitrogen + zinc copper, calcium + zinc copper and magnesium + zinc copper.

There is significant negative correlation between jassids and combination nitrogen + magnesium.

Table 15

Chi-square values of the jassids corresponding to different treatments in fourth count

Comparisons	df	X^2 value
Between levels of N	2	92.20[+] * *
,, ,, Ca	1	0.42
,, ,, Mg	1	12.25[+] * *
,, ,, Zn Cu	1	13.65[+] * *
Association between N Ca	2	12.97[+] * *
,, ,, N Mg	2	0.74
,, ,, N Zn Cu	2	12.45[+] * *
,, ,, Ca Mg	1	0.27
,, ,, Ca Zn Cu	1	4.93[+] *
,, ,, Mg Zn Cu	1	1.10

X_1^2 (.01) = 6.635 X_2^2 (.01) = 9.210
(.05) = 3.841 (.05) = 5.991

* * Significant at .01 level
* Significant only at .05 level

Table 16

Counts of E. devastens on bhindi plants under the various treatments observed thirty five days after sowing
(Fourth count)

Treatments.	R_I	R_{II}	Total
T_1	19	14	33
T_2	28	50	78
T_3	27	42	69
T_4	12	51	63
T_5	15	21	36
T_6	19	14	33
T_7	9	25	34
T_8	50	32	82
T_9	158	51	209
T_{10}	26	32	58
T_{11}	100	67	167
T_{12}	67	97	164
T_{13}	73	38	111
T_{14}	20	117	137
T_{15}	33	122	155
T_{16}	7	133	140
T_{17}	148	101	249
T_{18}	100	37	137
T_{19}	21	36	57
T_{20}	45	117	162
T_{21}	75	21	96
T_{22}	49	108	157
T_{23}	23	161	184
T_{24}	101	103	204

Table 17

Mean number of jassids corresponding to fifth count.

	N_0	N_1	N_2	mean
Ca_0	30.37	74.75	75.63	60.25
Ca_1	23.13	67.87	80.12	57.04
mean	26.75	71.32	77.88	58.65

	N_0	N_1	N_2	mean
Mg_0	22.50	64.38	79.87	55.58
Mg_1	31.00	78.25	75.87	61.71
mean	26.75	71.32	77.88	58.65

	N_0	N_1	N_2	mean
Zn Cu_0	21.50	80.25	73.25	58.33
Zn Cu_1	32.00	62.38	82.50	58.96
mean	26.75	71.32	77.88	58.65

	Ca_0	Ca_1	mean
Mg_0	63.67	47.50	55.58
Mg_1	56.83	66.58	61.71
mean	60.25	57.04	58.65

	Ca_0	Ca_1	mean
Zn Cu_0	65.33	51.33	58.33
Zn Cu_1	55.17	62.75	58.96
mean	60.25	57.04	58.65

	Mg_0	Mg_1	mean
Zn Cu_0	61.17	55.50	58.33
Zn Cu_1	50.00	67.92	58.96
mean	55.58	61.71	58.65

Table 18

Chi-square values of the jassids corresponding to different treatments in fifth count

Comparisons	df	X^2 value
Between levels of N	2	422.21^{+} * *
" " Ca	1	2.11
" " Mg	1	7.68^{+} * *
" " Zn Cu	1	0.799
Association between N Ca	2	11.71^{+} * *
" " N Mg	2	15.07^{-} * *
" " N Zn Cu	2	39.14^{+} * *
" " Ca Mg	1	35.60^{+} * *
" " Ca Zn Cu	1	24.03^{+} * *
" " Mg Zn Cu	1	28.73^{+} * *

X_1^2 (.01) = 6.635 X_2^2 (.01) = 9.210
(.05) = 3.841 (.05) = 5.991

* * Significant at .01 level
* Significant only at .05 level

(f) On forty two day old plants

Results and their statistical analysis are given in Tables 19, 20 and 21.

The chi-square values of the effects of all individual nutrients and their combinations are significant except that of zinc copper and nitrogen + magnesium.

Table 19

Counts of *E. devastans* on bhindi plants under the various treatments observed forty two days after sowing (Sixth count)

Treatments	R_I	R_{II}	Total
T_1	29	44	73
T_2	39	36	75
T_3	35	41	76
T_4	17	99	116
T_5	21	25	46
T_6	26	42	68
T_7	22	17	39
T_8	49	28	77
T_9	240	87	327
T_{10}	62	38	100
T_{11}	107	199	306
T_{12}	121	248	369
T_{13}	87	99	186
T_{14}	54	256	310
T_{15}	36	139	175
T_{16}	47	123	170
T_{17}	291	147	438
T_{18}	129	81	210
T_{19}	25	107	132
T_{20}	42	162	204
T_{21}	81	44	125
T_{22}	113	99	212
T_{23}	25	249	274
T_{24}	117	263	380

Table 20

Mean number of jassids corresponding to sixth count.

	N_0	N_1	N_2	mean
Ca_0	42.50	137.75	123.00	101.08
Ca_1	28.75	105.12	123.88	85.92
mean	35.62	121.44	123.43	93.50

	N_0	N_1	N_2	mean
Mg_0	32.75	115.37	123.13	90.42
Mg_1	38.50	127.50	123.75	96.58
mean	35.62	121.44	123.43	93.50

	N_0	N_1	N_2	mean
Zn Cu_0	29.25	124.25	121.12	91.54
Zn Cu_1	42.00	118.62	125.75	95.46
mean	35.62	121.44	123.43	93.50

	Ca_0	Ca_1	mean
Mg_0	101.92	78.92	90.42
Mg_1	100.25	92.92	96.58
mean	101.08	85.92	93.50

	Ca_0	Ca_1	mean
Zn Cu_0	112.67	70.42	91.54
Zn Cu_1	89.50	101.42	95.46
mean	101.08	85.92	93.50

	Mg_0	Mg_1	mean
Zn Cu_0	99.58	83.50	91.54
Zn Cu_1	81.25	109.67	95.46
mean	90.42	96.58	93.50

Thus there is significant positive correlation between the jassid infestation and the doses of nitrogen and magnesium and significant negative correlation between the jassids and the doses of calcium.

There is significant positive correlation between jassids and the combination nitrogen + calcium, calcium + magnesium, calcium + zinc copper and magnesium + zinc copper and significant negative correlation between jassids and the nitrogen + zinc copper combination.

Table 21

Chi-square values of the jassids corresponding to different treatments in the sixth count

Comparisons	df	X^2 value
Between levels of N	2	860.11^{+} * *
,, ,, Ca	1	29.52^{-} * *
,, ,, Mg	1	4.88^{+} *
,, ,, Zn Cu	1	1.97
Association between N Ca	2	27.23^{+} * *
,, ,, N Mg	2	3.72
,, ,, N Zn Cu	2	18.03^{-} * *
,, ,, Ca Mg	1	8.99^{+} * *
,, ,, Ca Zn Cu	1	96.57^{+} * *
,, ,, Mg Zn Cu	1	63.17^{+} * *

X_1^2 (.01) = 6.635 (.05) = 3.841 X_2^2 (.01) = 9.210 (.05) = 5.991

* * Significant at .01 level
* Significant only at .05 level

Table 22

Counts of E. devastens on bhindi plants under the various treatments observed forty nine days after sowing(Seventh count)

Treatments	R_I	R_{II}	Total
T_1	24	68	92
T_2	58	32	90
T_3	13	53	66
T_4	12	79	91
T_5	28	18	46
T_6	26	39	65
T_7	16	22	38
T_8	55	31	86
T_9	183	216	399
T_{10}	52	78	130
T_{11}	100	150	250
T_{12}	88	321	409
T_{13}	56	54	110
T_{14}	84	142	226
T_{15}	47	136	183
T_{16}	36	98	134
T_{17}	341	94	435
T_{18}	158	96	254
T_{19}	19	103	122
T_{20}	56	146	202
T_{21}	174	28	202
T_{22}	114	143	257
T_{23}	42	159	201
T_{24}	89	214	303

Table 23

Mean number of jassids corresponding to seventh count.

	N_0	N_1	N_2	mean
Ca_0	42.37	148.50	126.63	105.83
Ca_1	29.38	81.62	120.37	77.12
mean	35.87	115.06	123.50	91.48

	N_0	N_1	N_2	mean
Mg_0	36.62	108.13	143.50	96.08
Mg_1	35.13	122.00	103.50	86.88
mean	35.87	115.06	123.50	91.48

	N_0	N_1	N_2	mean
Zn Cu_0	30.25	117.75	120.00	89.33
Zn Cu_1	41.50	112.57	127.00	93.62
mean	35.87	115.06	123.50	91.48

	Ca_0	Ca_1	mean
Mg_0	116.67	75.50	96.08
Mg_1	95.00	78.75	86.88
mean	105.83	77.12	91.48

	Ca_0	Ca_1	mean
Zn Cu_0	113.67	65.00	89.33
Zn Cu_1	98.00	89.25	93.62
mean	105.83	77.12	91.48

	Mg_0	Mg_1	mean
Zn Cu_0	107.00	71.67	89.33
Zn Cu_1	85.17	102.08	93.62
mean	96.08	86.88	91.48

(g) <u>On forty nine day old plants</u>

Tables 22, 23 and 24 give the results. The chi-square value of the treatments are significant except that of zinc copper.

There is significant positive correlation between the jassid incidence and the doses of nitrogen and significant negative correlation between jassids and the dosses of calcium and magnesium.

There is significant positive correlation between jassids and all the nutrient combinations excepting nitrogen + magnesium which has significant negative correlation.

<u>Table 24</u>

<u>X^2 values of the jassids corresponding to different treatments in seventh count</u>

Comparisons	df	X^2 value
Between levels of N	2	817.38^{+} * *
,, ,, Ca	1	108.11^{-} * *
,, ,, Mg	1	11.12^{-} * *
,, ,, Zn Cu	1	2.42
Association between N Ca	2	69.14^{+} * *
,, ,, N Mg	2	47.66^{-} * *
,, ,, N Zn Cu	2	14.14^{+} * *
,, ,, Ca Mg	1	16.16^{+} * *
,, ,, Ca Zn Cu	1	57.48^{+} * *
,, ,, Mg Zn Cu	1	91.24^{+} * *

X_1^2 (.01) = 6.635 X_2^2 (.01) = 9.210
(.05) = 3.841 (.05) = 5.991

* * Significant at both levels
* Significant at only .05 level

Table 25

Counts of E. devastens on bhindi plants under the various treatments observed fifty six days after sowing (Eighth count)

Treatments	R_I	R_{II}	Total
T_1	33	66	99
T_2	61	44	101
T_3	21	53	74
T_4	10	78	88
T_5	22	17	39
T_6	24	39	63
T_7	23	18	41
T_8	58	31	89
T_9	172	200	372
T_{10}	59	85	144
T_{11}	99	106	205
T_{12}	149	330	479
T_{13}	54	49	103
T_{14}	81	144	225
T_{15}	45	173	218
T_{16}	40	108	148
T_{17}	333	98	431
T_{18}	289	95	384
T_{19}	25	114	139
T_{20}	42	162	204
T_{21}	168	48	216
T_{22}	88	202	290
T_{23}	33	81	114
T_{24}	94	138	232

Table 26

Mean number of jassids corresponding to eighth count.

	N_0	N_1	N_2	mean
Ca_0	45.25	150.00	144.75	113.33
Ca_1	29.00	86.75	106.05	74.08
mean	37.12	118.38	125.62	93.71

	N_0	N_1	N_2	mean
Mg_0	37.75	105.50	165.13	102.79
Mg_1	36.50	131.25	86.12	84.62
mean	37.12	118.38	125.62	93.71

	N_0	N_1	N_2	mean
Zn Cu_0	31.62	112.25	112.50	85.46
Zn Cu_1	42.62	124.50	138.75	101.96
mean	37.12	118.38	125.62	93.71

	Ca_0	Ca_1	mean
Mg_0	127.58	78.00	102.79
Mg_1	99.08	70.17	84.62
mean	113.33	74.08	93.71

	Ca_0	Ca_1	mean
Zn Cu_0	110.00	60.92	85.46
Zn Cu_1	116.67	87.25	101.96
mean	113.33	74.08	93.71

	Mg_0	Mg_1	mean
Zn Cu_0	105.00	65.92	85.46
Zn Cu_1	100.58	103.33	101.96
mean	102.79	84.62	93.71

(h) On fifty six day old plants

The data on the counts of jassids and their analysis are represented in Table 25, 26 and 27.

The chi-square values of the effects of the individual nutrients and their combination excepting that of the nitrogen + zinc copper combination are significant. There is significant positive correlation between the jassid infestation and the doses of nitrogen and zinc copper and significant negative correlation between jassids and the doses of calcium and magnesium.

Significant positive correlation exists between jassids and the rest of the combinations except nitrogen + magnesium which is negative.

Table 27

X^2 values of the jassids corresponding to different treatments in eighth count

Comparisons	df	X^2 value
Between levels of N	2	824.48^{+} * *
,, ,, Ca	1	197.28^{-} * *
,, ,, Mg	1	42.26^{-} * *
,, ,, Zn Cu	1	34.86^{+} * *
Association between N Ca	2	13.51^{+} * *
,, ,, N Mg	2	181.33^{-} * *
,, ,, N Zn Cu	2	3.15
,, ,, Ca Mg	1	5.86^{+} *
,, ,, Ca Zn Cu	1	23.99^{+} * *
,, ,, Mg Zn Cu	1	65.95^{+} * *

X_1^2 (.01) = 6.635 X_2^2 (.01) = 9.210
(.05) = 3.841 (.05) = 5.991

** Significant at .01 level
 * Significant at only .05 level

Table 28

Consolidated data of total number of fruits infested and not infested by *Earias fabia*

Treatments	R_I		R_{II}		Total		Grand total
	I	H	I	H	I	H	
T_1	14	11	5	9	19	20	39
T_2	5	19	10	15	15	34	49
T_3	6	15	14	15	20	30	50
T_4	12	9	12	21	24	30	54
T_5	5	6	5	11	10	17	27
T_6	10	17	1	5	11	22	33
T_7	7	13	7	16	14	29	43
T_8	7	19	8	16	15	35	50
T_9	17	33	16	38	33	71	104
T_{10}	16	21	12	23	28	44	72
T_{11}	22	35	13	38	35	73	108
T_{12}	17	37	17	46	34	83	117
T_{13}	15	40	12	19	27	59	86
T_{14}	17	37	22	42	39	79	118
T_{15}	13	19	20	33	33	52	85
T_{16}	11	13	20	38	31	51	82
T_{17}	28	40	18	39	46	79	125
T_{18}	17	27	12	11	29	38	67
T_{19}	12	8	9	17	21	25	46
T_{20}	19	22	13	38	32	60	92
T_{21}	20	40	9	13	29	53	82
T_{22}	21	43	30	35	51	78	129
T_{23}	14	26	23	48	37	74	111
T_{24}	26	44	27	32	53	76	129

Table 29

Mean number of fruits infested per plot corresponding to different treatment combinations

	N_0 I	N_0 H	N_1 I	N_1 H	N_2 I	N_2 H	Mean
Zn Cu_0	7.87	12.00	16.00	31.87	16.63	28.88	18.87
Zn Cu_1	8.13	15.12	16.50	32.13	20.62	31.50	20.67
Mean	8.00	13.56	16.25	32.00	18.62	30.19	19.77

	N_0 I	N_0 H	N_1 I	N_1 H	N_2 I	N_2 H	Mean
Mg_0	6.87	11.63	15.87	31.63	19.37	31.00	19.39
Mg_1	9.13	15.50	16.63	32.37	17.87	29.38	20.15
Mean	8.00	13.56	16.25	32.00	18.62	30.19	19.77

	N_0 I	N_0 H	N_1 I	N_1 H	N_2 I	N_2 H	Mean
Ca_0	9.75	14.25	16.25	33.88	16.00	25.25	19.23
Ca_1	6.25	12.87	16.25	30.12	21.25	35.13	20.31
Mean	8.00	13.56	16.25	32.00	18.62	30.19	19.77

	Ca_0 I	Ca_0 H	Ca_1 I	Ca_1 H	Mean
Mg_0	14.17	23.83	13.92	25.67	19.39
Mg_1	13.83	25.08	15.25	26.42	20.15
Mean	14.00	24.45	14.59	26.04	19.77

	Ca_0 I	Ca_0 H	Ca_1 I	Ca_1 H	Mean
Zn Cu_0	14.50	24.83	12.50	23.67	18.87
Zn Cu_1	13.50	24.08	16.67	28.42	20.67
Mean	14.00	24.45	14.59	26.04	19.77

	Zn Cu_0 I	Zn Cu_0 H	Zn Cu_1 I	Zn Cu_1 H	Mean
Mg_0	13.67	24.92	14.42	24.58	19.39
Mg_1	13.33	23.58	15.75	27.92	20.15
Mean	13.50	24.25	15.08	26.25	19.77

Effect of different fertilizers on the incidence of the fruit borer *Earias fabia*

Table 28 gives a consolidated statement of the total number of fruits infested and free of infestation. Table 29 gives the mean number of borers corresponding to the different treatments and Table 30 summarises the analysis of the data.

The chi-square values of the combinations nitrogen + calcium and calcium + zinc copper alone are significant. The rest of the treatments are not significant.

There is a significant negative correlation between the borers and the combination nitrogen + calcium and calcium + zinc copper.

Table 30

Chi-square values of the fruits infested and not infested by borers corresponding to different treatments

Comparisons	df	X^2 value
Between levels of N	2	3.561
,, ,, Ca	1	0.034
,, ,, Mg	1	0.009
,, ,, Zn Cu	1	0.081
Association between N Ca	2	26.126**
,, ,, N Mg	2	3.686
,, ,, N Zn Cu	2	0.052
,, ,, Ca Mg	1	0.573
,, ,, Ca Zn Cu	1	9.003**
,, ,, Mg Zn Cu	1	3.088

X_1^2 (.01) = 6.635 X_2^2 (.01) = 9.210
(.05) = 3.841 (.05) = 5.991

** Significant at both levels

DISCUSSION

DISCUSSION

The responses of the different doses of different nutrients and their associations to the aphids and borers are represented in Table 31 and jassids in Table 32.

There is a positive correlation between the aphid population on bhindi and the doses of nitrogen. A similar increase in the population of *Aphis craccivora* on groundnut (Waghray and Singh 1965) and Rhopalosiphum maidis on corn (Terry *et al*. 1966), as a result of increased doses of nitrogen application have been reported. But Arant and Jones (1951) found a negative correlation between the population of *Toxoptera graminum* on oats and doses of nitrogen applied. These contridicting observations cannot be explained in the light of findings in the present investigations, consequent on application of higher doses of nitrogen. The increased vegetative growth of the plant may be providing the aphid with favourable conditions for the building up of its population.

The significant positive correlation observed between aphid population and the doses of magnesium agrees with the findings of Davidson (1925) on the pests of beans. The nutrient associations nitrogen + calcium, nitrogen + magnesium, calcium + magnesium and nitrogen + zinc copper also show a significant positive correlation with the aphid population. There is a negative correlation between the doses of calcium and zinc copper and the aphid population when they are used individually. But the

Table 31

Responses of different nutrients on the population of aphids and borers on bhindi

Comparisons	Responses to Aphids	Responses to Borers
Between levels of N	+	0
" " Ca	-	0
" " Mg	+	0
" " ZnCu	-	0
Association between NCa	+	-
" " NMg	+	0
" " NZnCu	+	0
" " CaMg	+	0
" " CaZnCu	+	-
" " MgZnCu	0	0

Table 32

Responses of different nutrients on the population of jassids on bhindi at its different stages of growth

Comparisons	Responses at various stages of growth (days)							
	7	14	21	28	35	42	49	56
Between levels of N	0	+	+	+	+	+	+	+
" " Ca	0	-	0	0	0	-	-	-
" " Mg	0	0	+	+	+	+	-	-
" " ZnCu	0	0	+	+	0	0	0	+
Association between NCa	0	+	+	+	+	+	+	+
" " NMg	0	0	0	0	-	0	-	-
" " NZnCu	0	0	0	+	+	-	+	0
" " CaMg	0	0	0	0	+	+	+	+
" " CaZnCu	0	0	0	+	+	+	+	+
" " MgZnCu	0	0	0	0	+	+	+	+

\+ Positive correlation

\- Negative correlation

0 No correlation.

association of calcium and zinc copper increases the pest population in direct proportion. This phenomenon also cannot be explained in the light of the data collected in these experiments.

Table 32 gives an overall picture of the responses of the jassid population on bhindi receiving different doses of nutrients observed at the different stages of growth of the plant. It may be noted that doses of nitrogen have a positive correlation with the jassid population throughout the life of the plant. Calcium shows a negative correlation throughout. Magnesium shows a positive correlation during the active growth of the plants. All the associations have positive correlation including the associations containing calcium which by itself shows a negative correlation. However it is worth of note that calcium by itself helps in reducing the jassid infestation, a property which is not possessed by any other nutrients under the present studies.

The population of the fruit and shoot borer Earias fabia shows significant response only to two nutrient associations viz., nitrogen + calcium & calcium + zinc copper. These two fertilizer associations show a negative correlation between their increased doses and the infestation by bhindi borers.

Among the three pests under study the aphids and the jassids are amenable to control with insecticides, while the borer is not so. The present results show that calcium is effective in reducing jassid and aphid infestations and zinc copper in reducing aphid infestation. Both these are not effective in influencing the borer incidence. On the other hand nitrogen + calcium and calcium + zinc copper treatments are effective in decreasing borer infestation, while they increase the jassid and aphid infestations. Since aphids and jassids are amenable to insecticidal control and the borers not, the adjustments in the application of fertilizers for pest control should be made for the control of the borer. Thus application of increased doses of nitrogen + calcium or calcium + zinc copper supplemented with insecticidal application to control jassids and aphids may prove to be advantageous in increasing the fruit yield of the crop.

SUMMARY

SUMMARY

A field experiment has been conducted to study the effect of four important plant nutrients viz., nitrogen, calcium, magnesium and zinc copper and their various associations (total 24 treatments) on the major pests of Bhindi viz., *Aphis gossypii*, *Empoasca devastans* and *Earias fabia*.

Calcium and zinc copper reduce aphid population whereas the remaining nutrients as well as the various associations of the different nutrients give a positive increase in population.

All the treatments except calcium give a significant increase in the population of the jassids either throughout the life of the plant or during the active growth of the same. Calcium by itself shows a negative correlation with the jassid population though in association with the other nutrients, it increases the population.

The population of *Earias fabia* shows a significant negative response to two of the nutrient associations viz., nitrogen + calcium and calcium + zinc copper, the other treatments do not show any significant correlations.

It is suggested that since nitrogen + calcium and calcium + zinc copper are effective in inhibiting the increase of the borer population, though not effective in inhibiting the aphid and jassid population, an increased yield of fruits may be ensured by fertilizing the bhindi crop with

increased doses of nitrogen + calcium or calcium + zinc copper and controlling the aphids and jassids with insecticides.

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APPENDIX

APPENDIX I

Record of Temperature and Humidity
(October 1966 to January 1967)

Month	Week	Temperature		Humidity	
		Maximum	Minimum	Maximum	Minimum
	1	86	74	90	89
	2	86	74	90	86
October	3	86	76	90	89
	4	88	76	90	83
	5	88	76	90	86
	1	86	76	91	86
	2	88	74	95	86
November	3	88	76	90	86
	4	88	76	90	86
	5	88	78	90	86
	1	88	76	90	86
	2	88	76	90	86
December	3	88	76	90	86
	4	88	74	90	86
	5	88	74	91	86
	1	88	74	91	86
	2	88	78	90	86
January 1967	3	88	78	90	83
	4	88	78	83	80
	5	88	78	86	83

Appendix 2

Total number of aphids observed at various occasions

Treatments	I	II	III	IV	V	VI	VII	VIII	Total (1–8)
1. N_0 Ca_0 Mg_0 Zn Cu_0	37	37	11	547	855	173	140	156	1956
2. N_0 Ca_0 Mg_0 Zn Cu_1	79	54	16	174	566	1410	145	351	2795
3. N_0 Ca_0 Mg_1 Zn Cu_0	164	48	13	81	241	176	128	154	1065
4. N_0 Ca_0 Mg_1 Zn Cu_1	20	49	23	100	122	97	88	83	582
5. N_0 Ca_1 Mg_0 Zn Cu_0	22	13	54	189	94	73	63	72	580
6. N_0 Ca_1 Mg_0 Zn Cu_1	20	16	46	71	108	48	61	63	433
7. N_0 Ca_1 Mg_1 Zn Cu_0	50	51	43	118	477	359	197	139	1434
8. N_0 Ca_1 Mg_1 Zn Cu_1	222	31	12	110	415	241	108	109	1248
9. N_1 Ca_0 Mg_0 Zn Cu_0	151	105	138	315	789	116	177	192	1983
10. N_1 Ca_0 Mg_0 Zn Cu_1	74	53	76	178	175	134	117	112	849
11. N_1 Ca_0 Mg_1 Zn Cu_0	106	83	115	478	595	148	124	115	1764
12. N_1 Ca_0 Mg_1 Zn Cu_1	131	346	144	164	319	166	153	162	1585
13. N_1 Ca_1 Mg_0 Zn Cu_0	56	29	130	452	476	121	133	143	1540
14. N_1 Ca_1 Mg_0 Zn Cu_1	130	148	141	414	369	116	87	70	1475
15. N_1 Ca_1 Mg_1 Zn Cu_0	115	159	82	190	345	219	239	234	1623
16. N_1 Ca_1 Mg_1 Zn Cu_1	259	96	47	222	196	117	224	190	1351
17. N_2 Ca_0 Mg_0 Zn Cu_0	227	766	149	174	314	187	156	147	2120
18. N_2 Ca_0 Mg_0 Zn Cu_1	54	86	131	398	479	210	167	156	1681
19. N_2 Ca_0 Mg_1 Zn Cu_0	50	46	59	392	200	234	339	485	1805
20. N_2 Ca_0 Mg_1 Zn Cu_1	269	166	153	167	423	362	527	546	2613
21. N_2 Ca_1 Mg_0 Zn Cu_0	120	127	95	288	342	89	146	127	1334
22. N_2 Ca_1 Mg_0 Zn Cu_1	109	140	121	227	395	144	363	415	1914
23. N_2 Ca_1 Mg_1 Zn Cu_0	116	324	245	427	428	126	211	251	2128
24. N_2 Ca_1 Mg_1 Zn Cu_1	103	273	121	565	552	147	178	195	2134

Grand Total 37992

Appendix 3

Total number of jassids observed at various occasions

	Treatments	I	II	III	IV	V	VI	VII	VIII	Total (1-8)
1	N_0 Ca_0 Mg_0 Zn Cu_0	1	3	2	17	33	73	92	99	320
2	N_0 Ca_0 Mg_0 Zn Cu_1	1	4	18	34	78	75	90	101	405
3	N_0 Ca_0 Mg_1 Zn Cu_0	3	3	4	19	69	76	66	74	314
4	N_0 Ca_0 Mg_1 Zn Cu_1	2	3	17	41	63	116	91	88	321
5	N_0 Ca_1 Mg_0 Zn Cu_0	1	-	9	14	36	46	46	39	191
6	N_0 Ca_1 Mg_0 Zn Cu_1	1	-	4	22	33	68	65	63	256
7	N_0 Ca_1 Mg_1 Zn Cu_0	-	1	13	16	34	39	58	41	182
8	N_0 Ca_1 Mg_1 Zn Cu_1	-	1	13	21	82	77	86	89	369
9	N_1 Ca_0 Mg_0 Zn Cu_0	1	5	17	50	209	327	399	372	1385
10	N_1 Ca_0 Mg_0 Zn Cu_1	1	4	15	23	58	100	130	144	475
11	N_1 Ca_0 Mg_1 Zn Cu_0	-	2	14	57	167	306	250	205	1001
12	N_1 Ca_0 Mg_1 Zn Cu_1	1	4	30	56	164	369	409	479	1512
13	N_1 Ca_1 Mg_0 Zn Cu_0	-	2	14	28	111	186	110	103	554
14	N_1 Ca_1 Mg_0 Zn Cu_1	1	1	10	49	137	310	226	225	959
15	N_1 Ca_1 Mg_1 Zn Cu_0	3	2	9	42	155	175	183	218	787
16	N_1 Ca_1 Mg_1 Zn Cu_1	3	1	13	43	140	170	134	148	652
17	N_2 Ca_0 Mg_0 Zn Cu_0	1	4	24	56	249	438	435	431	1638
18	N_2 Ca_0 Mg_0 Zn Cu_1	2	8	12	39	137	210	254	384	1046
19	N_2 Ca_0 Mg_1 Zn Cu_0	3	1	18	32	57	132	122	139	504
20	N_2 Ca_0 Mg_1 Zn Cu_1	3	5	20	62	162	204	202	204	862
21	N_2 Ca_1 Mg_0 Zn Cu_0	3	3	8	29	96	125	202	216	682
22	N_2 Ca_1 Mg_0 Zn Cu_1	-	4	30	61	157	212	257	290	1006
23	N_2 Ca_1 Mg_1 Zn Cu_0	-	3	17	59	184	274	201	114	852
24	N_2 Ca_1 Mg_1 Zn Cu_1	1	9	41	82	204	380	303	232	1252

Grand Total 17521

Appendix 4

Total number of fruits infested and not infested by borers as observed at various occasions

Treatments	I		II		III		IV		V		VI		VII		VIII		IX		X		Total	
	I	H	I	H	I	H	I	H	I	H	I	H	I	H	I	H	I	H	I	H	I	H
1. N_0 Ca_0 Mg_0 Zn Cu_0	1	5	2	2	5	2	6	2	-	3	-	1	2	4	2	1	1	-	-	-	19	20
2. N_0 Ca_0 Mg_0 Zn Cu_1	2	7	2	6	1	5	2	4	2	5	1	2	1	2	2	2	-	1	2	-	15	34
3. N_0 Ca_0 Mg_1 Zn Cu_0	5	4	4	5	4	4	3	3	2	5	1	2	1	2	-	4	-	1	-	-	20	30
4. N_0 Ca_0 Mg_1 Zn Cu_1	2	4	5	2	3	5	3	4	2	4	1	2	3	2	3	2	2	3	-	2	24	30
5. N_0 Ca_1 Mg_0 Zn Cu_0	-	3	2	8	4	2	-	2	2	-	-	-	1	-	1	-	-	2	-	-	10	17
6. N_0 Ca_1 Mg_0 Zn Cu_1	1	5	2	2	3	1	1	3	1	2	-	3	1	3	2	1	-	2	-	-	11	22
7. N_0 Ca_1 Mg_1 Zn Cu_0	1	3	4	4	3	4	1	2	2	4	1	4	1	5	-	3	1	2	-	-	14	29
8. N_0 Ca_1 Mg_1 Zn Cu_1	2	10	3	5	3	6	1	6	4	1	-	-	1	1	-	4	-	1	1	1	15	35
9. N_1 Ca_0 Mg_0 Zn Cu_0	-	9	7	2	2	7	3	5	3	8	2	8	6	12	5	11	1	7	4	2	33	71
10. N_1 Ca_0 Mg_0 Zn Cu_1	1	7	2	4	5	3	2	3	3	6	2	8	2	5	3	3	3	4	5	1	28	44
11. N_1 Ca_0 Mg_1 Zn Cu_0	-	11	5	5	2	8	6	4	5	10	4	6	4	7	2	10	2	6	5	6	35	73
12. N_1 Ca_0 Mg_1 Zn Cu_1	1	12	4	8	5	8	5	4	3	12	3	7	4	9	2	12	3	6	4	5	34	83
13. N_1 Ca_1 Mg_0 Zn Cu_0	-	8	2	6	5	7	3	4	2	5	3	7	4	7	3	5	1	6	4	4	27	59
14. N_1 Ca_1 Mg_0 Zn Cu_1	2	9	5	5	4	8	1	7	3	9	3	8	4	9	9	8	2	9	6	7	39	79
15. N_1 Ca_1 Mg_1 Zn Cu_0	6	4	6	4	6	3	2	4	4	8	-	6	3	6	2	9	2	5	2	3	33	52
16. N_1 Ca_1 Mg_1 Zn Cu_1	1	7	4	2	3	6	5	3	3	10	2	5	5	9	4	2	2	3	2	4	31	51
17. N_2 Ca_0 Mg_0 Zn Cu_0	2	6	9	5	4	6	3	5	3	17	2	8	4	11	9	9	4	7	6	5	46	79
18. N_2 Ca_0 Mg_0 Zn Cu_1	2	5	4	5	2	7	3	4	4	4	4	4	4	6	3	1	3	2	-	-	29	38
19. N_2 Ca_0 Mg_1 Zn Cu_0	2	4	2	4	4	3	2	3	3	4	2	2	3	1	-	1	1	2	2	1	21	25
20. N_2 Ca_0 Mg_1 Zn Cu_1	1	6	3	5	2	9	5	4	1	5	2	3	2	8	6	7	3	6	7	7	32	60
21. N_2 Ca_1 Mg_0 Zn Cu_0	1	6	2	7	4	4	3	5	5	6	4	3	3	9	3	2	1	6	3	5	29	53
22. N_2 Ca_1 Mg_0 Zn Cu_1	1	8	6	4	5	6	4	3	7	9	3	8	5	12	6	11	6	9	8	8	51	78
23. N_2 Ca_1 Mg_1 Zn Cu_0	2	12	6	3	3	9	3	4	2	10	4	6	5	12	5	7	3	7	4	4	37	74
24. N_2 Ca_1 Mg_1 Zn Cu_1	2	7	5	7	5	6	4	4	10	11	3	8	5	12	9	7	3	10	7	4	53	76

I = Infested

H = Healthy - not infested