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EFFICACY OF COLEMANITE ORE AS BORON FERTILIZER FOR MAIZE *(ZEA MAYS* L.*)* GROWTH AND YIELD.

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ABSTRACT: *Maize (Zea mays L.) main cereal crop after rice and wheat and leading fodder crop in the world. Maize productivity decreases because of many factors including micro nutrients deficiencies. Boron deficiency in soil has increased in recent years. The colemanite ore ($Ca_2B_6O_{11}.5H_2O$) is a low-priced and slow releasing B source in comparison to other refined B products. The influence of B levels on maize crop growth and grain yield were studied in a glass house experiment. Colemanite ore was used as B fertilizer on hybrid 89Y32 maize variety. Four levels of B at the rates of 1.0 kg B ha^{-1}, 2.0 kg B ha^{-1}, 3.0 kg B ha^{-1}, and 4.0 kg B ha^{-1} were applied in four replications. A control treatment (no B) was also included in the experiment. Boron was applied as colemanite at the time of maize sowing. The study revealed that height of plant, stem width/girth, green and dry leaves plant^{-1}, ear head length and grain yield per pot significantly affected as a function of B levels. Although the B application at all levels positively affected all growth parameters of plant in compare to control but 3 kg B ha^{-1} were significantly higher in compare to other rates and at this level grain yield was highest.. Subsequently, this level of B in the shape of colemanite ore may be considered an optimum rate for healthy maize crop growth and yield. The B content in post-harvest soil samples was high in colemanite applied pots and it is expected that B residual effect on subsequent crop will be positive.*

Key words; Maize, Boron, Colemanite ore

INTRODUCTION

The maize (Zea mays L.) is one of the main grain crop of the world. It is abundantly cultivated in the tropical and sub-tropic and temperate areas of the world. It is a crop with numerous manners that delivers the food for human being, the feed for the animals and raw ingredients for industries. It has high yield prospective, quick growth, the broadest adaptability, the good fodder quality and can be harvested at any growth stage for fodder purpose. Improvement in average maize grain and fodder yield can be achieved through balanced soil fertility by including micronutrients in fertilizer application [1]. Micronutrient deficiencies in Pakistan are one of the main reasons of low crop yields and poor food quality. Boron insufficiency is most common micronutrient deficiency in soils after zinc and it is affecting production of different crops including cereal, oil and deciduous fruits [2]. Maize plant is sensitive to micronutrients deficiency and can show micronutrients insufficiency symptoms [3]. Application of micronutrients through fertilizers recovers the plant growth and production [4].

Boron is an important micronutrient for healthy crop growth and is required for meristems' cell formation and division near the tips of plant roots and shoots, carbohydrate breakdown and absorption, plasma membrane integrity, pollen tube development, evolution of the pollen tube through flower pollination and consequently imperative for healthy seed formation ([5, 6, 7]. Insuffient supply of B to plants can result in stoppage of terminal bud growth and ultimately reduction in number of young leaves, sugar transportation within plant, pollen evolution and development of nodules ultimately seed and grain production are negatively affected in its absence [8,9]. Boron insufficiency in soils is the second most important universal soil fertility issue. Pakistani soils are deficient in B due to calcareous conditions, mining of nutrients, small percentage of organic matter and inadequate fertilizer application [2, 10].

The sodium tetra borate, borax, sodium pentaborate, solubor and boric acid are refined B products and are widely used as B fertilizers. The colemanite ($Ca_2B_6O_{11}.5H_2O$), datolite, ascharite and hydroboracite are B containing minerals. These ones are only crushed in powder form and applied in soil as B fertilizers [11]. Boron from refined materials are promptly available for plant but can be lost from soil root zone in leaching. Crops need small but continuous supply of B for healthy growth. The colemanite and ulexite are slow releasing B fertilizers so the losses from soil are also scarcer, the application of these B minerals will deliver small but continuous B for healthy growth and development of plants [12]. It is necessary to apply required levels of B through proper methods and sources in B deficient soils for higher maize crop production. A glasshouse study was initiated to evaluate the effects of different rates of soil applied B on maize crop. The colemanite mineral is a low-priced and slow release B fertilizer in contrast to commonly used refined B sources. In this study colemanite were used as B source with the objectives to evaluate the effects of different B levels on growth and grain yield of maize crop and to define its suitable levels when colemanite is applied.

MATERIALS AND METHOD

The effects of colemanite as B fertilizer on maize crop were studied in a pot experiment at the glasshouse of Sindh Agriculture University Tandojam Pakistan. The soil used in pots were collected from the research farm of the university, then it was dried, ground and 15 kg soil was filled in pots of 18 cm Ø. The soil was loamy in textural class, calcareous and non-saline, low in organic matter %, deficient in total nitrogen, available phosphorus and B contents, adequate in exchangeable K (Table 1). The pots were placed in completely randomized design (CRD). The nitrogen and phosphorus were applied as per recommendation for variety. The five levels of B at the rates of 0 kg B ha^{-1}, 1 kg B ha^{-1}, 2 kg B ha^{-1}, 3 kg B ha^{-1} and 4 B kg ha^{-1} were applied with four replications. Required fertilizer rate per pot were calculated according to soil weight.

The crushed ore colemanite mineral containing 12% B was used as the source of B. Five healthy seeds of Hybrid (89Y32) maize variety were sown in every pot. Afterwards the germinated seedlings were thinned to maintain three plants in each pot. The pots were watered as per plant requirement and harvested after grain formation. The frames were used around the pots to control the lodging of taller plants. Before harvesting, height of plant, stem width/girth, number of fresh and dry leaves, ear head length and grain yield pot^{-1} in each of the treatments were recorded. The soil samples were analyzed for physico-chemical properties by internationally recognized methods. Soil B concentration was analysed by dilute hydrochloric acid method and in plant test was determined by dry ashing and afterwards B was measured by colorimetry [13]. The data was statistically analysed in the programme Statistix computer software version 8.1. The significant differences amongst means was equated by applying Least Significant Difference (LSD) test at p=0.05 value.

RESULTS AND DISCUSION

The B application significantly increased height of the plant (Table 2). The lowest height was recorded at control (176.91 cm) and tallest plants were in pots of 3 kg B ha^{-1} (194.13). Further increase in B levels at 4 kg ha^{-1} rather lessened the plant height (190.21) in compare to 3 kg ha^{-1}. Gupta [14] reported that application of various B levels increased the plant height at different growth stages. The stem girth also improved with B application. The highest stem girth was 5.87 cm measured in where 3 kg B ha^{-1} was applied. This was followed by 5.80 and 5.26 cm, in 4 kg B ha^{-1} and 2 kg B ha^{-1} respectively (Table 2). The tiniest stem thickness (3.67 cm) was measured in control treatment. These results are in accordance with the findings of Soomro [15] who reported that 3 kg B ha^{-1} is the perfect rate for achieving maximum maize stem thickness.

The number of green leaves in maize plant are shown in Table 2. The number of green leaves plant^{-1} varied significantly at B levels and the maximum green leaves were counted at 3 and 4 kg B ha^{-1} (16.0 and 16.5) the difference between these treatments were non-significant. Consequently, the reasonable amount of B may be considered as 3 kg ha^{-1} for maximum green leaves of maize plant. The root dry weight also improved with the addition of B fertilizer colemanite. The highest root weight (5.5 g) was documented at 4 kg B ha^{-1} and lowest dry weight (2.2) was from the pots with 0 kg B ha^{-1}. The ear head length is shown in Table 3. The ear head length significantly increased with the increase of B levels. The smaller ear head (77.50 cm) was from the plants of control and lengthy (98.5) one was at 4 kg B ha^{-1}. The comparison among treatments disclosed that the ear head length differences were non-significant at B levels 3 and 4 kg ha^{-1}. The higher rates of B decreased the ear head length.

The positive effects of colemanite application on maize plant growth parameters are attributed to the role of B in plant physiology. The lack of B causes a problem in the meristems, or stem cells of the plant and growing points in the plant withered which adversely affects the kernels and tassels [16]. Boron deficiency is harmful for reproductive development in plants by defective tassel growth and inflorescence meristems, vegetative and reproductive weaknesses including sterility [17]. The soil B contents after maize harvest showed significant increase with the increasing rate of B. The soil B content was minimum at control (0.45 mg kg^{-1}) and maximum at 4 kg B ha^{-1} (1.06 mg kg^{-1}). The soil analysis results after crop harvest are indicating that B losses from colemanite applied pots are fewer and this residual B will be beneficial for subsequent crop cycle. The same results were reported by Saleem [13] in their pot experiment to study the effects of colemanite on rice crop.

The plant straw B content significantly increased with the increasing levels of B. Its lowest concentration was in plants of control pots and highest was in plants which received 4 kg B ha^{-1}.

The grain yield pot^{-1} significantly increased at all B levels in compare to control. The pots with 3.0 kg B ha^{-1} were harvested with highest weight of grains (2055.8 g pot^{-1}) followed by 4.0 kg B ha^{-1} level (2040.6 g pot^{-1}). The minimum grain yield (1938 g pot^{-1}) was recorded from the control pots with no B application. The b application up to 3 kg significantly improved maize yield and further increase in B level beyond 3 kg rather started decreasing the grain yield and application was uneconomical.

The findings of our study are in agreement with the results of The results of our experiment are in agreement with the findings of other scientists [18, 19] they conducted experiments to find out the effect of B on maize crop and reported that B application had shown positive physiological and biochemical changes in plant, enhanced grain and fodder yield of crop and B deficiency depressed maize grain formation. The higher per hectare higher rates of B were applied because B fertilizer was slow release B source colemanite ore. The results of our experiment had shown that colemanite was effective fertilizer of B once it was applied in higher quantities and that was owing to slow release of B from it. The continuous supply of B is required for healthy growth cycle and for that reason colemanite is worthy choice for growers as it is also cheap in compare to other B sources. Beside this residual B level in soil after harvest was high in colemanite applied pots due to low leaching losses and this residual B will be fortunate for succeeding crop. The outcome of our experiment are supported by the reports of Saleem [20] s' experiments they comparatively evaluated the efficacy of colemanite ore and sodium tetraborate as fertilizers of B for rice crop under field and pot conditions in acidic and calcareous soil. They reported that tiny particles of colemanite ore were useful B source and significantly improved plant growth parameters including B content in grain.

CONCLUSION

The results of our experiment had shown that application of B is helpful in increasing the maize crop growth and yield, the colemanite ore is an effective B source and its residual effect

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can increase crop yields for more than one season due to its slow release nature and low leaching losses. Its application upto 3 kg B ha^{-1} gave significantly higher grain yield.

Table 1. Soil physico-chemical properties used in pots.

Textural Class	Loamy
EC (dS m^{-1}) (1:5 soil water extract)	0.41
pH (1:5 soil water extract)	7.9
Organic matter (%)	0.80
Lime ($CaCO_3$) %	8.2
Kjeldahl's N (%)	0.04
Olsen P (mg kg^{-1})	5.0
Exchangeble K (mg kg^{-1})	166
Boron (mg kg^{-1})	0.50

Table 2. The effects of B rates on maize plant height, stem girth, leaves per plant and root dry weight.

Treatments	Height of plant (cm)	Stem girth (cm)	Green leaves per plant	Root dry wt. (g)
0 kg B ha^{-1}	176.91 d	3.67 d	11.50 d	2.2 d
1 kg B ha^{-1}	182.31 c	4.86 c	13.00 c	3.9 c
2 kg B ha^{-1}	190.88 ab	5.26 bc	14.00 b	5.1 a
3 kg B ha^{-1}	194.13 a	5.87 a	16.00 a	4.8 b
4 kg B ha^{-1}	190.21 b	5.80 ab	16.50 a	5.2 ab

The values with similar letter inside each column are not significantly different at P=0.05.

Table 3. Effect of B levels on B content of soil and plant oil content % and seed yield.

Treatments	Ear head length (cm)	Soil B content after harvest (mg kg^{-1})	B content in plant (mg kg^{-1})	Grain yield pot^{-1} (grams)
0 kg B ha^{-1}	77.50 d	0.45 e	25.00 e	1938 e
1 kg B ha^{-1}	84.50 c	0.59 d	59.00 d	1953.2 d
2 kg B ha^{-1}	91.50 b	0.74 c	74.00 c	1995 c
3 kg B ha^{-1}	98.00 a	0.89 b	89.00 b	2055.8 a
4 kg B ha^{-1}	98.75 a	1.06 a	110.90 a	2040.6 b

The values with similar letter inside each column are not significantly different at P=0.05.

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