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Effectiveness of Colemanite Ore as Boron Source for Sunflower (*Helianthus Annuus* L.) Oil Content and Yield

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Abstract: Sunflower is a very important oil seed crop and it's per hectare yield in Pakistan is low in compare to genetic potential of crop. The imbalanced nutrition is one of the major cause. Boron (B) deficiency affects plant flowering and seed formation. Two kinds of B fertilizers are applied to the crops, the first type of B source are the refined completely soluble materials and the second type is crushed ore such as colemanite ($Ca_2B_6O_{11}.5H_2O$) minerals, these are slow release and cheap B fertilizer but not widely used as B fertilizer. A glass house study was conducted at the Sindh Agriculture Univesity Tandojam to assess the effect of colemanite as a source of B for sunflower oil content and yield. The six levels of B at the rates of control 0 kg ha^{-1}, 1.0 kg ha^{-1}, 2.0 kg ha^{-1}, 3.0 kg ha^{-1}, 4.0 kg ha^{-1} and 5.0 kg ha^{-1}) were applied with four replications. At the time of sunflower sowing B fertilizer colemanite were applied. The results of the experiment had shown that colemanite application improved agronomic parameters of crop at all B levels in compare to control. The maximum plant height, number of achenes per head, stem diameter and achene yield were higher at 4 kg B ha^{-1} as at this rate and 5 kg ha^{-1} B levels difference was not significant. The B application in the shape of colemanite at the rate of 4 kg B ha^{-1} was found optimum for better sunflower yield and oil content. The B content in post-harvest soil samples was high in colemanite applied pots and it is showing that B residual effect on subsequent crop will be positive. It has been concluded that colemanite is an effective and cheaper source of B for sunflower and can be used for higher yield and better oil content.

Keywords: Sunflower, Boron, Colemanite ore

1. INTRODUCTION

Oil seed crops including sunflower keep much importance in Pakistan s' economy because lot of foreign exchange reservoirs are used for importing cooking oil. Since area and production of sunflower is being increased many times in last decade but Pakistan is still suffering a scarcity of cooking oil. The production is tinier than the demand of increasing population. Every year billions of rupees are spent to import eatable oils. In the financial year 2014-15 Rs. 139.3 billion were spent to import 1.789 million tons edible oil was imported. Indigenous production of edible oil from oil seed crops during 2014-15 was about 0.546 million tons and total oil production from all resources is estimated at 2.33 million (GOP 2015). Pakistan s' major oil seed crops are canola, rapeseed, sunflower and cotton seed. The sunflower is non-conventional oilseed crop and extensively scattered around the world because it can survive in different areas. After soybean and groundnut, sunflower is on third position for oilseed productio in the world (Ramula *et al.*, 2011). It consists twenty to twenty seven percent protein and oil content from forty to forty seven percent (Saleem *et al.*, 2003). It is a rich source of vitamins A and D because of the presence of linoleic acid ($C_{18}H_{32}O_2$) 72.5% with high percentage 60% polyunsaturated fatty acid and oleic acid ($C_{18}H_{34}O_2$)16.2% its oil is called top quality oil (Rathore, 2001). The sunflower seed cake is used for cattle feed because it is a decent source of protein for animals (Gandhi *et al.*, 2008). Sunflower has good potential for narrowing up the gap between the supply and demand of edible oil among non-traditional oilseed crop. But due to different factors sunflower genetically potential yield is very higher than the native production in Pakistan and the imbalanced fertilization is one of the major cause of low sunflower grain production. The introduction of high yielding varieties, inadequate use of organic matter, exhaustive agriculture activity and very small use of micronutrient fertilizers Pakistani soils are micronutrient deficient. Boron insufficiency in the soil is the second most important universal soil fertility issue (Alloway, 2008).

Boron is a most required micronutrient. It is vital for the crops cell division, cell wall solidification, hormonal growth, seed and fruit formation and sugar translocation. It takes part in the plants reproduction and spikelet pollen germination and pollen tube growth. Born in the plant have positive correlation with the quantity of flowers and weight of fruit (Bolanos *et al.*, 2004; O'Niell *et al.*, 2004). Boron possess an important nutritional value for human. It affects the energy, nitrogen and brain function, metabolism of macro minerals (Nielson, 2008). Boron is also very important for animals and its deficiency may cause impaired bone

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development and growth, disturb macro mineral position and can increase urinary calcium emission (Devirian and Volpe, 2003). Boron application shows positive responses in B deficient soils. It is predicted that nearly 15 to 16 million hectare are treated with B annually (Tahir *et al.,* 2014, Shorrocks 1997). Boron deficiency problem is commonly seen in soils of Pakistan where the cotton crop is grown on regular basis (Abid *et al.,* 2002). Pakistani calcareous soils are deficient in available B specially the areas growing wheat and rice (Rashid and Ryan, 2008, Rashid and Ryan, 2004). Consequently, B application to the plants is unavoidable in calcareous soils and where intensive crop raising is common. Sunflower is the most sensitive crop in relation of B. All arround the world B deficiency and its low supply in this crop, been reported (Blamey *et al*., 1997). Complete refined soluble materials and the crushed ores are two types of B containing fertilizers, which could be applied either in solids or solution forms. Colemanite and ulexite are the crushed ores which can be applied to the soil as a B source (Bell, 2008). The colemanite ore ($Ca_2B_6O_{11}.5H_2O$) is a low-priced and slow releasing B source in relation to refined products but such source of B is not frequently used as fertilizer. The number of studies on colemanite crushed ores as B fertilizers for different crops is negligible and rather than crop response most of studies are carried on toxicity and leaching in pot experiments (Shorrocks, 1997). Therefore an experiment was designed to assess the efficacy of colemanite mineral as B source for Sunflower to find out suitable B levels for normal growth and oil content of sunflower.

2. MATERIAL AND METHOD

The pot experiment was conducted at greenhouse of the Department Soil Science, Sindh Agriculture University Tandojam. The soil was air dried, grinded and tested in laboratory before filling in the pots. Experiment was laid out in (CRD) completely randomize design. Twenty four pots were filled with 25 kg soil and each pot was of 18 cm Ø. The soil moister in the pots was maintained according to plant requirement. The pest was controlled manually without application of any chemical. The recommended doses of N and P were applied. The six levels of B at the rates of control 0, 1.0, 2.0, 3.0, 4.0 and 5.0 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 fertilizer of B. The equal number of Hybrid (Hysun-39) seeds of sunflower was sown in every pot. Thinning was performed after plant germination by maintaining 2 plants per pot. The pots were irrigated according to plant requirement and harvested after sixteen weeks of growth. The frames were used around the pots to control the lodging of taller plants. Before harvesting the plant height, stem and flower head diameter (cm), number of seeds $disc^{-1}$, seed yield per pot and oil content percentage of every treatment were recorded. The standard procedures were followed to record the data for agronomical parameters. The soil samples were prepared and chemicaly analyzed in the laboratory for physico-chemical properties by internationally recognized methods. Boron concentration in soil samples was analyzed by dilute hydrochloric acid method (Ponnamperuma *et.al.,* 1981) and in plant by dry ashing (Chapman and Pratt, 1961) and consequent measurement of B in extract by Colorimetry using Azomethine-H (Bingham, 1982). The data was analysed for variance (ANOVA) through the method described by Gomez & Gomez (1984). The statistical analysis of the data was performed by using the computer software Statistix version 8.1. The Least Significant Difference (LSD) test was used to see the significance of differences among means.

Table 1. Physico-chemical characteristics of the soil used for pot experiment

Name of property	Value
Textural Class	Loamy
EC (dS m^{-1}) (1:5 soil water extract)	0.39
pH (1:5 soil water extract)	7.58
Organic matter (%)	0.75
Lime ($CaCO_3$) %	8.2
Kjeldahl's N (%)	0.037
Olsen P (mg kg^{-1})	4.59
NH4OAc-extractable K (mg kg^{-1})	166
Boron (mg kg^{-1})	0.55

3. RESULTS AND DISCUSSION

According to soil laboratory analysis **(Table.1)** the soil sample was loamy in texture with particle size distribution of 44.5% sand, 30.5% silt and 25.0%, alkaline in reaction pH 7.58, non-saline with EC 0.39 dS m^{-1}, low in organic matter 0.75%, low Kjeldahl's N (0.05%, Melherb, 1963) with 0.037% N, low in available P (5-10 mg kg^{-1},Olsen, 1954) with 4.59 mg kg^{-1} Olsen P and adequate in NH_4OAc-extractable K (>120 mg kg^{-1}, Soltanpour and Schwab, 1977) with 166 mg kg^{-1}. With boron content 0.55 mg kg^{-1} before sowing. Plant height reflects its growth behavior. The data taken at the time of harvest shows significant effects of boron application on plant height (Table 2). At the rate of 4 kg B ha^{-1} the highest plant height 129.5 cm was observed and at the level of 5 kg B ha^{-1} the height of plant started decreasing (128.7). The lowermost plant height 110.3 cm of sunflower was recorded in the pots where B was not applied. This result can be evident of increase in plant height upto certain B level application but when the B accedes from appropriate dose than the plant shows the negative effect as reduction in height. This increases in height was most probably because B is responsible for many enzymatic and other biochemical reactions. The higher level of B affects soil enzymatic reactions and causes toxicity due to enzymatic problems and it may reduce plant height. Same results were stated by Zahoor *et al*., (2011), Gitte *et al*., (2005) and Kolesnikov *et al*. (2008) they reported that right level of B increased sunflower plant height. Vigorous stem growth means potential development of sunflower plant. The results revealed that stem diameter was significantly affected by B levels (Table 2). For the stem diameter both 4.0 kg B ha^{-1} and 5.0 kg B ha^{-1} rates showed maximum stem diameter of 1.9 cm. However the minimum stem diameter (1.2 cm) was recorded when no B was applied. The B is required in cell structure therefore deficiency of B negatively affects cell enlargement in growing tissues hence reduced stem diameter O'Neill *et al*., (2004). One of the most important yield components of sunflower is head diameter. Although it is genetical character, but soil environment also significantly affects it. The application of B at all levels significantly affected flower head diameter **(Table 2**) and the maximum head diameter 6.0 and 5.8 cm was witnessed when B was applied at the rate of 5 and 4 kg B ha^{-1}. There was no significant difference between these B treatments. Whereas the lowermost head diameter (4.9 cm) was documented where B was not applied. These outcomes are in agreement with the finding of Somroo *et al*., (2007), Reddy *et al*., 2003 and Oyinlola (2007) they stated that sunflower plant head diameter can be increased with the application of B fertilizers. The number of achenes per head is one of another vital yield component. The maximum number of achenes per head (397) was counted from the pots which were applied at the rate of 4 kg B ha^{-1}. While the lower number of achene per head (319) was recorded from control pots (0 kg B ha^{-1}). These results match with results of Somroo *et al.,* (2007), and Reddy *et al*., (2003). They stated that number of achenes $head^{-1}$ augmented due to increased translocation of assimilates and due to that number of achenes also increased.

Table 2. Effect of B levels on sunflower plant height, stem diameter, flower head and number of achens per head.

Treatments	Plant Height (cm)	Stem diameter (cm)	Flower head diameter (cm)	Number of Achene $head^{-1}$
(Control) 0 kg B ha^{-1}	110.3 e	1.2 d	4.9 d	319 f
1 kg B ha^{-1}	115.4 d	1.3 d	5.2 cd	349 e
2 kg B ha^{-1}	118.4 c	1.5 c	5.3 c	374 d
3 kg B ha^{-1}	125.2 b	1.7 b	5.5 bc	381 c
4 kg B ha^{-1}	129.5 a	1.9 a	5.8 ab	397 a
5 kg B ha^{-1}	128.7 a	1.9 a	6.0 a	391 b

The values with same letter within columns are not significantly different at p=0.05

Sunflower production worth is measured by its achene oil content percentage. The highest achene oil % (42.5) was observed when 4 kg B ha^{-1} was applied which was statistically at par with 5 kg B ha^{-1} (Table 2). Whereas lowest achene oil content percentage (40.1%) was observed where B was not applied. As B have role in seed formation so the healthy achens have higher oil content. The findings of this study are supported Oyinlola, (2007) he also observed same positive effects of B on sunflower. The B concentration in soil was analyzed after the harvest. The highest B content (0.91 mg kg^{-1}) was in the pots where given B level was 5 kg ha^{-1} **(Table 3).** While the lowest soil B content (0.55 mg kg^{-1}) was in control pots. The result regarding B concentration in plant leaf shown a significant difference in all treatments. The highest B concentration (64.75 mg kg^{-1}) in leaf was recorded at the rate of 5 kg B ha^{-1}. Though the lowest leaf B content (55.50 mg kg^{-1}) was analysed in plants from pots with no B application.

Achene yield is a function which is related to various yield components and as B application improved all agronomic parameters so the achene yield also increased. The data regarding achene yield per plant is shown in Table 2 B application significantly affected achene yield per plant at all B levels. The maximum yield (32.20 g $plant^{-1}$) was recorded when 4 kg B ha^{-1} was applied whereas lowest achene yield was (14.90 g $plant^{-1}$) with no any B application. Oyinlola, (2007) and Patil *et al*., (2006) also noted same observations. They identified that by application of adequate B levels sunflower seed yield increased, because when B deficiency affects the internal tissues of plant, which may adversely affect seeds and yield decrease.

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

Treatments	Oil content %	Soil B analysis after harvest	B concentration in leaf mg kg^{-1}	Seed yield $plant^{-1}$
(Control) 0 kg B ha^{-1}	40.1 c	0.55 d	55.50 d	14.90 f
1 kg B ha^{-1}	40.8 bc	0.56 d	57.75 c	17.63 e
2 kg B ha^{-1}	41.10 bc	0.65 c	59.50 c	20.93 d
3 kg B ha^{-1}	41.2 b	0.70 b	62.00 b	26.50 c
4 kg B ha^{-1}	42.5 a	0.75 b	62.00 b	32.20 a
5 kg B ha^{-1}	40.1 c	0.91 a	64.75 a	30.80 b

The values with same letter within columns are not significantly different at p=0.05.

Although higher per hectare rates of B were applied but 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 and this B will be favorable for succeeding crop. The results of this study are reinforced by the conclusions of Saleem *et al.* (2010 and 2013) s' experiments they comparatively evaluated the efficacy of mineral colemanite and sodium tetraborate as fertilizers of B for rice crop under field and pot conditions in acidic and calcareous soil. They reported that colemanite with lesser particle size was an effective B fertilizer and significantly improved plant growth parameters including B content in grain.

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