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Effect of Sulphur, Zinc and Boron on Growth, Yield and Economics of Watermelon [*Citrullus lanatus* (Thunb.)] in *Vertisol* of Northern Karnataka

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ABSTRACT: A field experiment was carried out at farmer's field of Kamaknur village of Kalagi taluka in Kalaburagi district Karnataka to study the effect of sulphur, zinc and boron on growth, yield and economics of watermelon in *Vertisol*. The experiment consisted of ten treatments with different levels of sulphur, zinc and boron and laid out in randomized complete block design with three replications. The yield parameters were recorded at different growth stages.

The analyses of soil and plant samples had been completed with the aid of following the standard methods and procedures. It is observed that utility of 30 kg S ha^{-1}, 1% Zn and 0.2% B at flower initiation stage (T_{10}) has produced higher fruit length (35.26 cm), higher fruit girth (55.33 cm) with no cracking of fruits. It has resulted in higher number of fruits per plant (3.96) and higher fruit yield (65.31 t ha^{-1}). It was profitable in terms of higher returns and B:C ratio (5.33) of watermelon production, however it was found to be on par with treatment receiving 20 kg S ha^{-1}, 0.5% Zn and 0.1% B (T9). These results concludes that soil application of sulphur (20 kg ha^{-1}) through bentonite sulphur @ 22 kg ha^{-1}, foliar application of zinc (0.5 %) through zinc sulphate @ 2.5 kg ha^{-1} and foliar spray of boron (0.1 %) through solubor @ 0.5 kg ha^{-1} along with recommended dose of fertilizers was found superior in increasing the fruit yield and additionally progressed first-rate and economics of watermelon crop.

Keywords: Soil application, sulphur, fruit yield, RDF.

INTRODUCTION

Watermelon [*Citrullus lanatus* (Thunb.)] is a succulent fruit and vine like plant belonging to the Cucurbitaceae family; local of equatorial Africa and grown all over the world. The fruit is normally eaten raw and consists of vitamin A and vitamin-C. Watermelon is a popular fruit this is loved through each the wealthy and the negative. The ripe fruit's delicious, luscious pulp is eaten up sparkling throughout the tropical and subtropical regions. After adding a chunk of salt and black pepper to the fruit juice, it is also drunk. Among the several factors controlling the productivity and net return of crops, plant nutrient is an important factor. When the roots are unable to deliver adequate nutrients, foliar micronutrient spraying may be very beneficial. Foliar feeding is an effective approach of delivering nutrients during a period of intense plant growth, when it can improve the mineral status of the plants and increase crop yield. The proper nutrition of NPK and micronutrients is critical for watermelon growth. In watermelon, fruit size is the most important factor affecting yield (Karchi *et al.,* 1977). Except yield in terms of the burden of fruit, pleasant element of fruit is likewise equally vital. Fruit yield and fine of watermelon might be boosted via supplying proper dose of macro and micronutrients.

MATERIAL AND METHODS

The experiment was conducted during *Rabi* 2021 at Kamaknur Village, Kalagi taluka of Kalaburagi district which belongs to North Eastern Dry Zone (Zone-2) of Karnataka state (17° 20' N, 77° 09' E and 436.23 MSL) with an objective of determining the effects of S, Zn and B on Watermelon. The soil of the experimental site belongs to *Vertisols* (medium black soil). The soil was low in organic carbon (4.30 g kg^{-1}), available nitrogen (231.00 kg ha^{-1}), phosphorus (59.10 kg ha^{-1}) and medium potassium (450.00 kg ha^{-1}) with pH of 7.80. The experiment was laid out in randomized complete block design (RCBD) with three replications. There were 10 treatments consisting of sulphur, zinc and boron levels along with control. The watermelon variety Melody was selected the study. Seedlings of 15 days old were transplanted in the experiment plot on 11th November, 2021, adopting a spacing of 2.5 m × 1.0 m. Gap filling was done wherever necessary within a week after transplanting. Fertilizers were applied to soil on the day of transplanting as per the treatment details. 50 % of

Nitrogen, full dose of P and K were applied on the day of transplanting. While, remaining N was applied after 30 Days of transplanting using urea. Sulphur applied to soil at 30 days of crop growth stage as per the treatment details, zinc and boron were supplied through foliar spray at the time of flower initiation stage as per the treatment requirements through bentonite sulphur (90 % S), zinc sulphate (21 % Zn and 12 % S) and solubor (19 % B) fertilizers, respectively. From randomly tagged five plants, observations were recorded. The observation on fruit yield was recorded at harvest. The economics was worked out based on the prevailing market price for the existing year. Data analysis and interpretation was done using Fischer's method of variance technique as described by Gomez and Gomez (1984). The level of significance used in 'F' test was P=0.05.

RESULT AND DISCUSSION

A. Growth parameters

Length of fruits. The application of 30 kg S ha^{-1}, 1% Zn and 0.2% B at flower initiation stage (T_{10}) recorded significantly higher fruit length (35.26 cm) compared to all other treatments. However, it was on par with 20 kg S ha^{-1}, 0.5% Zn and 0.1% B (T_9, 34.24 cm). Significantly lower fruit length (23.00 cm) was recorded in control (T_1) represented in (Table 1). Utility of sulphur, zinc and boron through soil or in combination had more desirable photosynthetic and other metabolic activities which cause boom in various plant metabolites responsible for cell division and elongation beneficial effect on growth of watermelon. This may be due to added sulphur enhanced the synthesis of chlorophyll content in the leaves. Similarly, zinc and boron play an essential role in plant growth through the biosynthesis of endogenous hormones, which is liable for promotion of plant growth, and role in cell division, meristematic activity of plant tissue and expansions of cells by Hatwar *et al*. (2003). The outcomes are similar to findings of Da Silva *et al.* (2018).

Girth of fruits. Sulphur, zinc and boron levels significantly influenced girth of watermelon. Significantly higher girth (55.33 cm) was recorded with application of 30 kg S ha^{-1}, 1% Zn and 0.2 % B at flower initiation stage (T_{10}) as compare to other treatments (Table 1). However, it was on par with 20 kg S ha^{-1}, 0.5% Zn and 0.1% B at flower initiation stage (T_9) (55.10 cm) and lowest girth of fruit (36.29 cm) was noticed in control (T_1). This may be due to boron and zinc enhances the enzyme activity, which in turn triggers the physiological process like protein and carbohydrate metabolism in plants, and sulphur performs many physiological functions like synthesis of sulphur containing amino acids. This leads to faster synthesis and translocation of photosynthates from source (leaves) to sink (fruit). This in turn increases the girth of fruit. These results were in conformity with Da Silva *et al.* (2018).

Percentage of fruit cracking of watermelon. Sulphur, zinc and boron levels significantly influenced percentage of fruit cracking of watermelon (Table 1). No cracking was observed (0.00 %) with application of 30 kg S ha^{-1}, 1% Zn and 0.2 % B at flower initiation stage (T_{10}) as compare to other treatments. Similar results of no fruit cracking (0.00 %) were observed with application 20 kg S ha^{-1}, 0.5% Zn and 0.1% B at flower initiation stage (T_9) and highest cracking of fruit was noticed in control (T_1) (1.93 %). It is postulated that boron is involved in the synthesis of cell-wall compounds. Bolanos *et al.* (2004) also stated that the boron formed bonds with molecules like polysaccharides, glycoproteins and glycolipids and acted as a molecular staple that gave stability and functionality to biomolecules like pectins that made up the cellular wall of higher plants. It is possible that the plants under the treatments of borax have developed better structure of not only plant but also of fruits particularly that of the outer-mesocarp tissues in rind which resulted in lower per cent of fruit cracking.

Table 1: Effect of different levels of sulphur, zinc and boron on growth and growth components of watermelon crop.

Treatment		Length of fruits (cm)	Girth of fruits (cm)	Percentage of fruit cracking (%)
T_1	Control (C)	23.00	36.29	1.93
T_2	RDF	27.99	42.81	1.65
T_3	RDF + sulphur @ 20 kg ha^{-1}	30.88	47.72	1.20
T_4	RDF + sulphur @ 30 kg ha^{-1}	31.88	51.17	1.10
T_5	RDF + 0.5 % Zinc sulphate	31.07	50.38	1.00
T_6	RDF + 1 % Zinc sulphate	31.16	51.34	0.95
T_7	RDF + 0.1 % Solubor	31.19	50.72	0.85
T_8	RDF + 0.2 % Solubor	31.36	51.05	0.75
T_9	RDF + sulphur @ 20 kg ha^{-1} + 0.5 % Zinc sulphate + 0.1 % Solubor	34.24	55.10	0.00
T_{10}	RDF + sulphur @ 30 kg ha^{-1} + 1 % Zinc sulphate + 0.2 % Solubor	35.26	55.33	0.00
S.Em±		0.93	1.63	0.04
CD @ 5%		2.79	4.84	0.13

B. Yield attributes

Weight of fruits vine^{-1}. The significantly higher number of fruits per plant (3.96) was recorded with application of 30 kg S ha^{-1}, 1% Zn and 0.2 % B at flower initiation stage (T_{10}) as compare to other treatments (Table 2). However, it was on par with 20 kg S ha^{-1}, 0.5 % Zn and 0.1 % B at flower initiation stage (T_9) (3.84) and least number of fruits was noticed in control (T_1) (2.06). The number of fruits per plant was found statistically significant among all the treatments. Since application of sulphur, zinc and boron increase the fruits per plant, it is likely that a higher number of fruits per plant will be observed. The progressive increase in number of fruits per vine may be attributed to the fact that the boron might have helped in the absorption of water and carbohydrates metabolism enhanced photosynthesis (Haque *et al*., 2011).

Number of fruits vine^{-1}. Application of different levels of sulphur, zinc and boron had significant effect on weight of fruits per vine (Table 2). Significantly higher weight of fruits per vine (16.33 kg) was recorded in application of 30 kg S ha^{-1}, 1% Zn and 0.2 % B at flower initiation stage (T_{10}) as compare to other treatments, while which was on par with 20 kg S ha^{-1}, 0.5 % Zn and 0.1 % B at flower initiation stage ($T_{9,}$ 15.80 kg) and significantly lower fruit weight per plant (10.33 kg) was recorded in control (T_1). Sulphur, zinc and boron grew profusely, attained physiological condition to produce female flower early, developed the plants with higher number of branches per vine, and lengthier main axis, higher number of leaves as well as leaf area thereby produced higher quantity of food material which was utilized to develop bigger and heavier fruits per vine which contributed to significantly higher yield per vine. The findings are accordance with the findings of Verma *et al.* (1986).

Average weight of fruits plot^{-1}. Sulphur, zinc and boron levels significantly influenced the average weight of fruits per plot (Table 2). Average weight of fruits per plot was observed significantly maximum (195.93 kg) with application of 30 kg S ha^{-1}, 1 % Zn and 0.2 % B at flower initiation stage (T_{10}) which was found on par (189.63 kg) with application of 20 kg S ha^{-1}, 0.5% Zn and 0.1% B at flower initiation stage (T_9). While, minimum average weight of fruits plot^{-1} (123.99 kg) recorded in control (T_1). There is significant increase in fruit yield per plot with increase in application of sulphur, zinc and boron levels. This may be due to the improved growth characters. Because of foliar application of micronutrients, this would have enhanced photosynthesis, and other metabolic activities, which lead to increase in cell division and elongation. These results are agreement with Babu and Varaprasad (2018).

Yield. Sulphur, zinc and boron levels significantly influenced the fruit yield of watermelon (Table 2). Significantly higher fruit yield (65.31 t ha^{-1}) was recorded with application of 30 kg S ha^{-1}, 1 % Zn and 0.2 % B at flower initiation stage (T_{10}) as compare to other treatments.

Table 2: Effect of different levels of sulphur, zinc and boron on yield and yield components of watermelon crop.

Treatment		No. of fruits per vine	Weight of fruit per vine (kg)	Avg. weight of fruits per plot (kg)	Yield (t ha^{-1})
T_1	Control (C)	2.06	10.33	123.99	41.33
T_2	RDF	2.60	12.66	154.26	51.42
T_3	RDF + sulphur @ 20 kg ha^{-1}	3.18	14.08	168.99	56.33
T_4	RDF + sulphur @ 30 kg ha^{-1}	3.28	14.31	171.69	57.23
T_5	RDF + 0.5 % Zinc sulphate	3.16	14.04	168.42	56.14
T_6	RDF + 1 % Zinc sulphate	3.27	14.26	171.12	57.04
T_7	RDF + 0.1 % Solubor	3.18	14.06	168.72	56.24
T_8	RDF + 0.2 % Solubor	3.28	14.56	174.69	58.23
T_9	RDF + sulphur @ 20 kg ha^{-1} + 0.5 % Zinc sulphate + 0.1 % Solubor	3.84	15.80	189.63	63.21
T_{10}	RDF + sulphur @ 30 kg ha^{-1} + 1 % Zinc sulphate + 0.2 % Solubor	3.96	16.33	195.93	65.31
S.Em±		0.17	0.42	3.15	1.64
CD @ 5%		0.52	1.26	9.35	4.86

However, it was on par (63.21 t ha^{-1}) with 20 kg S ha^{-1}, 0.5 % Zn and 0.1 % B at flower initiation stage (T_9) and lowest fruit yield (41.33 t ha^{-1}) was noticed in control (T_1). Significant increase in fruit yield per plot and fruit yield per hectare with increase in application of sulphur, zinc and boron levels which was attributed to higher dry matter accumulation in plant would ensure higher individual fruit weight and larger fruit diameter (Table 1) which collectively increases the fruit yield of watermelon and also higher photosynthetic efficiency of watermelon resulting in more photosynthates must translocated to the fruit, realizing in higher fruit yield. These results are in accordance with the findings of Babu and Varaprasad (2018).

Economics. The data on economics of watermelon crop as affected by sulphur zinc and boron levels at harvest are presented in (Table 3). Among the all treatments, significantly highest gross returns (₹783720 ha^{-1}), net returns (₹636567 ha^{-1}) and B:C ratio (5.33) with 30 kg S ha^{-1}, 1% Zn and 0.2% B (T_{10}) followed by marginal decrease in gross returns (`758520 ha^{-1}), net returns (₹612455 ha^{-1}) and B:C ratio (5.19) with 20 kg S ha^{-1}, 0.5% Zn and 0.1% B (T_9) and lowest gross returns (495960 ha^{-1}), net returns (₹360760 ha^{-1}) and B:C ratio (3.67) under control plot (T_1). The highest net returns and B:C ratio recorded with 30 kg S ha^{-1}, 1% Zn and 0.2% B (T_{10}) was attributed to higher fruit yield (Table 2) resulting in highest gross returns (₹783720 ha^{-1}). Similar results were also reported by Hariyappa *et al.* (2011); Babu and Varaprasad (2018).

Table 3: Effect of different levels of sulphur, zinc and boron on economics of watermelon crop cultivation.

Treatments		Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
T_1	Control (C)	135200	495960	360760	3.67
T_2	RDF	144278	617040	472762	4.28
T_3	RDF + sulphur @ 20 kg ha^{-1}	145678	675960	530282	4.64
T_4	RDF + sulphur @ 30 kg ha^{-1}	146378	686760	540382	4.69
T_5	RDF + 0.5 % Zinc sulphate	144466	673680	529215	4.66
T_6	RDF + 1 % Zinc sulphate	144653	684480	539827	4.73
T_7	RDF + 0.1 % Solubor	144478	673680	529202	4.66
T_8	RDF + 0.2 % Solubor	144678	698760	554082	4.83
T_9	RDF + Sulphur @ 20 kg ha^{-1} + 0.5 % Zinc sulphate + 0.1 % Solubor	146066	758520	612455	5.19
T_{10}	RDF + Sulphur @ 30 kg ha^{-1} + 1 % Zinc sulphate + 0.2 % Solubor	147153	783720	636567	5.33

CONCLUSIONS

Primarily based on the outcomes acquired below present investigation, it can be concluded that soil application of sulphur (20 kg ha^{-1}) through bentonite sulphur @ 22 kg ha^{-1}, foliar application of zinc (0.5 %) through zinc sulphate @ 2.5 kg ha^{-1} and foliar spray of boron (0.1 %) through solubor @ 0.5 kg ha^{-1} along with recommended dose of fertilizers became determined superior not only in increasing the fruit yield however additionally improved quality and economics of watermelon crop.

Conflict of Interest. None.

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