EFFECT OF DIFFERENT CONTENTS OF FREE CALCIUM CARBONATE IN BLACK COTTON SOIL ON YIELD AND UPTAKE OF COPPER AND BORON IN HYBRID JOWAR, CSH-1

47929

By

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B. Sc. (Agri.)

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CANDIDATE'S DECLARATION

I hereby declare that the dissertation or part thereof has not been previously submitted by me for a degree of any university.

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C E R T I F I C A T E

This is to certify that Shri Krishna Ramrao Mohite has satisfactorily prosecuted his course of research for a period of not less than one academic session and this thesis entitled

" Effect of different contents of free calcium carbonate in Black cotton soils on yield and uptake of copper and boron in hybrid jowar, CSH-1 " submitted in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in soil science is a record of bonafide research conducted by him under my supervision and guidance.

The results submitted are of original and is of a sufficiently high standard to warrant its presentation for the examination.

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" EFFECT OF DIFFERENT CONTENTS OF FREE CALCIUM CARBONATE IN BLACK COTTON SOIL ON YIELD AND UPTAKE OF COPPER AND BORON IN HYBRID JOWAR, CSH-1 "

A DISSERTATION SUBMITTED TO THE PUNJABRAO KRISHI VIDYAPEETH IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE MASTER OF SCIENCE (AGRICULTURE) IN SOIL SCIENCE

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CHAPTER I

INTRODUCTION

The mounting growth in population warrants more food production. Naturally efforts are being made to augment the food production. The main channels of achievement of the above objective are use of high yielding varieties, application of increased doses of fertilizers, tapping of the sources of irrigation etc. The use of high yielding varieties accounts for the most promising channel for achieving the goal of self sufficiency in respect of food grains. The high yielding varieties are found to absrob more amount of essential nutrient elements. So far, attention was paid to the needs of these crops for major nutrient elements i.e. nitrogen, phosphate and potash. However, practically no cognizance was taken of the needs of the plants for micronutrients, i.e. copper, boron, zinc, manganese, molybdenum, iron and chlorine.

The work done in India on this aspect of crop nutrition upto 1963 has been critically reviewed by Reheja et al (1959) and Bokde (1963). These reviews indicate that in many soils of India, micronutrients are becoming a limiting factor in raising the crop production levels. In some cases no response was observed to nitrogen and phosphate application unless the micronutrient deficiencies were corrected. Some experiments were carried out by the Department of Agriculture, Maharashtra State, on different types of soils with different improved varieties of different crops for assessing the crop response to the soil application of micronutrients.

Copper is considered to be active in the process of respiration, and in association with protein serves as catalyst in various oxidation processes in plants. Copper increase chlorophyll content and act as a protectective agent against the destruction of chlorophyll.

Boron is belived to promote the nitrogen metabolism and nutrient uptake. Boron deficiency disturb the meristimati growth of growing point and affect the pollen formation.

Soils of Maharastra specially of our Vidharbha Regio are rich in free calcium carbonate. Application of micronutrients like Cu and B in such soil containing varying quantities of free Calcium carbonate may adversly affect their availability. Free calcium carbonate decrease the availability of copper by bringing about the change in soil pH (Kavimandan, 1964). The uptake of boron by plants is also affected by free calcium carbonate because of adverse physiological effect (Olsen and Berger, 1946). Consequently response of different crops to copper and boron differ under different levels of free calcium b carbonate. The present investigation was undertaken to find out the level of $CaCO_3$ at which there is optimum uptake of copper and boron. The findings of the present investigation will be useful in deciding the potential of particular soil in enhancing the food production.

CHAPTER II

REVIEW OF LITERATURE

Beeson (1941, 1946, 1954), Sommer (1945), Hoagland (1945), Gilbert (1952), Mulder and Gerretsen (1952), Thorne (1957) and Jocob (1958) have presented exhaustive review of literature in respect of the effect of different micronutrients on growth, yield and quality of the crops.

A review of literature presented here pertains principally to the effect of copper and boron singly and in combination with major nutrients viz. N, P, K on the yield of various crops with different levels of calcium carbonate.

The availability of copper and boron in soil depends upon a number of factors of which, soil pH, organic matter content, calcium carbonate content, clay content in soil etc. are important. Out of these factors the content of calcium carbonate can be considered to be a major one in Black Cotton Soils so far as the availability of the above micronutrients are concerned because there is less variability in other factors in these soils.

IMPORTANCE OF COPPER

Copper is one of the heavy metal cation from the stand point of soil chemistry. It is held in soil principally on organic or inorganic surfaces or substituted as accessary constituents in common soil minerals. The essentiality of copper as essential plant nutrient was established in the year 1931. It is considered to be active in the process of respiration. Copper in association with protein serves as a catalyst in various oxidation processes in the plant. Copper application results in a higher chlorophyll content and acts as a protective agent against the destruction of chlorophyll. Copper is taken by the plant as copper cation (Cu^{++}). Copper is also an activator of several enzymes.

EFFECT OF CALCIUM CARBONATE ON THE UPTAKE OF COPPER

Total copper ranges from one to less than 100 ppm in normal soils of world (Swaine 1955). Black cotton soils of Gujarat and Maharashtra have comparatively high contents of copper. Total copper in soils of Maharashtra ranges from 77 to 234 ppm. (Randive et al, 1964) and available copper contents in black soil range from 0.38 - 1.53 ppm (Kavimandan et al, 1964).

Mishra and Sharma (1961) stated that the amount of available copper is dependent upon the soil pH. The availability of copper is increased as the soil acidity is increased. The applied copper which is not chelated by organic matter is probabally precipitated as copper hydroxide ($Cu(OH)_2$) when the pH of the soil solution is greater than 4.7 pH. Hodgson (1963) reported that the availability of naturally occurring form of copper was affected to a lesser degree than that of the added copper by application of calcium carbonate. Kavimandan, Badhe and Ballal (1964) observed a positive though statistically non-significant relationship between pH and available copper content of Vidharbha soils.

Rai and Mishra, showed no correlation of available copper and pH and total copper content. As the finer particles or organic carbon increased, the availability of copper was also increased. On the other hand it was found that as the calcium carbonate increased, the availability of copper decreased. Agarwala, Sharma and Sinha (1964) and Nilkantan and Mehta (1961) observed a negative relationship between pH and availability of copper in Gujarat soils.

EFFECT OF COPPER ON YIELD

Densch and Hunnius (1924) observed that copper increased the yield of grain but decreases the straw. Russell and Manns (1933 - 34) and Mann et al (1936) observed an increase in yield of 4.5 to 20.0% over control by a dose of 50 lbs copper sulphate per acre. Joret Gand, (1939) obtained an increase in grain yield of wheat with application of copper in addition to the balance dose of N, P and K fertilizers. Steenbjerg (1948) found that copper application enhanced the yield of cereals upto 87% on several soil types. Other workers who noted the possitive response in yield of cereals to copper application includes Randhawa (1955), Scharrer and Jung (1956) and Joshi (1954, 56), Gopalrao and Govindrajan, (1954), Jogi and Ahuja (1965).

Koraddi and Seth (1964) reported that application of copper (5.08 Kg per hectare) + NPK increased the yield of wheat grain by 16.9% over that from NPK treated control. Pareek and Jain (1966) observed increase in yield of maize grain over NPK by soil application of copper with a dose of 5.6, 11.2 and 22.5 Kg per hectare in Rajastan soils. Sadaphal and Das (1961) observed in field experiment on sandy loam soils (pH 7.9) of medium fertility that soil application of 5 lbs per acre of copper stimulate vegetative growth, hasten earing and increased 1000 grain weight.

IMPORTANCE OF BORON

The essentiality of boron for the growth of crops was established in the year 1915. Total boron in Indian soils has been found to vary from 7 to 670 ppm. Satyanarayan (1958) studied the soils of

Bombay region and has shown that the black cotton soils contain 24.5 to 29.6 ppm boron. Boron is held in the soil in anionic form. It is succeptible to leaching.

Eaton and Wilcox (1939) considered three possible mechanisms for chemical combination of boron with soil.

(1) anion exchange

(2) chemical precipitation

(3) molecular adsorption.

Philipson (1953) made similar classification substituting complex formation with acid groups in clays for molecular adsorption. This explains the effect of lime on boron fixation. Bobko et al (1936) and Naftel (1938) originally interpreted the effect of lime on boron retention in soils due to stimulation of microbes in soils, but Midgley and Dunklee (1939) found that microbial activity was not necessary to account for the effect of lime on boron. Olsen and Berger (1946) demonstrated that calcium was not required to bring about fixation. The action of sodium hydroxide was similar to lime. Calcium has a specific physiological effect in reducing uptake of boron by plant. Parks (1944) and Hofner (1958) indicated that the presence of high pH and high clay content may seriously reduce the movement of boron in soil profiles.

EFFECT OF CALCIUM CARBONATE ON THE UPTAKE OF BORON.

Agulhon (1912) observed marked positive effect on the growth of crops due to application of boron at the rate of 3 Kg per hectare particulerly on cereal crops in presence of lime. Truninger (1944) reviewing the original experiments with vegetable fodder and cereal crop and of the effect of lime in conjunction with boric acid, observed that even 5 Kg of boric acid per hectare increase the boron content of all crops several times and plants supplied with boron were able to make more efficient and economical use of the other nutrients of the fertilizers. Reeve and Shive (1944) found that with high amount of calcium, plants are able to withstand larger amount of boron without toxicity symptoms. Midgley and Dunklee found that borax benefited the crop plants suffering injury from excess lime.

Bhattacharjee (1956) reported that the availability of boron was comparatively more between pH 6.8 to 8.0 and it decreased below and above this range. He again reported that none of the workers in India got statistically significant relationship between calcium carbonate and water soluble boron content of the soil. Kanwar and Singh (1961) observed that water soluble boron increases with an increase in soil pH. Brenchley and Warington studied the boron / calcium ration in soils and plants and the inter relationship of various other elements with boron. It has been observed that normal growth of plants occur only when a certain balance in the intake of calcium and boron exists. Mathur, Modi and Talati (1964) obtained a significant positive correlation between available boron and pH of irrigated soils. The range of pH was 7.8 to 8.2.

EFFECT OF BORON ON YIELD

Mandal, Ali and Mukherjee (1956) got 100% increase in yield of maize by the application of borax at the rate of 22.5 Kg per hectare. Joshi (1956) also got the same result by the application of boron in Jowar. Kanwar et al (1958 - 62) and Bhambla et al (1963 - 65) obtained a significant increase in yield of rice in calcareous soils by application of boron in one experiment out of seven. Pareek and Jain (1966) got increase in yield of maize grain over NPK control by soil application of boron (5.6, 11.2 and 22.5 Kg per hectare).

Gandhi and Mehta (1960) have analysed plant for their boron content. Jowar crop has 50 ppm boron content. Crops which contain low boron have low boron for good growth and high contents of boron have high requirement.

INTERACTION OF COPPER AND BORON ON YIELD

Raychaudhari (1953) reported a significant increase in yield of wheat with application of copper and boron seperately in experiment at Poona (Maharastra). Pandya, Yawalkar and Ranbir Singh (1955) and Joshi (1956) stated that boron and boron + manganese increased the yield of jowar by 35 - 40 % respectively. Sadaphal and Das (1956) reported that with a number of micronutrients viz. Cu, Mn, and Zn, wheat yields were increased by these nutrients when applied in conjunction with NPK fertilizers. The same result was found out by Nieschlag and Teichmann (1956) in yield of cereals.

Raheja, Yawalkar and Ranbir Singh also found the same result but stated several soil factors which influence the availability of micronutrients.

CHAPTER III

MATERIALS AND METHODS

An experiment was laid out in pot culture to study the effect of different levels of free calcium carbonate on yield of hybrid jowar, CSH - 1 and uptake of copper and boron during the Kharif season of 1972-73 in the premises of Department of soil Science and Agricultural Chemistry, Punjabrao Krishi Vidyapeeth, Akola.

DETAILS OF EXPERIMENT

Description of soil :-

The soil used for the experiment was brought from field No.94, Bhabulgaon Block, Central Reserch Farm, P.K.V. Akola. It was slightly alkaline in reaction (pH 7.7) with 1.392 % of organic matter content. The free calcium carbonate was 1.363 %. It was medium in nitrogen and phosphate and high in potash.

Preparation of soil and description of pots :-

The soil was first dried in shade and then ground carefully to break the soil clodes. Earthen pots were used for the experiment and had the following dimensions.

(i) Top diamter = 45 cm

(ii) Depth or height = 30 cm

There were 51 pots numbered according to treatments. There were seventeen treatments and each treatment was replicated thrice. Tar was applied to the pots to prevent loss of nutrient. Some broken pieces were placed on the hole at the bottom of the pots to allow easy drainage. 10 Kg air dried soil was filled in each pot. Ammonium sulphate, single super phosphate and muriate of potash were added to the soil. Calcium carbonate (commercial) was applied as per the treatments. Copper and boron were applied in the form of copper sulphate ($CuSO_4.5\ H_2O$) and borax ($Na_2\ B_4\ O_7.10\ H_2O$) respectively according to treatments. The soil in each pot was thoroughllly mixed with the fertilizers added.

Sowing and other operations :-

All pots were arranged randomly in the field. Sowing was carried out by dibbling method on 6th July. Water was given in alternate day and whenever required. Weeding was done whenever necessary. Thining was done so as to keep six plants in each pot 20 days after sowing.

OTHER DETAILS OF EXPERIMENTS

1. Design of experiment : Completely Randomise block design.
2. Number of treatment : 17
3. Number of replication : 3
4. Total number of pots : 51

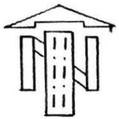
TREATMENT DESCRIPTION

1. Control	+ NPK		
2. 1% $CaCO_3$	+ NPK		
3. 2% $CaCO_3$	+ NPK		
4. 3% $CaCO_3$	+ NPK		
5. 4% $CaCO_3$	+ NPK		
6. 5% $CaCO_3$	+ NPK		
7. Control	+ NPK	+ Cu	+ B
8. 1% $CaCO_3$	+ NPK	+ Cu	+ B
9. 2% $CaCO_3$	+ NPK	+ Cu	+ B
10. 3% $CaCO_3$	+ NPK	+ Cu	+ B
11. 4% $CaCO_3$	+ NPK	+ Cu	+ B
12. 5% $CaCO_3$	+ NPK	+ Cu	+ B
13. 1% $CaCO_3$	+ NPK	+ Cu	+ B
14. 2% $CaCO_3$	+ NPK	+ Cu	+ B
15. 3% $CaCO_3$	+ NPK	+ Cu	+ B
16. 4% $CaCO_3$	+ NPK	+ Cu	+ B
17. 5% $CaCO_3$	+ NPK	+ Cu	+ B

Doses of fertilizers

1. Ammonium sulphate = 30 Kg N per acre
2. Single super phosphate = 20 Kg P_2O_5 per acre
3. Muriate of potash = 14 Kg K_2O per acre
4. Copper sulphate
   - (i) for 0 to 6 treatments = Nil
   - (ii) for 7 to 12 treatments = 4 to 9 Kg per acre
   - (iii) for 13 to 17 treatments = 4 Kg per acre each
5. Borax:- As per copper sulphate

PLAN OF LAYOUT



DESIGN RANDOMIZED BLOCK DESIGN.

12	15	10	2	5	1	3	7	9	14	4	13	6	11	17	8	16
3	13	16	5	14	6	12	8	11	1	17	4	2	15	7	9	10
5	11	3	7	10	12	14	16	13	2	1	17	6	9	4	15	8

Fig. 1

TABLE 1

QUANTITY OF FERTILIZERS APPLIED PER POT (10 Kg SOIL) IN GRAMS

Treatment Nos.	Calcium carbonate	Ammonium sulphate	Single super phosphate	Muriate of potash	Copper sulphate	Borax
1.	Nil	1.5	1.25	0.233	-	-
2.	100	1.5	1.25	0.233	-	-
3.	200	1.5	1.25	0.233	-	-
4.	300	1.5	1.25	0.233	-	-
5.	400	1.5	1.25	0.233	-	-
6.	500	1.5	1.25	0.233	-	-
7.	Nil	1.5	1.25	0.233	0.04	0.04
8.	100	1.5	1.25	0.233	0.05	0.05
9.	200	1.5	1.25	0.233	0.06	0.06
10.	300	1.5	1.25	0.233	0.07	0.07
11.	400	1.5	1.25	0.233	0.08	0.08
12.	500	1.5	1.25	0.233	0.09	0.09
13.	100	1.5	1.25	0.233	0.04	0.04
14.	200	1.5	1.25	0.233	0.04	0.04
15.	300	1.5	1.25	0.233	0.04	0.04
16.	400	1.5	1.25	0.233	0.04	0.04
17.	500	1.5	1.25	0.233	0.04	0.04

PHYSICO - CHEMICAL PROPERTIES OF SOIL

A. Mechanical Composition of soil	Percent on oven dry basis
(i) Moisture	5.92
(ii) Coarse sand	6.212
(iii) Fine sand	18.516
(iv) Silt	26.117
(v) Clay	43.301
(vi) Total soluble salt (s/w ratio 1:2.5)	0.49
(vii) Free calcium carbonate	1.363

B. Fertility constituents	Percent on oven dry basis
(i) Total nitrogen	0.068
(ii) Available phosphorous	0.0018
(iii) Available potassium	0.023
(iv) Organic carbon	0.79
(v) Organic matter	1.3919

C. Exchangeable Constituents	Milliequivalent/100 gm of soil
(i) Total C.E.C.	41.65
(ii) Exchangeable sodium	0.78
(iii) Exchangeable potassium	0.01
(iv) Exchangeable calcium	31.05
(v) Exchangeable magnesium	7.87

D. Other properties	
(i) Electrical conductivity (s/w ratio 1:2.5)	0.35 m. mhos/cm
(ii) Soil pH (s/w ratio 1:2.5)	7.7
(iii) Available copper	9.525 ppm
(iv) Water soluble boron	0.647 ppm

METHODS OF ANALYSIS

A. SOIL ANALYSIS

Preparation of soil samples:-

Before conducting an experiment original soil was dried, ground and placed in a cloth bag for analysis. After harvesting stage again soil samples were taken from all pots with the help of screw auger, dried in shade, ground and stored in a cloth bag.

Determination of physical properties:-

1. Moisture:- Moisture percentage was determined by heating method to constant weight as described by Wright, 1934.

2. Mechanical Analysis:- The method used was standard international pipette method. (Piper, 1966)

3. Physical characteristics of soil:- It was determined by using keen and Raczkowski boxes (Dastane, 1972).

4. Total soluble salt :- Determined by using 1:2.5 ratio of soil and water by gravimetric method. (Piper, 1966)

5. Electrical conductivity :- Determined in soil-water extract of 1:2.5 ratio by Elico-soil bridge.

Determination of Chemical properties :-

1. Total nitrogen :- Kjeldahl (modified) method was followed as described by Jackson (1967) using sodium thiosulphate and salicylic acid to include nitrate nitrogen.

2. Available phosphate :- It was estimated by following Olsen's method as described by Jackson, 1967.

3. Available potash :- It was determined by flame photometer by neutral ammonium acetate extract. (Jackson, 1967)

4. Organic carbon :- Wet digestion method of Walkley and Black (1934) as modified by Walkley (1935). (Piper, 1966)

5. Organic matter :- Organic carbon x 1.724.

6. pH of soil :- Determined in soil-water suspention

of 1:2.5 ratio by glass electrode pH meter as described by Jackson, (1967).

7. Total copper :- Determined by carbamate method. Butterworths scientific publication 1959 (Jackson,1967)

8. Water soluble boron :- Determined by colorimetric method using carmine.
(U.S.D.A. Hand book No.60, Jackson, 1967)

9. Cation Exchange capacity :- Determined by using neutral 1 N ammonium acetate extractant method as described in Piper, 1966).

(i) Exchangeable sodium and potassium :- Determined by Piper, 1966 using Flame-photometer.

(ii) Exchangeable calcium and magnesium :- Determined as described in Piper, 1966.

B. PLANT ANALYSIS :-

Collection of plant samples :- Plant samples from each pot were collected for dry matter studies at 60 days and 110 days intervals, after sowing the samples were first dried in air and then in oven at 70^{0} - 80^{0}C. Samples were weighed for dry matter yields. They were then ground in an electrically operated grinder. Samples were then stored in a brown paper bags for determination of copper, boron, nitrogen, phosphate and potassium.

Grains were separated from husk by wooden thresher. All portions of plant except grains were considered as a straw. Both grain and straw were used for analysis.

Preparation of plant extract :-

Plant samples were pre-digested with nitric acid and then completely digested with tri-acid mixture. (10:4:1 ratio of nitric, perchloric and sulphuric acid respectively) (Jackson, 1967).

Tri-acid extract of plant samples were used for analysing copper, boron, phosphorous and potassium.

1. Determination of copper in plant :- Copper was determined by carbamade method. (Butterworths scientific Publication 1959, Jackson, 1967)

2. Determination of water soluble boron :- Boron was determined by colorimetric determination using carmine method.

3. Determination of Phosphate :- It was estimated by Vanado-molybdophosphoric yellow colour method in nitric acid system. (Jackson, 1967)

4. Determination of Potash :- Potassium was estimated by

using Flame photometer as described by Jackson, 1968 (Piper, 1966).

5. Determination of nitrogen :- Nitrogen was estimated by Kjeldahl's method as described by Piper, 1966.

CHAPTER IV

EXPERIMENTAL FINDINGS .

GRAIN AND FODDER YIELD OF HYBRID JOWAR.

The average grain and fodder yields obtained per pot in different treatments are given in Table 2 and have been graphically shown in Fig. 2.

Effect of increasing levels of calcium carbonate on yield of jowar :-

In general, grain and fodder yields were in the declining order with the increasing levels of calcium carbonate. At initial i.e. 1.363 % of calcium carbonate, grain as well as fodder yields were highest. However, no significant differences were observed amongst 1.363, 2.363 and 3.363 % levels of calcium carbonate. At 4.363, 5.363 and 6.363 % of calcium carbonate levels, grain yields were significantly lower than at 3.363 % level, where as fodder yields obtained at 4.363 %, 5.363 % and 6.363 % calcium carbonate levels were significantly lower than initial level of calcium carbonate.

Effect of increasing doses of micronutrients i.e. copper and boron on yield of jowar :-

Highest grain yield was obtained at initial i.e.

TABLE 2

GRAIN AND FODDER YIELD IN GRAMS PER POT

GRAIN YIELD

Levels of $CaCO_3$	Levels of copper and boron		
	0 Control	With varying dose of Cu & B	With constant dose of Cu & B
0	10	13.0	13.0
1	10	9.5	9.5
2	8.6	11.3	10.1
3	6.5	10.1	11.5
4	4.0	8.8	9.0
5	3.1	7.6	7.5

'F' Test:-Significant S.E. 0.673 C.D.at 5% 2.002

FODDER YIELD

Levels of - $CaCO_3$	Levels of copper and boron		
	Control	With varying dose of Cu & B	With constant dose of Cu & B
0	19.00	25.66	
1	17.33	19.00	19.33
2	16.66	20.66	22.00
3	14.66	20.00	24.66
4	8.00	18.00	18.33
5	6.66	16.66	15.33

'F' Test:-Significant S.E. 1.1 C.D.at 5% 3.2725

GRAIN AND FODDER YIELD IN GRAMS PER POT.

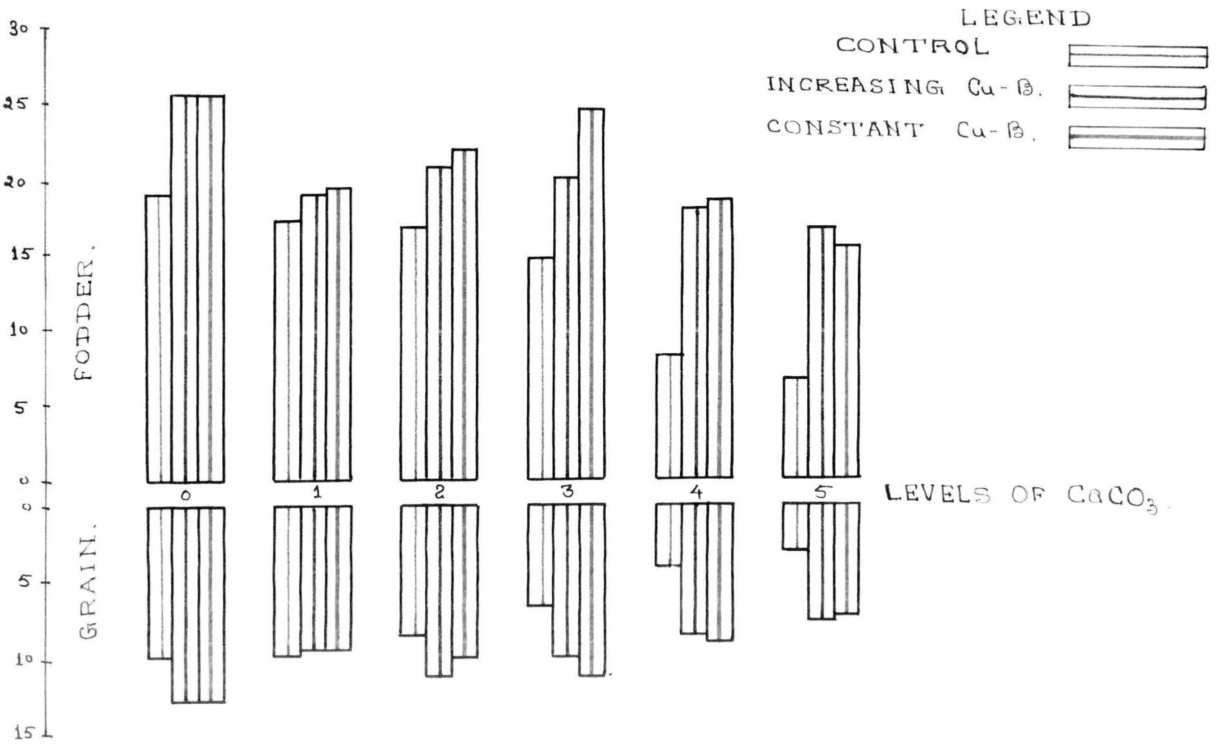


fig. 2.

1.363 % level of calcium carbonate with no significant difference between 3.363 % and 4.363 % levels. The grain yields at 3.363 %, 4.363 % and 2.363 % levels of calcium carbonate significantly increased over those at 5.363 % and 6.663 % calcium carbonate levels. Dose of 6 Kg. per acre each of copper and boron at 3.363 % level of calcium carbonate was superior over 7, 5, 8 and 9 Kg. per acre doses of each copper and boron. However, the yield obtained from this dose was lower than 4 Kg dose of each copper and boron at 1.363 % level of calcium carbonate.

Dose of 4 Kg per acre of each copper and boron at 1.363 % level of calcium carbonate gave significantly higher fodder yield over other doses of copper and boron. No significant differences were observed amongst 6, 7, 5, 8 and 9 Kg per acre doses of copper and boron. In general, grain as well as fodder yields obtained were in the declining order with increasing doses of copper and boron.

<u>Effect of constant dose (4 Kg per acre) of micronutrients on yield of jowar</u> :-

A constant dose of 4 Kg per acre of each copper and boron at 4.363 % level of calcium carbonate has given more grain and fodder yields. The yield was highest and significantly superior to other levels of calcium carbonate except those of 3.363 % and 1.363 % level of calcium carbonate.

CONTENTS OF COPPER AND BORON IN PPM AT 60 DAYS AND 110 DAYS GROWTH OF HYBRID JOWAR.

The plant samples from different treatments were analysed at 60 days and 110 days growth for copper, boron, nitrogen, phosphate and potash. The results were given in tables 3 and 4.

Contents of copper decreased with increasing levels of calcium carbonate alone. However, amount of boron increased with the increasing doses of copper and boron in combination with levels of calcium carbonate, concentration of copper was decreased where as amount of boron increased. At a constant dose of 4 Kg per acre each of copper and boron, the contents of copper decreased with increasing levels of calcium carbonate and that of boron increased.

Contents of copper and boron in straw decreased at harvesting stage as compared to 60 days growth, but a similar trend of behaviour was observed in case of concentration of copper and boron.

Amount of copper and boron was more in grain as compared to fodder. With increasing levels of calcium carbonate alone, contents of copper in grain decreased while that of boron increased. A dose of 4 Kg per acre each of copper and boron at 2.363 % level of calcium

TABLE 3

CONCENTRATIONS OF COPPER AND BORON IN PPM AT 60 DAYS GROWTH OF HYBRID JOWAR CSH-1

CONCENTRATION OF COPPER IN PPM

Levels of $CaCO_3$	Levels of copper and boron		
	Control	Varying levels of Cu & B	Constant dose of Cu & B
0	79.56	89.16	
1	77.50	82.50	83.73
2	76.23	79.56	80.83
3	71.66	75.40	78.33
4	67.50	70.00	74.96
5	54.16	65.40	72.50

'F' Test:-Significant S.E. 1.1 C.D.at 5% 3.27

CONCENTRATION OF BORON IN PPM

Levels of $CaCO_3$	Levels of copper and boron		
	Control	Varying levels of Cu & B	Constant dose of Cu & B
0	44.16	53.33	
1	45.41	56.25	46.66
2	46.66	58.16	48.33
3	47.08	60.75	50.83
4	47.91	62.08	51.28
5	49.16	65.00	52.08

'F' Test:-Significant S.E. 0.52 C.D.at 5% 1.54

carbonate is found to be superior in increasing the contents of copper in grain. However, the amount of boron increased with increasing doses of copper and boron and at constant levels of copper and boron, contents of boron in grain decreased with increasing levels of calcium carbonate.

CONTENTS OF NITROGEN, PHOSPHATE AND POTASH IN PERCENTAGE AT 60 DAYS AND 110 DAYS GROWTH OF HYBRID JOWAR.

The data on contents of nitrogen at 60 and 110 days stage is given in table 4 and 7 respectively. From the data given, it is observed that the concentration of nitrogen at 60 days growth was found to be decreased with increasing levels of calcium carbonate. With increasing doses of copper and boron, in combination with increasing levels of calcium carbonate, amount of nitrogen also decreased. Similar trend in behaviour was also found in case of constant dose of copper and boron. However, it is remarkable to note that the amount of nitrogen was more in plants receiving micronutrients than in the plants not receiving micronutrients. Contents of nitrogen in fodder as well as in grain at 110 days growth was comparatively lesser than at 60 days growth, and similar trend in behaviour of contents of nitrogen was observed.

TABLE 4

PERCENTAGE OF N, P205 AND K20 AT 60 DAYS GROWTH OF HYBRID JOWAR CSH-1

NITROGEN PERCENTAGE

Levels of $CaCO_3$	Levels of copper and boron		
	Control	Varying levels of Cu & B	Constant dose of Cu & B
0	1.97	2.01	
1	1.88	1.78	1.88
2	1.72	1.49	1.67
3	1.56	1.46	1.57
4	1.36	1.24	1.37
5	1.11	1.02	1.06
'F' Test:-Significant	S.E. 0.039	C.D.at 5% 0.1160	

PHOSPHOROUS PERCENTAGE

0	0.94	1.01	
1	0.88	0.87	1.01
2	0.76	0.89	0.89
3	0.65	0.94	0.76
4	0.54	0.93	0.59
5	0.46	0.97	0.50
'F' Test:-Significant	S.E. 0.032	C.D.at 5% 0.0925	

POTASSIUM PERCENTAGE

0	1.90	1.90	
1	2.30	2.30	2.40
2	2.76	2.93	2.60
3	2.93	3.20	2.93
4	3.30	3.60	3.20
5	3.60	3.90	3.23
'F' Test:-Significant	S.E. 0.114	C.D.at 5% 0.3391	

Contents of phosphate at 60 days and at harvest stage:-

Contents of phosphate at 60 days growth period decreased with increasing levels of clacium carbonate alone, but with increase in the doses of copper and boron, content of phosphate remained more or less constant. But, at constant dose of copper and boron, phosphate contents decreased with increase in calcium carbonate levels. However, amount of phosphate in plant and grain is increased when calcium carbonate is applied in combination with copper and boron than only increasing levels of calcium carbonate alone.

Amount of phosphate in fodder decreased with increasing levels of calcium carbonate alone and when combined with a constant dose of copper and boron. However, it increased with increasing doses of copper and boron when combined with calcium carbonate. Contents of phosphate increased upto 4.363 % level of calcium carbonate and latter on it decreased.

Similar trend in behaviour in respect of contents of phosphate in grain was observed as that of straw at 60 days growth.

Contents of potash at 60 days and at harvest stage :-

Reverse was the case in potash content. Here with increase in the levels of calcium carbonate alone and combined with constant and increasing doses of copper and boron, the amount of potash also increased. However, its amount were higher with levels of calcium carbonate combined with copper and boron than those with levels of calcium carbonate alone.

Similar trend in respect of its contents in grain and straw was noticed. Amount of potash in plant decreased at maturity.

TOTAL UPTAKE OF COPPER IN MILLIGRAMS PER POT BY HYBRID JOWAR (GRAIN + STRAW).

The result of copper content in grain and fodder in ppm as well as total uptake of copper in milligrams per pot in grain and fodder are given in table 5 and have been graphically represented in fig. 3.

Total uptake of copper decreased with increasing levels of calcium carbonate alone. Similar trend was observed with varying doses of copper and boron when combined with levels of calcium carbonate. Maximum total uptake of copper was recorded with a constant dose of copper and boron at initial i.e. 1.363 % of calcium carbonate add further reduced with increasing levels of calcium carbonate and remained more or less constant with 2.363 % to 4.363 % levels of calcium carbonate. Uptake of copper was observed to increase with levels of calcium carbonate combined with

TABLE 5

TOTAL UPTAKE OF COPPER IN MILLIGRAMS PER POT OF HYBRID JOWAR CSH-1

TOTAL UPTAKE BY GRAIN

Levels of $CaCO_3$	Levels of copper and boron					
	Contral		Varying levels of Cu & B		Constant dose of Cu & B	
	Copper content in ppm	Total uptake	Copper content in ppm	Total uptake	Copper content in ppm	Total uptake
0	40.0	0.400	49.1	0.639		
1	40.8	0.408	45.8	0.435	50.0	0.475
2	38.3	0.330	43.7	0.495	46.6	0.475
3	32.5	0.211	40.0	0.406	43.3	0.500
4	25.8	0.102	35.8	0.317	37.5	0.327
5	22.9	0.072	30.0	0.230	32.9	0.245
'F'Test:-Significent			S.E.1.28		C.D.at5%	0.2856
			Significant	0.096	3.808	

TOTAL UPTAKE BY FODDER

0	35.00	0.665	41.66	1.070		
1	33.33	0.576	37.50	0.710	37.50	0.726
2	30.00	0.501	34.16	0.714	32.50	0.710
3	26.66	0.299	26.23	0.589	29.56	0.725
4	22.50	0.216	25.00	0.448	24.56	0.447
5	17.50	0.120	21.23	0.352	24.13	0.377
'F'Test:-Significant			S.E.0.458		C.D.at 5%	0.1844
			Significant	0.062	1.3625	

TOTAL UPTAKE BY TOTAL DRY MATTER

0	1.065	1.709	
1	0.984	1.145	1.201
2	0.831	1.209	1.185
3	0.500	0.995	1.225
4	0.318	0.765	0.784
5	0.174	0.582	0.622

Total Uptake Of Copper In Milligrams Per Pot.

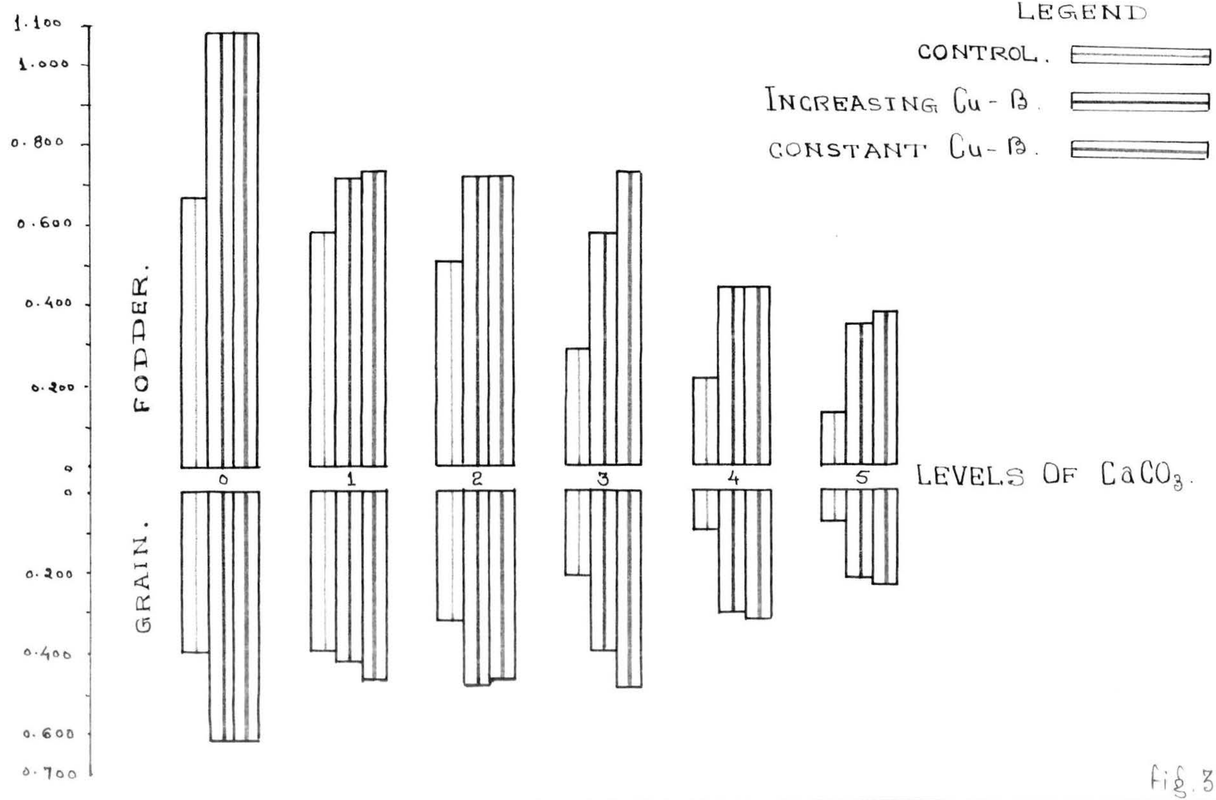


Fig. 3.

application of copper and boron. Uptake of copper was found to be more in fodder than in grain, although its contents was more in grain. Uptake of copper in grain and fodder decreased with increasing levels of calcium carbonate alone and combined with a constant and increasing doses of copper and boron. At 4.363 % level of calcium carbonate, a constant dose of copper and boronwas observed superior to a dose of 7 Kg per acre each of copper and boron. However, a constant dose of copper and boron at 2.363 % and 3.363 % level did not differ much with 5 and 6 Kg doses of each copper and boron.

<u>TOTAL UPTAKE OF BORON IN MILLIGRAMS PER POT BY HYBRID JOWAR (GRAIN + STRAW).</u>

The results of boron contents in grain and fodder in ppm as well as total uptake of boron in milligrams per pot in grain and straw are given in table 6 and graphically shown in fig. 4.

Total uptake of boron remained more or less constant at 1.363 %, 2.363 % and 3.363 % levels of calcium carbonate alone and decreased with further increasing levels of calcium carbonate. With increasing doses of copper and boron at increasing levels of calcium carbonate, total uptake of boron decreased where as a constant dose i.e. 4 Kg per acre each of copper and boron at 4.363 % level of calcium carbonate recorded its maximum uptake which was

TABLE 6

TOTAL UPTAKE OF BORON IN MILLIGRAMS PER POT OF HYBRID JOWAR CSH-1

TOTAL UPTAKE BY GRAIN

Levels of $CaCO_3$	Levels of copper and boron					
	Contral		Varying levels of Cu & B		Constant dose of Cu & B	
	Boron content in ppm	Total uptake	Boron content in ppm	Total uptake	Boron content in ppm	Total uptake
0	34.58	0.345	36.83	0.478		
1	36.83	0.368	39.00	0.370	46.75	0.443
2	37.91	0.328	40.83	0.462	48.50	0.460
3	39.00	0.253	43.75	0.444	50.83	0.585
4	40.25	0.160	45.41	0.401	51.66	0.464
5	40.83	0.129	46.75	0.358	51.75	0.387

'F' Test:-Significant S.E.0.955 C.D.at5% 0.08627
Significant C.C29

TOTAL UPTAKE BY FODDER

0	31.83	0.604	36.66	0.940	33.32	
1	33.58	0.581	38.33	0.728	33.33	0.645
2	36.25	0.603	39.41	0.814	36.33	0.799
3	37.08	0.419	41.16	0.823	37.91	0.935
4	38.33	0.306	43.00	0.774	39.58	0.725
5	39.16	0.260	44.16	0.735	42.08	0.643

'F' Test:-Nonsignificant S.E. C.D.at 5%
Nonsignificant

TOTAL UPTAKE BY TOTAL DRY MATTER

0	0.949	1.418	
1	0.950	1.098	1.088
2	0.931	1.276	1.259
3	0.672	1.267	1.520
4	0.466	1.175	1.189
5	0.389	1.093	1.030

TOTAL UPTAKE OF BORON IN MILLIGRAMS PER POT.

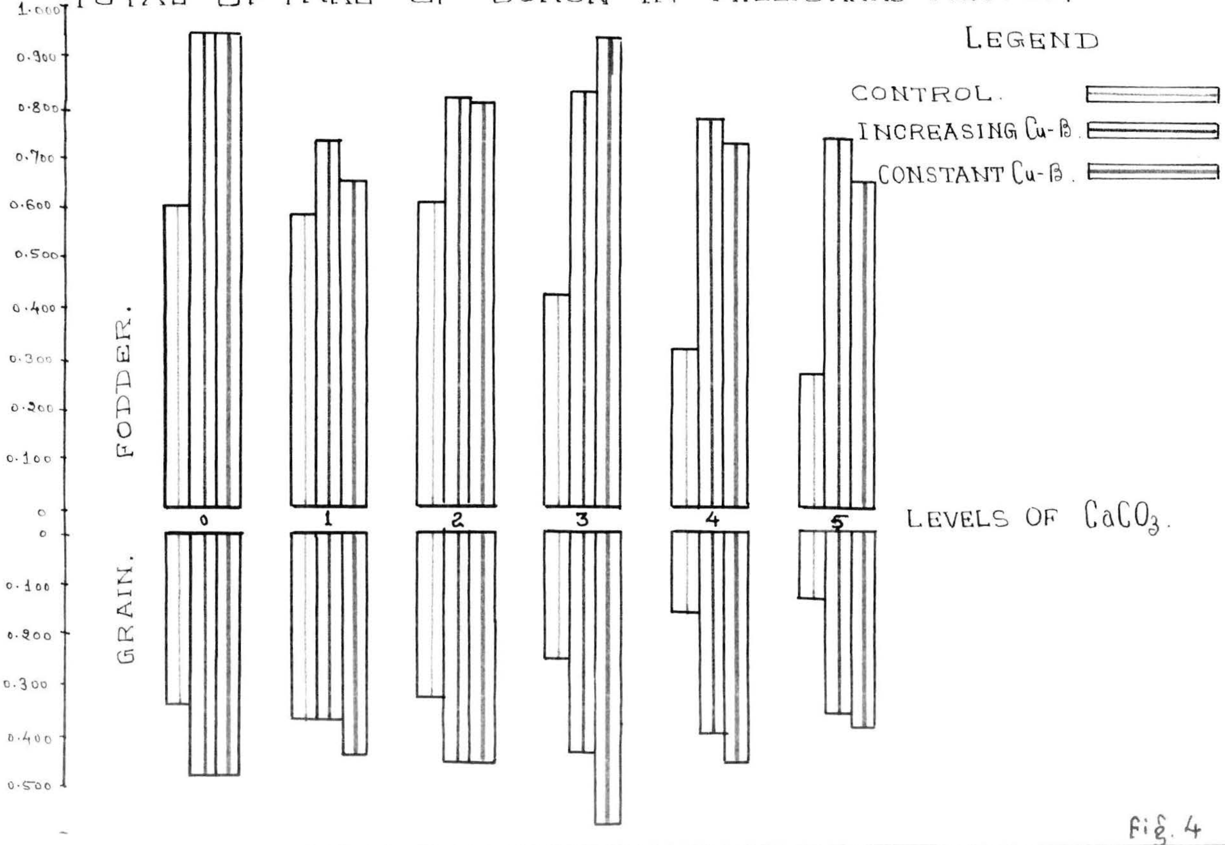


Fig. 4

slightly more than that at 1.363 % level of calcium carbonate. A constant dose of copper and boron each of 4 Kg per acre at different levels of calcium carbonate did not differ much in respect of total uptake of boron.

Uptake of boron in fodder was observed to be comparatively more than in grain. Uptake of boron in grain and fodder decreased with increasing levels of calcium carbonate alone. Uptake of boron in both grain and fodder increased with increasing levels of calcium carbonate combined with application of copper and boron. With a constant dose of copper and boron, 4 Kg per acre of each at 4.363 % level of calcium carbonate, uptake of boron in grain was significantly higher over other levels of calcium carbonate. Uptake of boron in fodder was also recorded maximum at this level of calcium carbonate.

TOTAL UPTAKE OF NITROGEN IN GRAMS PER POT BY HYBRID JOWAR (GRAIN + STRAW)

The data on contents and uptake of nitrogen in grain and fodder are given in table 7 and have been graphically shown in fig. 5.

It was observed that although the dose of nitrogen was the same in all treatments, yet the percent nitrogen either in grain or in fodder and the total uptake of nitrogen per pot were quite different.

Total uptake of nitrogen was observed in the

TABLE 7

TOTAL UPTAKE OF NITROGEN IN GRAMS PER POT OF HYBRID JOWAR CSH-1

TOTAL UPTAKE BY GRAIN

Levels of $CaCO_3$	Levels of copper and boron					
	Control		Varying levels of Cu & B		Constant dose of Cu & B	
	Percent N content	Total uptake	Percent N content	Total uptake	Percent N content	Total uptak
0	1.22	0.122	1.23	0.161		
1	1.03	0.103	1.11	0.105	1.10	0.105
2	0.92	0.077	1.01	0.115	1.01	0.103
3	0.84	0.057	0.91	0.090	0.87	0.100
4	0.78	0.032	0.84	0.074	0.79	0.071
5	0.70	0.017	0.77	0.058	0.73	0.55

'F'Test:-Significant S.E.0.055 C.D.at5% 0.2469
Significant 0.083 0.1636

TOTAL UPTAKE BY FODDER

0	0.91	0.172	0.94	0.242		
1	0.84	0.145	0.87	0.166	0.84	0.162
2	0.77	0.127	0.75	0.157	0.73	0.162
3	0.70	0.078	0.68	0.135	0.64	0.158
4	0.63	0.050	0.57	0.103	0.56	0.102
5	0.49	0.032	0.46	0.078	0.51	0.078

'F' Test:-Significant S.E.0.0258 C.D.at 5% 0.04165
Significant 0.014 0.07675

TOTAL UPTAKE BY TOTAL DRY MATTER

0	0.294	0.403	
1	0.248	0.271	0.267
2	0.204	0.272	0.265
3	0.135	0.225	0.258
4	0.082	0.177	0.173
5	0.049	0.136	0.133

TOTAL UPTAKE OF NITROGEN IN GRAMS PER POT.

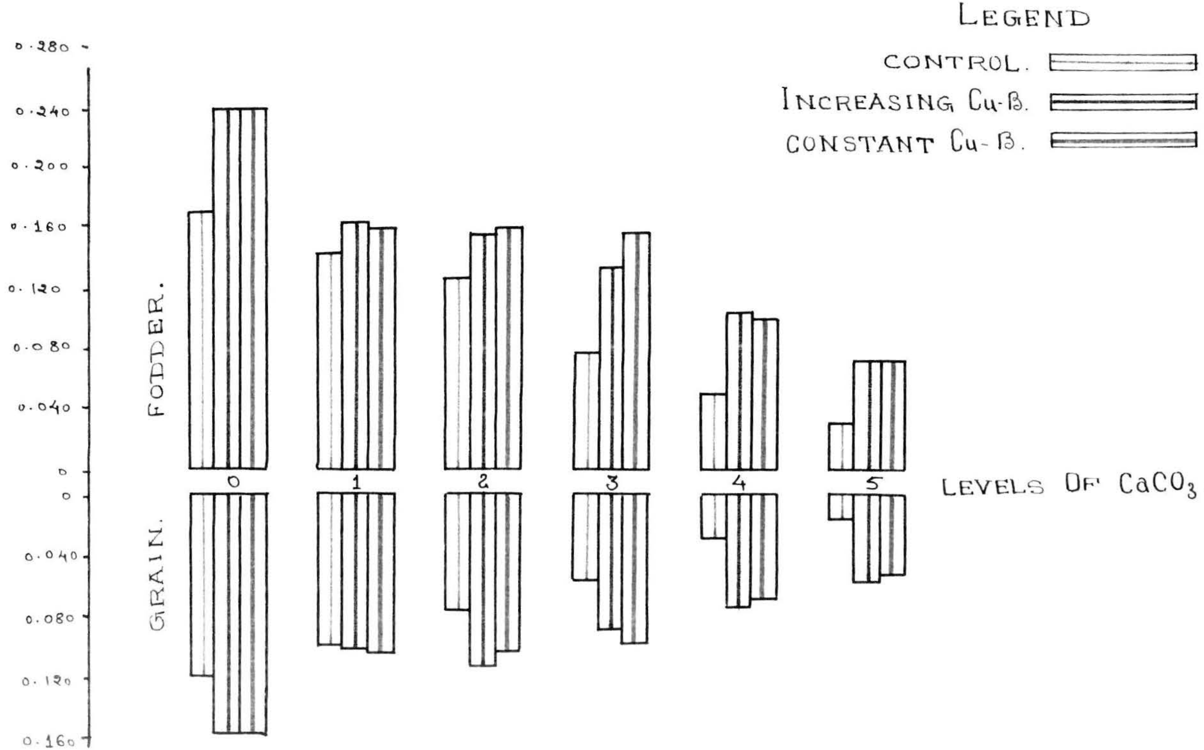


Fig. 5.

declining order with the increasing levels of calcium carbonate alone and combined with increasing doses of copper and boron, but uptake was more where micronutrients were applied. With a constant dose of copper and boron, its uptake was recorded maximum at 1.363 % level of calcium carbonate, but the magnitude of decrease was small from 2.363 % to 4.363 % levels of calcium carbonate.

Similar trend in uptake of nitrogen in both grain and fodder was also noticed. Nitrogen uptake was observed to be increased with the application of copper and boron at all levels of calcium carbonate.

TOTAL UPTAKE OF PHOSPHATE IN GRAMS PER POT BY HYBRID JOWAR (GRAIN + STRAW).

The data on contents and total uptake of phosphate per pot as well as its uptake in grain and straw seperately are given in table 8 and graphically represented in fig. 6.

With the increasing levels of calcium carbonate alone, and combined with constant and increasing doses of copper and boron, total uptake of phosphate per pot as well as in grain and fodder decreased. However, uptake of phosphate was found to increase with increasing levels of calcium carbonate combined with application of copper and boron.

TABLE 8

TOTAL UPTAKE OF P205 IN GRAMS PER POT OF HYBRID JOWAR CSH-1

TOTAL UPTAKE BY GRAIN

Levels of $CaCO_3$	Levels of copper and boron					
	Control		Varying levels of Cu & B		Constant dose of Cu & B	
	Percent P205 content	Total uptake	Percent P205 content	Total uptake	Percent P205 content	Total uptake
0	0.61	0.061	0.60	0.079		
1	0.56	0.056	0.56	0.053	0.64	0.061
2	0.49	0.042	0.58	0.066	0.59	0.060
3	0.44	0.028	0.62	0.064	0.49	0.056
4	0.36	0.014	0.66	0.058	0.44	0.039
5	0.33	0.010	0.66	0.051	0.34	0.026

'F' Test:-Significant S.E.0.114 C.D.at5% 0.01151
Significant 0.00387 0.03391

TOTAL UPTAKE BY FODDER

0	0.68	0.129	0.74	0.192		
1	0.62	0.107	0.64	0.122	0.75	0.146
2	0.54	0.090	0.68	0.142	0.62	0.137
3	0.49	0.071	0.74	0.149	0.53	0.131
4	0.41	0.033	0.73	0.132	0.41	0.076
5	0.31	0.021	0.68	0.114	0.31	0.052

'F' Test:-Significant S.E.0.017 C.D.at5% 0.05057
Significant 0.098 0.029155

TOTAL UPTAKE BY TOTAL DRY MATTER

0	0.191	0.271	
1	0.163	0.175	0.207
2	0.132	0.208	0.197
3	0.099	0.213	0.187
4	0.047	0.190	0.115
5	0.031	0.165	0.078

TOTAL UPTAKE OF P_2O_5 IN GRAMS PER POT

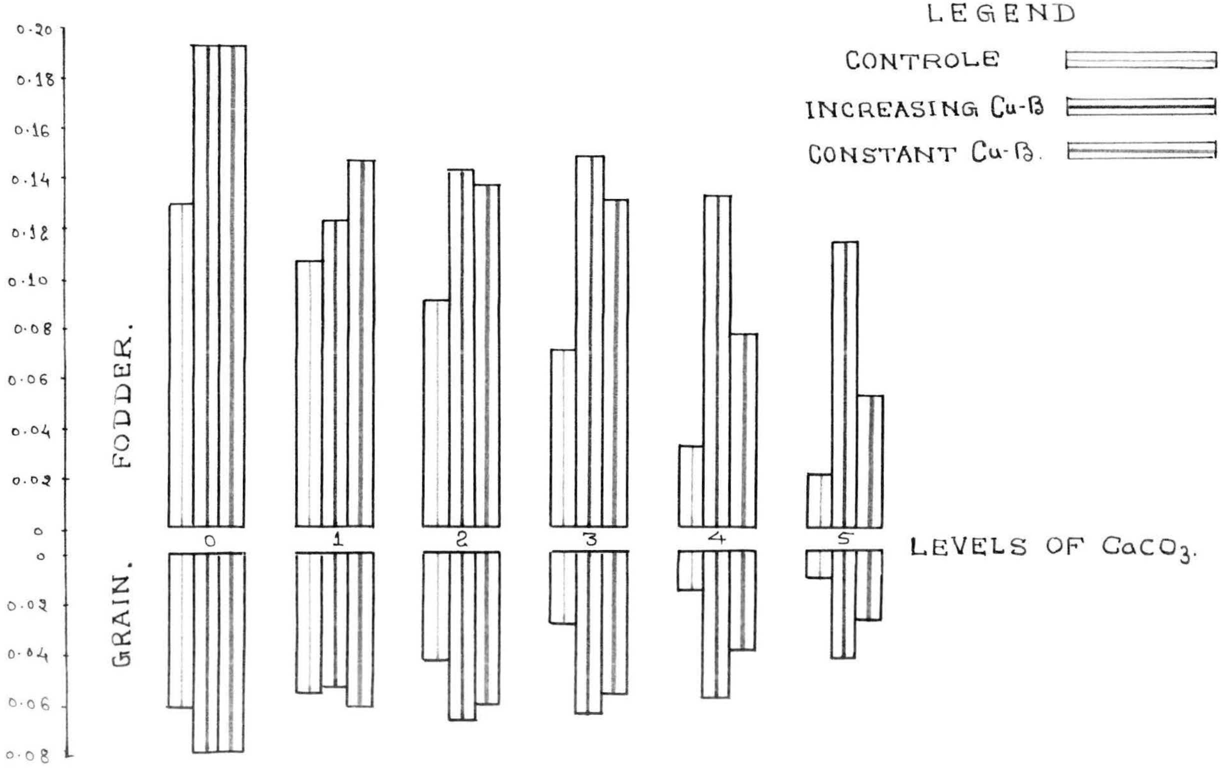


Fig. 6

TOTAL UPTAKE OF POTASH IN GRAMS PER POT BY HYBRID JOWAR (GRAIN + STRAW).

The data on contents and total uptake of potash per pot as well as its uptake in grain and straw are given in table 9 and graphically represented in fig. 7.

Total uptake of potash was not affected upto 3.363 % level of calcium carbonate alone. However, it decreased further with increase in the levels of calcium carbonate. This was also observed in uptake of grain as well as in fodder.

With a dose of 6 Kg per acre each of copper and boron at 3.363 % levels of calcium carbonate, uptake of potash in grain was observed to be significantly superior to all other treatments. Total uptake of potash was observed maximum at 1.363 % level of calcium carbonate with a constant dose 4 Kg per acre each of copper and boron. Total uptake of potash was slightly superior to all other levels of calcium carbonate except 1.363 % level of calcium carbonate.

A constant dose of copper and boron at 4.363 % levels of calcium carbonate recorded maximum uptake than at other levels of calcium carbonate except at 1.363 % levels. In case of fodder it was slightly superior, its uptake in grain and fodder increased with levels of calcium carbonate combined with application of copper and boron.

TABLE 9

TOTAL UPTAKE OF K20 IN GRAMS PER POT OF HYBRID JOWAR CSH-1

TOTAL UPTAKE BY GRAIN

Levels of $CaCO_3$	Levels of copper and boron					
	Control		Varying levels of Cu & B		Constant dose of Cu & B	
	Percent K20 content	Total uptake	Percent K20 content	Total uptake	Percent K20 content	Tota uptake
0	1.32	0.132	1.30	0.169		
1	1.36	0.186	1.43	0.136	1.95	0.187
2	1.37	0.115	2.72	0.308	1.60	0.163
3	1.42	0.092	1.60	0.163	1.64	0.189
4	1.46	0.058	1.63	0.144	1.71	0.154
5	1.49	0.047	1.72	0.132	1.74	0.131

'F' Test:-Significant S.E.0.092 C.D.at 5% 0.2737
Significant 0.039 0.1160

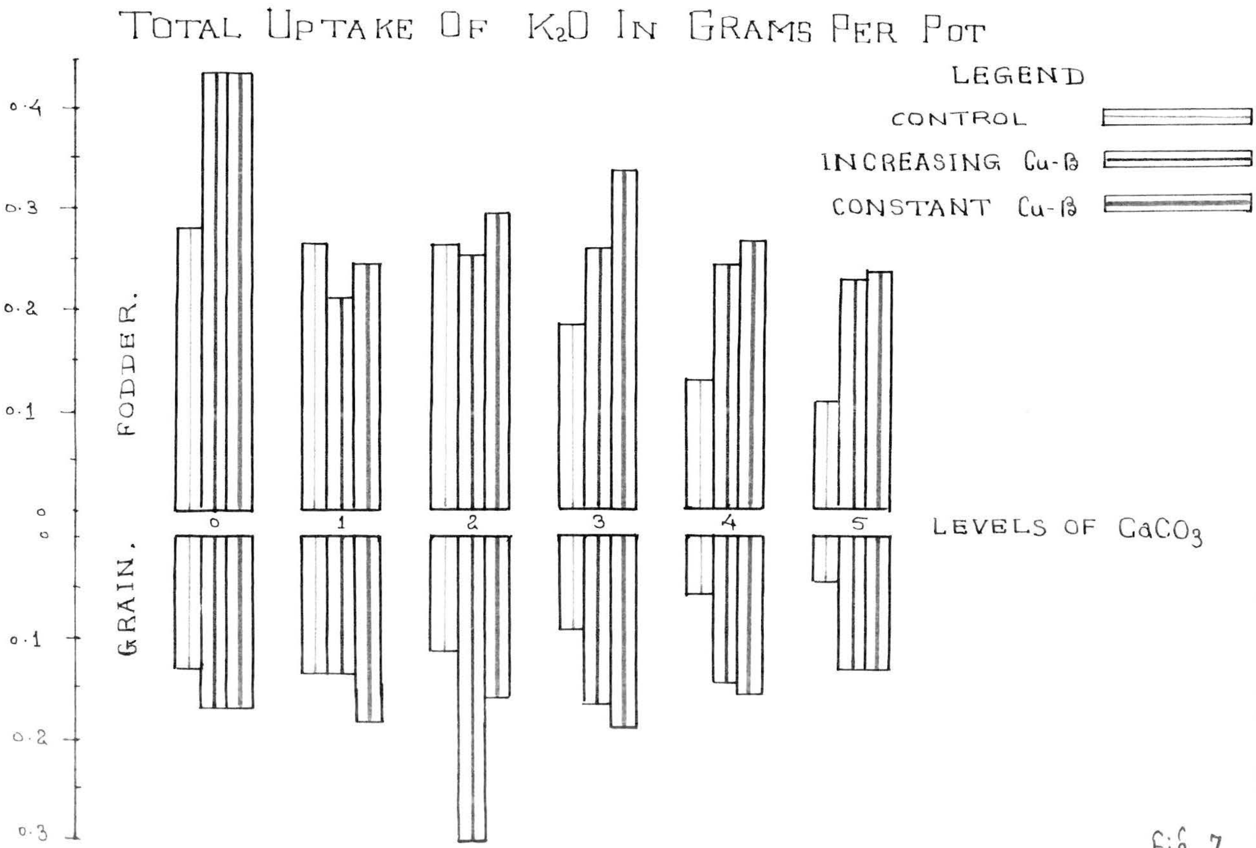
TOTAL UPTAKE BY FODDER

0	1.49	0.283	1.70	0.438		
1	1.54	0.267	1.13	0.214	1.29	0.248
2	1.59	0.265	1.22	0.253	1.35	0.297
3	1.61	0.183	1.30	0.259	1.39	0.341
4	1.65	0.132	1.36	0.244	1.49	0.273
5	1.68	0.112	1.39	0.230	1.58	0.243

'F' Test:-Significant S.E.0.023 C.D.at 5% 0.0684
Significant 0.0093 0.02766

TOTAL UPTAKE BY TOTAL DRY MATTER

0	0.415	0.607	0.607
1	0.409	0.650	0.435
2	0.380	0.561	0.460
3	0.275	0.422	0.530
4	0.190	0.388	0.427
5	0.159	0.362	0.374



TOTAL UPTAKE OF K_2O IN GRAMS PER POT
LEGEND
CONTROL
INCREASING Cu-B
CONSTANT Cu-B
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
FODDER.
GRAIN.
0
1
2
3
4
5
LEVELS OF $CaCO_3$

Fig. 7

CHAPTER V .

DISCUSSIONS

The experimental findings of the pot culture experiment in connection with the effect of different levels of free calcium carbonate alone and in combination with increased doses as well as with constant dose of copper sulphate and borax on yield and total uptake of copper, boron, nitrogen, phosphorous and potassium by hybrid jowar, CSH-1, have been presented in chapter IV. It is discussed under following heads :-

1) Effect of varying levels of calcium carbonate alone and in combination with constant as well as increasing doses of copper and boron on yield of hybrid jowar, CSH-1.

2) Effect of varying levels of calcium carbonate alone and in combination with constant as well as increasing doses of copper and boron on the uptake of copper and boron.

3) Effect of varying levels of calcium carbonate alone and in combination with constant as well as increasing doses of copper and boron on the uptake of nitrogen, phosphate and potash.

1) Effect of varying levels of calcium carbonate alone and in combination with constant and increasing doses of copper and boron on yield of hybrid jowar CSH-1.

Grain and fodder yields of hybrid jowar, CSH-1 in grams per pot have been represented in chapter IV, table 2. It is found that the grain and fodder yields decreased with increasing levels of calcium carbonate alone. Highest but same grain yields are obtained at 1.363 % and 2.363 % level of calcieum carbonate. The grain yield obtained per pot are 10, 10, 8.66, 6.50, 4.00 and 3.16 grams at 1.363 %, 2.363 %, 3.363 %, 4.363 %, 5.363 % and 6.363 % levels of calcium carbonate respectively, with a basal dose of NPK fertilizer. The lowering of yields with increasing levels of calcium carbonate may be due to adverse effect of calcium carbonate on increasing soil pH consequently low availability of nutrients. With increasing levels of calcium carbonate soil pH recorded during crop growth were 8.6, 8.2, 8.1, 8.1 and 8.0 at 6.363 %, 5.363 %, 4.363 %, 3.363 % and 2.363 % levels of calcium carbonate respectively whereas it was 7.9 at 1.363 % level of càlcium carbonate.

The yields of grain and fodder obtained are lower in different levels of calcium carbonate alone treatments than in combination with doses of copper and boron. However, the trend of yield obtained is in the declining order with increasing levels of calcium carbonate alone as well as in combination with increasing doses of copper and boron. It indicates a favourable response in respect of yield with the application of copper and boron.

Copper and boron at higher levels of calcium carbonate i.e. 6.363 % lowered the yield, which may be due to the excess of lime as well as higher dose of 9 Kg per acre of copper and boron. Neischlag and Teichmann (1956); Sadapal and Das (1956) noted an increased in yield of cereals due to application of minute quantities of trace elements like Cu, B, Zn, Mn, etc. with NPK fertilizers. Boron increased the yield of jowar by 35 % [Pandya, Yawalkar and Ranbir Singh (1955) and Joshi (1956); Raychaudhari (1953)]. Joshi and Joshi (1952-57) reported that the lower dose of copper sulphate gave maximum yield over other higher doses. The same results was obtained by Koraddi and Seth (1964); steenbjerg (1948). Randhawa (1955), Scharrer and Jung (1956) and Joshi (1954-656) that the smaller doses of copper sulphate and borax gave a maximum grain yield.

From this we can come to the condlusion that smaller doses of micronutrients i.e. copper and boron can give very good response to yield. Gandhi and Mehta (1960) said that crops with higher contents of boron have relatively higher requiremement for boron.

2) Effect of varying levels of calcium carbonate alone and in combination with constant as well as increasing doses of copper and boron on the uptake of copper and boron.

From the data on uptake of copper and boron in grain and fodder given in table 5 and 6 respectively, it is observed that with increasing levels of calcium carbonate, copper uptake is reduced. This effect of increasing levels of calcium carbonate is also reflected on grain and fodder yields. This might be due to increased soil pH affecting the availability of nutrients and consequently the uptake of nutrients and yield of crops. However, the uptake of boron is not much affected with increasing levels of calcium carbonate and it remained more or less constant at all levels. Mishra and Sharma (1961) have reported that the amount of available copper is dependent on the soil pH. Similar results in respect of availability and pH range is also reported by Kanwar and Singh (1961), Bhattacharjee (1956), Mathur, Modi and Talati (1964). However, Rai and Mishra did not observe correlation between available copper and pH as well as total copper content.

Total uptake of copper and boron is slightly increased upto 3.363 % level of calcium carbonate in combination with a constant dose of each copper and boron as well as their increasing doses over levels of calcium carbonate alone. At 4.363 %, 5.363 % and at 6.363 % of calcium carbonate in combination with constant and increasing doses of coppe and boron, the uptake of these nutrients became comparatively doubled to the levels of calcium carbonate alone. Large differences in uptake of boron observed at 4.363 % to 6.363 % levels of calcium carbonate alone and in combination with increasing doses of copper and boron, may be due to the beneficial effect of applied borax. A beneficial effect of borax application on crop plant and there exists certain balance in the uptake of copper and boron for normal growth of plants require small doses of micronutrients, so that they could make use of other nutrients more efficiently and economically (Midgley and Dunklee, Branchley and Warington ; Truninger (1944) ; Agulhon (1912)).

3. <u>Effect of varying levels of calcium carbonate alone and in combination with constant and increasing doses of copper and boron on uptake of nitrogen, phosphate and potash</u>.

A constant dose of copper and boron not only increased their uptake but also of nitrogen, phosphate and potash. However, uptake of nitrogen, phosphate and potash as well as of copper and boron is not increased with increasing doses of copper and boron. A dose of 4 Kg and 6 Kg per acre each of copper and boron is found to be equally superior for the uptake of nitrogen, phosphate and potash as well as copper, boron at 1.363 % and 4.363 % levels of calcium carbonate respectively.

In general, it is observed that utilization of major nutrients and of copper and boron is improved with the application of a constant dose of these micronutrients, as well as with their increasing doses at increasing levels of calcium carbonate. However, increasing a dose of copper above 6 Kg per acre did not reflect much on yield as well as on uptake of nutrients.

CHAPTER VI

SUMMARY AND CONCLUSIONS.

An experiment was laid out in pot culture in the Department of Soil Science and Agricultural Chemistry with a view to stu dy the effect of levels of calcium carbonate alone and in combination with different doses of copper and boron on yield and uptake of these micronutrients as well as nitrogen, phosphate and potash by Hybrid Jowar, CSH-1. The soil used for this study was brought from Bhabulgaon block, field No. 94, Punjabrao Krishi Vidyapeeth, Akola. Soil was neutral to alkaline in reaction, high in organic matter and potash. However, it was medium in available phosphate and nitrogen. Its free calcium carbonate content was 1.363 %, soil type was silty clay loam.

In all there were 17 treatments replicated thrice, consisting of six (1.363 % to 6.363 %) levels of calcium carbonate. These increasing levels of calcium carbonate were combined with 4, 5, 6, 7, 8 and 9 Kg per acre of each copper sulphate and borax respectively. A constant dose of 4 Kg per acre each of copper and boron was also combined with the increasing levels of calcium carbonate.

Grain and fodder yields obtained from each treatment were recorded. Plant samples at 60 days and harvest stage (grain and straw) were analysed for copper, boron and major nutrients i.e. nitrogen, phosphorous and potash content. Uptake of these nutrients were calculated by taking into consideration the total dry matter and the percent content of these nutrients. The result of this study is summerized and conclusions are as under.

1) Increasing levels of calcium carbonate alone, and combined with increasing and constant doses of copper and boron resulted in lowering the grain and fodder yields. However, the yields obtained more with levels of calcium carbonate combined with application of copper and boron than only levels of calcium carbonate. Maximum grain and fodder yields were obtained with a dose of 4 Kg per acre each of copper and boron at 1.363 % level of calcium carbonate, followed by its 4.363 % level. A dose of 6 Kg per acre of each copper and boron at 3.363 % level of calcâcum carbonate yielded slightly less than with a dose of 4 Kg per acre each of copper and boron at 4.363 % level.

2) Contents and uptake of copper in plants at harvest (grain + straw) decreased with increase in calcium carbonate alone and combined with constant and increasing doses of copper and boron also. Reverse trend in respect of boron content and uptake was observed. Amount of these micronutrients were more at 60 days growth than that at harvest stage in straw.

3) Concentration and uptake of these micronutrients were found to be more when levels of calcium carbonate combined with the application of copper and boron than alone. Total uptake of copper and boron was observed to be maximum with a dose of 4 Kg per acre each of copper and boron at 1.363 % and 4.363 % level of calcium carbonate respectively.

4) Concentration and uptake of copper was more in grain than in fodder, where as that of boron was more in fodder than in grain.

5) Maximum total uptake of nitrogen and phosphate were noted with 4 Kg per acre of each copper and boron at 1.363 % level of calcium carbonate whereas that of potash was with 5 Kg per acre of each copper and boron at 2.363 % level of calcium carbonate.

6) With increasing levels of calcium carbonate alone and combined with constant and increasing doses of copper and boron, their concentration and uptake at harvest (straw and grain) decreased, whereas the concerntration of potash increased, but its uptake decreased.

7) Concentration of N, P_2O_5, N_2O and Cu, B decreased with the maturity.

8) Yield and uptake of N, P_2O_5, K_2O and Cu, B and their concentration were increased when levels of calcium carbonate combined with the application of copper and boron.

LITERATURE CITED

Aguthon H 1912 The use of boron as a catalytic fertilizers (Int.Congr.Appl.Chem. Volu.15. No.9)

Bhattacharjee J.C. 1956 Water soluble boron in soils of Murshidabad (West Bengal) Jour.Ind. Soc.Soil Sci.Vol.4: 161-66

Brenchley and Warington Micronutrient reserch in soil and plant in India quoted by Kanwar J.S. and N.S.Randhawa.

Dean H.C. 1936 The effect of liming on the liberation of potassium in some Iowa soils. Iowa Agri.Expt. Sta.Bull. 197.

Densch A. and Hunnius T 1924 Experiments with copper sulphate (Ztschr. pflanzenernahr. V. Dungung 3:369)

Dhawan C.L. and A.D.Dhand 1950 The occurence and significance of trace elements in reaction to soil deteriaration II Boron ibid Volu.20: 479-485

Gaither E.W. 1910 Effect of lime upon the solubility of soil constituents (Jour.Indus. and Engin.Chem. 2: 315-316)

Gandhi S.C. and Mehta B.V. 1960 Note on boron content of plants grown in Goradu soils (Ind.Jour. of Agronomy, Volu.V (1): 36-38) 1960.

Gopalrao H.G. and Govindrajan S.V. 1954 The infludnce of copper sulphate on paddy.(Proc. 41st Ind. Sci. Congr. Part III : 265.

Guthie F.C. and Cohen 1907 Note on the effect of soil constituents (Jour. and Proc. Roy. Soc. New South Wales 41 (61-66)

Hodgson 1963 Micronutrient research in soil and plant in India quoted from Kanwar J.S. and Randhawa N.S.

Jogi S. and Ahuja L.R. 1965 Micronutrient fertilization of hybrid maize in hilly soils (Sci. & Cult. Vol. 31 No.2 Page 95.

Joret Gand, Malterre H. 1939 Action of copper sulphate. Recherches furtilization sta. Agro. Ministere Agro. France 12 Page 226.

Joshi N.V. and Joshi S.G. 1952-57 Copper as a fertilizer (Jour. Indi. Soc. Soil Sci. Vol. No. 21).

Joshi S.G. 1956 The response of jowar to application of different micronutrients (Jour.Ind. Soc. Soil Sci. Vol.4 Pages 147-49).

Kanwar J.S. and Randhawa N.S. 1959 Possibilities of utilizing micronutrient for increasing crop production (Papers presented to the seminar on recent advances in Agro. & Soil Sci.I.C.A.R New Delhi.

Kanwar et al 1958-62 Annual progress report of scheme of distribution of micronutrients in Punjab soils & their effect on yield of crops for 1958, 59, 60, 61 and 62).

Kanwar J.S. and Singh S.S. 1961 Boron in normal and saline alkali soils of the irrigated areas of Punjab (Soil Sci. Vol.92 Page 207).

Kavimandan S.K., Badhe N.N. and Ballal D.K. 1964 Available copper and molybdenum in vidharbha soils, (Jour. Ind. Soc. Soil Sci. Vol.12 Page 281-88).

Koraddi V.R. and Seth V. 1964 Effect of soil and foliour application of micro-nutrients on yield and auality of wheat (Jour. Ind. Soc. Soil Sci. Vol. 12 Page 387-92).

Lee C.K. 1947 Variation in yield and composition of the wheat plant as affected by a time of applying,phosphatic fertilizers (Jour. Amer. Soc. Agro. Vol. 32 Page 782-88).

Mandal S.C., M.A. Ali and H.N. Mukherjee 1956 Boron requirement of some Bihar soils (Jour.Ind.Soc. Soil Sci. Vol. 4 Pages 79-86).

Mathur C.M., V.R.Modhi and Talati M.R. 1964 Distribution of boron in soils of Western Rajastan irrigated with high boron water. (Jour. Ind. Soc. Soil Sci. Vol. 12 Pages 319-24).

Merry D.E.M. 1945 Top dressing in Nelson Newzea (Jour. Agri. Dec. Pages 609-613).

Midgley A.R. and D.E. Dunklee - Cause and nature of overliming injury (Vt. Agri. Expt. Sta. Bull. 460 Pages 3 to 22)1940.

Mishra S.G. and Sharma M.D.	1961	Micronutrient status of upland and lowland rice soils of India (Soil and plant Vol.6 Page 103)
Montgomerry K.M.	1946	Pasture top dressing in Northern kind country N New-eal. (Jour. of Agri. Page 185-89).
Nieschlag F. and Teichmann W.	1956	Field experiments with the complete fertilizers (Hoechst Landow Forschs Pages 213-18).
Pandya P.C., K.S.Yawalkar and Ranbir Singh	1955	Crop response to micro-nutrients under Indian conditions (Ind. Jour. Agro. Vol. 8 Pages 254-64).
Pareek B.L. and S.V. Jain	1966	Effect of micronutrients on Maize in alluvial soil region of Rajastan (Ind. Jour. Agro. Vol.11 Page 291-93).
Pierre W.	1928	Nitrogenous fertilizers and soil acidity (Jour. Amer. Soc. Agro. Vol.20 Pages 270-79) 1928.
Raheja P.C., K.S. Yawalkar and Ranbir Singh	-	Crop responses to micro-nutrients under Indian conditions (Ind. Jour. Agro. Vol.1 No.4 Pages 254-60) 1959.
Rai M.M. and M.K. Mishra	-	Available copper in Madya Pradesh soils (Jour. SInd. Soc. Soil Sci. Vol.15(1) 1967.
Raychaudhari S.P.	1953	Review of the progress of research work on soil science and Agril. Chem. in India during 1952-53. Quoted from Mathur et al. (Ind.Jour.Agro. Vol.4(1) Pages 36-42.

Reeve and Shive 1944 Potassium/boron relation in plants (Better crop with plant food 57(1) (original not seen).

Russelt R. and Manus T.F. 1933-34 The value of copper sulphate as a plant nutrients. (Trans. Peninshla Hort. Soc.Vol. 5 Pages 97-129).

Sadaphal M.N. and Das N.B. 1956 Effect of micronutrient element fertilization on wheat. (Soil and Cult. Vol.32(4) Pages 233-35.

Sadaphal M.N. and Das N.B. 1961 Effect of micronutrients. (Soil and Cult.)

Steenbjerg. F. 1948 Mikronaeringsstufferne ogjordbruget Resultafer af nyere undersogelserog Forsagi Danmark Nord. Jordbr. (Forsk Vol.4 No.6 Pages 722-33.

Swaine D.J. 1955 The trace element content of soils common wealth Bureau of soil Sci. Technical communication No. 48.

Thorne C.E. 1957 A Review - Micronutrient research in soil and plant in India quoted by Kanwar J.S. and Randhawa N.S.

Truninger E. 1944 Experiments and studies on the effect of boron as a trace element (Londw. Jahrb. Schweiz Vol. 58 Pages 1 to 36).

WEEKLY METEROLOGICAL DATA FOR THE YEAR 1972

KHARIF SEASON

Month	Metero logical week No	Rainfall in mm per week	No.of rainy days/week	Temp.in °C Max.	Temp.in °C Min.
June	23	0.0	0.0	42.6	27.1
	24	18.0	2.0	41.6	25.6
	25	28.8	3.0	37.6	25.4
	26	71.2	7.0	32.4	22.6
July	27	74.2	7.0	29.4	22.6
	28	8.9	2.0	33.6	22.3
	29	0.8	1.0	33.9	23.6
	30	0.0	0.0	36.0	23.4
	31	83.2	1.0	36.1	23.3
Aug.	32	0.0	0.0	32.7	22.9
	33	169.9	5.0	28.2	20.7
	34	63.5	6.0	28.5	21.6
	35	0.5	1.0	29.8	21.3
Sept.	36	36.8	2.0	33.0	31.7
	37	51.7	3.0	31.7	21.3
	38	0.0	0.0	35.4	20.0
	39	0.0	0.0	35.4	15.1
Oct.	40	0.0	0.0	35.4	18.6
	41	0.0	0.0	35.5	16.0
	42	0.0	0.0	36.9	18.7
	43	0.0	0.0	34.4	18.8
	44	21.6	1.0	29.5	18.0
Nov.	45	0.0	0.0	32.1	11.9
	46	0.0	0.0	32.7	12.5
	47	0.0	0.0	32.1	13.1
	48	0.0	0.0	29.9	13.5
Dec.	49	0.0	0.0	29.8	12.8
	50	3.1	1.0	29.9	13.8
	51	0.0	0.0	31.9	12.2
	52	0.0	0.0	36.7	15.9

TABLE 10

SOIL pH AT VARIOUS STAGES OF HYBRID JOWAR CSH-1

pH AFTER 30 DAYS

Levels of $CaCO_3$	Levels of copper and boron		
	Control	Varying levels of Cu & B	Constant dose of Cu & B
0	7.7	7.8	
1	7.8	7.9	7.9
2	8.0	8.0	8.0
3	8.1	8.1	8.1
4	8.0	8.2	8.1
5	8.5	8.5	8.5

pH AFTER 70 DAYS

0	7.8	8.0	
1	7.9	8.0	7.9
2	7.9	8.1	7.9
3	8.0	7.9	8.0
4	8.1	8.3	8.2
5	8.8	8.8	8.8

pH AFTER HARVESTING

0	7.9	8.0	
1	8.0	8.1	8.0
2	8.1	8.1	8.0
3	8.1	8.3	8.1
4	8.2	8.4	8.2
5	8.6	8.6	8.4