

## CHAPTER ~ 5

### SUMMARY AND CONCLUSION

Maize (*Zea mays*) commonly referred to as corn is used as staple food in America. The most probable origin of maize is Mexico (Central America), from where it spread to other parts of the world. It is reported that maize has been introduced to other countries in 1400s' where it has been cultivated in spring and winter seasons. Presently the maize is cultivated throughout the year in almost every part of the world. The potential yield of maize per unit land area is highly dependent upon fertility levels, plant population, management practices, and inherent potential of the variety adapted to that area. Present day maize hybrids show better response towards maximization of fertilizers. Higher yields are achieved from hybrid maize because it uses nutrients more efficiently than synthetic varieties (Kogbe and Adedrian, 2003).

Maize variety (BIO 9681) is one of the most important cereal crop grown year around in the district. In Nabarangpur district, its importance is much more as it fetches remunerative price and improve their economic status. The crop shows the deficiency symptoms of Zn causing reduction of yield.

In view of these facts, the present study was designed to investigate the combined effect of NPK organic matter, ZnSO<sub>4</sub> and nano Zinc on soil characteristics, yield and yield attributes of maize and nutrient uptake in Nabarangpur district.

The field experiment was conducted in the farmers field during kharif-rabi (2013-14) and kharif-rabi (2014-15) in the village Chingudiguda, block adopted village of krishi Vigyan Kendra, Nabarangpur. The experimental site is situated at 19.6864° N latitude and 82.2751° E longitude it comes under Eastern Ghat high land Zone.

There were nine treatment combinations consisting of NPK, lime, organic matter, zinc sulphate and nano zinc.

The results obtained in these studies are summarized.

#### **Delineation of available micronutrients (Zn, Cu, Fe, Mn and B ) and S status in soils**

- For the delineation of available micronutrients (Zn, Cu, Fe, Mn and B ) and S status in soils, 154 nos. of soil samples were collected from three blocks viz. Umerkote, Raighar and Jharigaon of Nabarangpur district of Odisha with the help of global positioning system (GPS) and recorded the longitude and latitude of the area. Thematic soil fertility maps were prepared by using GPS and Geographical Information System (GIS).

The soil pH of maize growing blocks of Nabarangpur district ranged from 5.28 to 6.79. The soils of these are strongly acidic to neutral in nature. The electrical conductivity of the soil varied from 0.01 to 0.188 dS m<sup>-1</sup> indicating non-saline nature of soils. The organic carbon ranged between 0.03 to 2.37 %. The DTPA-Zn in soils varied from 0.06 to 7.8 mg kg<sup>-1</sup>. Out of 154 soil samples analyzed, 60.4% samples were found to be deficient in DTPA extractable Zn whereas 29.9 and 9.7 per cent soil samples were registered as marginal and adequate category, respectively. The results showed that the samples were deficient in Zn needs to be supplemented with Zn fertilizer for the better crop yield specifically for maize which have high Zn requirement.

The average content of Fe and Mn in the soils were 71.8 and 48.8 mg kg<sup>-1</sup>, respectively. The DTPA extractable Cu content of the soil ranges from 0.07 to 2.4 mg kg<sup>-1</sup> with a mean of 4.23 mg kg<sup>-1</sup>. The results showed that only 4% of the soil are deficient in Cu, 16% as marginal and 80% of the soils were adequate in B content.

The results showed that sulphur content varied from 0.39 to 22.3 mg kg<sup>-1</sup> with a mean of 3.9 mg kg<sup>-1</sup>. It is alarming to note that the soils of Nabarangpur district registered 94% deficiency of S whereas only 4 and 2% were in marginal and adequate level, respectively. So there is an immediate need to apply sulphur fertilizer to enhance the crop growth.

The hot water soluble Boron status varied from 0.04 to 20.53 mg kg<sup>-1</sup> with a mean value of 2.5 mg kg<sup>-1</sup> in soil. The results indicate that about 33% of soils are deficient in B whereas 18 and 49% soils respectively are in the marginal and adequate range. There is an urgent need to apply B fertilizer for better crop grain formation particularly for maize crop.

### **Vertical distribution of available Zn in soil profiles of alluvial, black, red and Laterite soil**

- In the vertical distribution of the DTPA-extractable Zn decreases with increase in depth. The zinc content was maximum in 0 to 15cm in all the soils and minimum in 45cm to 60cm depth and laterite soil has maximum zinc content 1.0 ppm and then followed by Black soil (0.9ppm), Red soil (0.88ppm) and alluvial soil (0.45ppm) in 0-15cm depth.

### **Adsorption characteristics of Zn in alluvial, black, red and Laterite soils**

- The amount of adsorption of Zinc was found different for different soils when Zinc was added at different rates 2, 4, 8, 16 and 32 µg Zn/ml. Generally Zinc adsorption increased with increasing rate of Zinc addition. From the results it was proved that the Zinc adsorption was highest in alluvial soils followed by

black soil, red soil and then red and lateritic soil having (b) value 30.30 (mg/kg) highest in alluvial soils followed by black soil 29.41 (mg/kg) red soil 28.7 (mg/kg) and then red and lateritic 27.77 (mg/kg)

### **Efficacy of Zinc on growth, yield and yield attributing characters of maize as influence by application of organic matter, NPK, lime and Zn in pot experiment during 2013-14**

- The yield of maize in pot experiment increased significantly from 252.09 (g/plant) to 520.15 (g/plant) in best treatment (T<sub>9</sub>) over control in pot experiment during 2013-2014. The increase in yield of maize (g/plant) in increasing order as follows: T<sub>9</sub>>T<sub>8</sub>>T<sub>5</sub>>T<sub>3</sub>>T<sub>4</sub>>T<sub>6</sub>>>T<sub>7</sub>>T<sub>1</sub>
- The length of cob in pot experiment ranged from 9.21cm to 12.73cm. Results revealed that the combined application of NPK, organic matter, Nanozinc @ 0.3% spray before and after flowering resulted the maximum cob length of maize. The treatments T<sub>9</sub> and T<sub>8</sub> are *at par* with regards to length of maize cob. But the table shows that the T<sub>2</sub> and T<sub>4</sub> treatment has got the length 9.56cm and 9.59cm with application of NPK along with 2.5 kg Zn and also NPK along with 5 kg Zn registered *at par* results.
- The cob diameter (cm) in pot experiment increased from 5.60cm to 7.33cm. The highest cob diameter was recorded in treatment (T<sub>9</sub>) as a result of combined application of NPK, organic matter, Nanozinc @ 0.3% spray before and after flowering. Treatments T<sub>8</sub> and T<sub>9</sub> were *at par* with regards to cob diameter.
- The number of cob/plant varied from 1.33 to 2.90 in pot experiment. The combined application of NPK, organic matter, Nano zinc @ 0.3% spray before and after flowering resulted the highest yield (T<sub>9</sub>). However, the application of NPK+OM+2.5kgZn/ha+3spray of ZnSO<sub>4</sub> @0.5% in T<sub>8</sub> registered the *at par* result with regards to number of cobs / plant and the treatment T<sub>2</sub>,T<sub>3</sub>,T<sub>4</sub>,T<sub>5</sub> and T<sub>6</sub> registered non-significant result over control.

### **Effect of Zn in maize cob (g/ha) in pot experiment**

- It increased significantly from 15.3(g/ha) to 60.2(g/ha) in best treatment (T<sub>9</sub>) over control in pot experiment during 2013. Results revealed that the combined application of NPK, organic matter, Nanozinc @ 0.3% spray before and after flowering resulted the maximum uptake in maize.

## **Efficacy of Zinc on growth, yield and yield attributing characters of maize as influence by application of organic matter, NPK, lime and Zn in field experiment during 2013-14 and 2014-15**

- The yield of maize in field experiment (pooled data) increased significantly from 44.15 (q/ha) to 57.25(q/ha) in best treatment (T<sub>9</sub>) over control in field experiment during 2013-2014 and 2014-15. The increase in yield of maize (q/ha) in increasing order as follows: T<sub>9</sub>>T<sub>8</sub>>T<sub>5</sub>>T<sub>7</sub>>T<sub>3</sub>>T<sub>2</sub>>T<sub>6</sub>>T<sub>1</sub>. The highest cob yield was related to nano Zn foliar application (q/ha) and the control (without application) had the lowest yield. Nanoparticles (NPs) with small size and large surface area are expected to be the ideal material for use as a Zn fertilizer in plants. It is interesting to note that application of Zn along with NPK or NPK+OM+Lime as soil application or soil+ foliar application or in the form of nano Zn has profound effect on increasing yield of maize.
- The length of cob in field experiment increased significantly from 13.33cm to 15.85cm. The combined application of NPK, organic matter, Nanozinc @ 0.3% spray before and after flowering resulted the maximum cob length of maize. The increase in the length of cob in increasing order as follows: T<sub>9</sub>>T<sub>8</sub>>T<sub>7</sub>>T<sub>5</sub>>T<sub>4</sub>>T<sub>6</sub>>T<sub>3</sub>>T<sub>2</sub>.
- The cob diameter (cm) in field experiment (pooled data) increased significantly from 7.52cm to 8.88cm. The combined application of NPK, organic matter, Nanozinc @ 0.3% spray before and after flowering resulted the maximum cob diameter (cm) of maize among all the treatment. The cob diameter is in increasing order as follows: T<sub>9</sub>>T<sub>8</sub>>T<sub>3</sub>>T<sub>7</sub>>T<sub>2</sub>>T<sub>5</sub>>T<sub>4</sub>>T<sub>6</sub>.
- The number of cob/plant increased significantly varied from 2.18 to 3.86 in field experiment. The combined application of NPK, organic matter, Nanozinc @ 0.3% spray before and after flowering resulted the highest yield in (T<sub>9</sub>) over control and all other treatments. The application of NPK, organic matter, Nanozinc @ 0.3% spray before and after flowering registered the highest number of cobs / plant than the application of NPK+OM+2.5kgZn/ha+3spray of ZnSO<sub>4</sub> @0.5% in T<sub>8</sub>.

### **Yield (q/ha) and concentration (mg/kg) of Zn in field experiment as influenced by treatments**

- The stover yield of maize increased significantly from 101.96 (q/ha) to 113.43 (q/ha) in field experiment during 2013-2014 and 2014-15. The increase in yield of maize (q/ha) in increasing order as follows: T<sub>9</sub>>T<sub>8</sub>>T<sub>5</sub>>T<sub>7</sub>>T<sub>3</sub>>T<sub>4</sub>>T<sub>6</sub>>T<sub>2</sub>>T<sub>1</sub>.

The results also showed that the highest stover yield was related to nano Zn foliar application and the control (without application) had the lowest.

- The concentration of zinc in cob increased significantly from 21.35mg/kg to 27.79mg/kg in field experiment during 2013-2014 and 2014-15. The increase in yield of maize (q/ha) is in increasing order as follows: T<sub>9</sub>>T<sub>8</sub>>T<sub>5</sub>>T<sub>7</sub>>T<sub>4</sub>>T<sub>3</sub>>T<sub>2</sub>>T<sub>6</sub>>T<sub>1</sub>. The combined application of NPK, organic matter, Nano zinc @ 0.3% spray foliar application gave the highest concentration among all the treatment in both the year and all the treatments like T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>7</sub>, T<sub>8</sub> and T<sub>9</sub> showed the significant result over control.
- The concentration of zinc in stover increased significantly from 21.35mg/kg to 27.79 in best treatment (T<sub>9</sub>) over control in field experiment during 2013-2014 and 2014-15. The increase in yield of maize (q/ha) in increasing order as follows: T<sub>9</sub>>T<sub>8</sub>>T<sub>5</sub>>T<sub>7</sub>>T<sub>4</sub>>T<sub>3</sub>>T<sub>2</sub>>T<sub>6</sub>>T<sub>1</sub>. The all treatment T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>7</sub>, T<sub>8</sub> and T<sub>9</sub> showed the significant result over control and the treatment (T<sub>6</sub>) has got the concentration 25.28 (mg/kg) with application of NPK with organic matter 5 t/ha registered non significant result.

### **Uptake of Zn by cob (g/ha) and stover of maize (g/ha) (pooled data) in field experiment**

- The cob uptake of Zn in field experiment increased significantly from 71.98 (g/ha) to 122.81(g/ha) in best treatment (T<sub>9</sub>) over control in field experiment during 2013-2014 and 2014-15. The combined application of NPK, organic matter, Nanozinc @ 0.3% spray before and after flowering resulted the maximum uptake in maize. The treatment T<sub>2</sub> is at *par* with regards uptake of maize cob.
- The stover uptake of zinc in maize increased significantly from 257.57 (g/ha) to 412.01 (g/ha) in best treatment (T<sub>9</sub>) over control in field experiment during 2013-2014 and 2014-15. The increase in stover uptake of maize (g/ha) in increasing order as follows: T<sub>9</sub>>T<sub>8</sub>>T<sub>5</sub>>T<sub>7</sub>>T<sub>4</sub>>T<sub>3</sub>>T<sub>2</sub>>T<sub>6</sub>>T<sub>1</sub>. The application of NPK+OM +Nano Zn @ 0.3% spray before and after flowering (T<sub>9</sub>) resulted highest stover uptake among all the treatment. But the treatment (T<sub>6</sub>) has got the stover uptake (261.5 g/ha) with application of NPK with organic matter 5 t/ha registered non significant result.

### **Yield and stover yield of Greengram as influenced by Zn**

- The pod yield of greengram increased significantly from 8.85 (q/ha) to 11.71 (q/ha) in best treatment (T<sub>9</sub>) over control in field experiment during 2013-2014 and 2014-15. The yield increased significantly in all treatment except

treatment T2 resulted *at par* over control. The combined application of NPK, organic matter, Nanozinc @ 0.3% spray before and after flowering in maize has greatest residual effect of Zn on Greengram yield than other treatments.

- The stover yield of greengram increased significantly from 37.99 (q/ha) to 43.84 q/ha in best treatment (T<sub>9</sub>) over control in field experiment during 2013-2014 and 2014-15. The yield increased significantly in all treatment except treatment T2 and T6 resulted *at par* over control. So the combined application of NPK, organic matter, Nanozinc @ 0.3% spray before and after flowering in maize has greatest residual effect of Zn on Greengram stover yield than other treatments.

#### **Yield Studies Cob Yield**

- In the pooled analysis, Cob yield recorded with T<sub>9</sub> is 57.25(q/ha) with combined application of NPK, organic matter, Nano zinc @ 0.3% foliar spray which was 29.67% higher over control T<sub>1</sub> (44.15 (q/ha).

## Conclusion:

Based on the research results emerged from the present study, the following conclusions can be drawn:

- Delineation of 154 nos. of soil samples of maize growing blocks of Nabarangpur district revealed that the soils were deficient in Zn and need to be supplemented with Zn fertilizer for the better crop yield specifically for maize which have high Zn requirement.
- In the vertical distribution of the DTPA-extractable Zn revealed that availability of Zn decreases with increase in depth. Due to fixation, the micronutrient Zn is not available to the plant, though it is needed in small quantities as compared to primary nutrients, and have major role in terms of impact on crop growth and productivity. Farmers of these areas preferred to add more NPK to maize crop but ignorant about application of Zn for getting higher yield. Maize is highly responsive to Zn fertilization.
- Generally Zinc adsorption increased with increasing rate of Zinc addition. Continuous use of high analysis fertilizer and cropping system results heavy removal of nutrient and causes deficiency of micronutrient. The amount of adsorption of Zinc was found different for different soils when Zinc was added at different rates of 2, 4, 8, 16 and 32  $\mu\text{g/ml}$ . So the required amount of Zn addition provide favorable environment for crop growth and development.
- The combined application of NPK, organic matter, Nanozinc @ 0.3% spray increased more cob yield over control in pot experiment.
- The combined application of NPK, organic matter, Nanozinc @ 0.3% spray increased the cob yield by 29.67% over control in field experiment.
- The combined application of NPK, organic matter, Nano zinc @ 0.3% spray increased the cob length, the cob diameter and number of cobs/plant in maize plant in best treatment (T9) over control. So it is interesting to note that application of Zn along with NPK or NPK+OM+Lime as soil application or soil+ foliar application or in the form of nano Zn has profound effect on increasing yield of maize.
- The Zn uptake in cob and stover in pot as well as field experiment increased significantly in best treatment (T9) which signifies nutrient content in cob and stover can be improved by combined application of Zn along with NPK or NPK+OM+Lime as soil application or soil+ foliar application or in the form of nano Zn.

- The combined application of NPK, organic matter, Nanozinc @ 0.3% spray before and after flowering in maize has greatest residual effect of Zn on Greengram yield and stover yield than other treatments.