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Foliar nutrition of zinc on growth and development of ber, cv. Thailand apple

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Abstract:
An investigation was conducted on Ber to study the effect of different sources and concentration of zinc on growth, yield and quality of ber. Treatments consisted of various concentrations of zinc viz., 0.3%, 0.4%, 0.5% for each source. There were one control where no zinc was applied .The results revealed that leaf area, leaf relative water content (RWC) and leaf chlorophyll contents were significantly increased with the increasing concentration of zinc. The highest leaf area (18.06cm^2) and the highest RWC (89.85%) and the highest chlorophyll content (1.24mg/g) of leaves were recorded in 0.5% chelated treatment. Similarly, Nitrogen and Zinc contents recorded at harvest were significantly affected by chelated treatment. The highest N content (3.12%) and Zn (28.80%) were recorded in 0.5% chelated treatment. The quality attributing characters viz.,Total Soluble Solid (11.73) was found highest in 0.5% chelated treatment, Titrable acidity and ascorbic acid was found highest in control i.e. (0.55%) and (74.61mg/100g), TSS/ acid ratio was found highest in 0.5% celated treatment i.e. (51.01%), total sugar (11.04%), reducing sugar (4.84%), non reducing sugar (6.23%) were recorded highest in 0.5% chelated treatment, thickness of pulp (23.60mm), weight of the pup (66.51g), were increased in 0.5% chelated treatment, stone weight(4.37g) was increased in control. Fruit juice per volume (cc) was increased in 0.5% chelated treatment (52.52). The highest number of flower per plant was in 0.5% chelated zinc i.e. (18277.02), Flowering to harvesting interval was increased in control i.e. 117 (days) No. of fruit per plant (1395.04), weight of the fruit (70.53g), volume of the fruit (75.05cc), yield (123.43kg/plant) was recorded highest in 0.5% chelated zinc. Fruit drop (9.04%) was increased in control.The highest fruit length (6.07cm) and girth (6.08 cm) were recorded in 0.5% chelated zinc treatment. Chelated zinc 'Chelamin' at the concentration of 0.5% has favourably influenced the growth, flowering, fruit set, yield attributing characters and yield and fruit quality of ber.
***Key Word**: Ber, micronutrients, growth, fruit quality, yield.*

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I. Introduction

Ber (*Zizyphus mauritiana* L.) is cultivated under wide range of climatic conditions in different states of India, i.e. Madhya Pradesh, Rajasthan, Gujarat, Punjab, Haryana, Uttar Pradesh, Maharashtra and to limited extent in several other states. The ber can be cultivated on wide range of soils. It can grow well upto a height of 100m above sea level. Plants can tolerate pH > 9 and soil or water salinity to a limited extent. Studies at central soil salinity research Institute, Karnal, India have revealed that ber can also be grown satisfactorily in alkali soils characterized by high pH and sodicity. However, sandy loam soils with neutral or slightly alkaline reaction make good growth of ber plants. Normally ber prefers drier climate for good quality of fruits but it can also be grown well under tropical and subtropical zones of the country. The trees can withstand to extreme high temperatures. Some of the species of ber are also found growing in foot hills of temperate regions . In view of the recent development in production technology of this crop the cultivation of ber crop is becoming increasing popular in many parts of India. It occupied an area of 8.7 lac/ha with an annual production of 8.9 lac tonnes in India. It is cultivated for its fresh fruits, which are rich in vitamins C, A and B complex. It is popularly called as poor man's apple due to its high nutritional and medicinal value (Gajbhiya et al., 2003). Ber fruit is more nutritive than apple because for its higher protein (0.8 g), β-carotene (70 IU) and vitamin C (50-100 mg) contents (Rai and Gupta, 1994). Ber fruit pulp contains 12.8 to 13.6 percent carbohydrates (Jawanda et al., 1981) of which, 5.6 percent are sucrose, 1.5 per cent glucose, 2.1 percent fructose and 1.0 percent starch. The fruits are rich in edible fibre and also meet to some extent the fuel wood in rural areas.

The areas receiving annual rainfall of 400-650mm are ideal for its cultivation. It is known for its ability to withstand adverse conditions such as salinity, drought and water logging.

Importance of zinc for increasing crop production and improving fruit quality has been observed by a numbers of workers. Both non chelated and chelated forms of zinc can be successfully used as foliar nutrition in crop production in respect of ,growth, yield and quality as well as increasing in leaf nutrient status. The maximum absorption of zinc would be possible when it is applied as foliar spray (Khanna et al., 1969).

Zinc deficiency is considered as the most wide spread and damaging micronutrient deficiency of ber. Several workers have observed reduced fruit drop. Singh and Vashishtha (1997) observed that tree sprayed with zinc sulphate had higher fruit retention, yield and quality and reduced fruit drop. Foliar application of nutrients (urea 1.0%, ZnSO4 0.5% and potassium sulphate 1.0%) significantly reduced fruit drop (Jeetram *et al*., 2009)..

II. Material And Methods

The present investigation was carried out to study the effect of "foliar nutrition of zinc on growth and development of Ber (Zizyphus mauritiana L), cv. Thailand apple". The experiment was conducted at the Experimental orchard of the Department of Horticulture, Assam, Assam Agricultural University, Jorhat.

Season of the Experiment

The experiment was continued from September 2016 to February 2017. The prevailing climatic condition of Jorhat as a whole is subtropical humid having hot summer and cold winter.

Experimental Design

The experiment was laid out in a simple Randomised Block Design (RBD) of total seven treatment combination with three replications. The Ber plantation was of 3 years old and was spaced at 2.5m apart from each plants .Selected plants were free from pest and diseases and with normal growth.

Sources of Zinc and Treatments

Zinc sulphate ($ZnSO_4$) and chelamin (Zn- EDTA, Ethylene Diamine Tetra Acetic Acid) were used as sources of zinc. There are total seven treatment viz. T_1, T_2, T_3, T_4, T_5, T_6 and T_0 were taken into experiment for evaluation of different parameters of ber and each treatment replicated in three times. . Following were the notations used for concentration of zinc.

Table 1.Details of treatment used in the experiment are as follows

Sl. No.	Treatment code	Details of treatment
1.	T_1	0.3% ($ZnSo_4$)
2.	T_2	0.4% ($ZnSo_4$)
3.	T_3	0.5% ($ZnSo_4$)
4.	T_4	0.3% (chelated zinc chelamin)
5.	T_5	0.4% (chelated zinc chelamin)
6.	T_6	0.5% (chelated zinc chelamin)
7.	T_0	Control (without zinc)

Mode of application of Zinc

Two foliar sprays of zinc were given with the help of 'Marooti' foot sprayer. The first spray was given in 7th October 2016 at flower bud initiation stage and the second spray at 15 days interval after first spray and the third 15 days interval after second spray in the year 2016.

Time and Methods of Application of Fertilizers

The recommended dose of nitrogen, phosphorus and potassium were applied to each plant in two split doses. The first split dose was applied in July, 2016 and the remaining dose in August,2016.

The fertilizers were applied to the soil in a circular trench oh 10 cm depth and 6cm width at 20cm away from the base of the plant. The dose of urea ,single super phosphate and muriate of potash were 200g urea 100gSSP ,200g MOP , fertilizers were mixed with decomposed cattle manure @ 5 kg per plant.

Intercultural operation and after care

In intercultural operation weeding and loosening of soil is done manually in time to time and when it was found necessary in order to keep the plot weeds free Irrigations was given at an interval of 15 days during flowering upto fruit setting stage. The drooping bearing branches were propped with the help of bamboos. Necessary plant protection measures were taken timely to protect the crop from disease and insect pest.

Observations

The plants were tagged for each treatment and different observations were recorded in subsequent stage of the growth.

Plant Characters

I) **Leaf area:** The mature leaves from the mid portion of the terminal shoots were collected. Leaf area of three sampling leaves was measured by graphical method.

II) **Leaf relative water content (RWC):** Leaf relative water content at one month after fruit set was determined as per the method suggested by Barrs and Weatherlay (1962). The mature leaves from the mid portion of the terminal shoot were collected in the morning. In the laboratory, ten leaf disc of 50 mm diameter were punched out, surface dried, weighed and allowed to float over distilled water in a petridish. After six hours, leaf dics were removed from the water; surface dried, weighed and allowed to float over distilled water in a petridish. After six hours, leaf discs were removed from the water, surface dried with filter paper and the weight was taken. The leaf discs were then over dried till the weight became constant. Leaf RWC was estimated as follows and expressed in percentage.

Leaf RWC = $(W_{1-} W_3/W_2\text{-}W_3)\times 100$

Where W_1 = Fresh weight (g)

W_2 = Fully turgid weight (g)

W_3= Dry weight (g)

III) **Estimation of chlorophyll:** Total chlorophyll content of the fresh leaf samples at harvest was determined by colorimetric method as described by Singh (1977). Freshly plucked leaf samples of 2g was weighed accurately and crushed in a morter by adding little quantity of 80 percent acetone. Few clean sand particles were also added at the bottom of the morter. The leaf samples were completely ground in the acetone solution. After adding another small quantity of acetone solutions the mixture was carefully filtered through a sintered funnel under suction. The solid mass was brought back to the original morter and the sample was reextracted with the same solvent. The dark green filtrate was collected in 50ml volumetric flask. The leaf tissues were extracted for several times until green tint disappeared. The morter was rinsed with the solvent and collected in volumetric flask. The volume was made up to the mark by the extractant. The optical density values at 645nm and 663nm were recorded for each sample and the total chlorophyll was estimated by the following formula and expressed as mg per g of tissues.

Total chlorophyll= 20.2 (OD at 645 nm) +8.02(OD at 663nm) ×V/1000×W

Where, OD= Optical density

V= Volume of the extractant (ml)

W= Weight of the samples (g)

IV) **Leaf nitrogen and zinc contents of leaves:** The leaf samples were collected from the mature leaves of the mid portion of the terminal shoot. The collected leaf samples were sun dried as well as oven- dried, powdered and stored in sealed butter paper bags for estimation of total nitrogen and zinc content.

The estimation of total nitrogen, zinc was done by Micro-Kjedahl method, colorimetric method and flame photometric method, respectively, as described by Jackson (1973).

Yield Attributing Characters and Yield

I) Total number of flowers: The number of flowers produced by each plant was counted from first flower opening to the last flower opening in the season and total number was recorded.

II) Flowering to harvesting interval: The time taken from date of flowering to the date of harvest was counted in days. The fruits were considered to be ready for harvest at the time when the fruits became firm and smooth.

III) Number of fruit per plant: Total number of fruits harvested from one plant was counted.

IV) Length of fruit: The length of the fruit was measured in cm from the base to the apex of the fruit. The length of the fruit was measured at harvest.

V) Girth of the fruit: The girth of fruit were measured at the middle part of the fruit and expressed in cm.

VI) Volume of the fruit: Fruit volume was determined by water displacement method and expressed in cc.

VII) Fruit weight: The individual fruit was weighed and the weight was expressed in g.

VIII) Yield: The fruit yield in kg per plant was determined by weighing all the fruits harvested from each plant.

Fruit Quality

The tagged mature fruits of each treatment were harvested and brought to the laboratory for the following analysis.

I) Fruit juice: The juice content of the representative fruit samples was squeezed out and measured and expressed in cc.

II) Total Soluble Solids (TSS): TSS of the fruit juice was determined by Zeiss Hand Brix Refractometer and expressed as percentage.

Titrable acidity, total sugars, reducing sugars and non-reducing sugars were estimated by adopting the standard methods of AOAC (1975).

III) Titrable acidity: Ten ml of fruit juice was taken in a 100ml volumetric flask and volume was made up with distilled water and filtered. Ten ml of filterate was titrated against n/10 NaoH using phenolphthelin as indicator. Titrable acidity was determined with the following formula and expressed as percentage .

Titrable acidity = (Titrate value × Normality of alkali ×Volume made up x Equivalent wt of citric acid /Weight of sample × Aliquat × 1000) × 100

IV) Reducing sugar: Twenty five ml of fruit juice was taken in a 250 ml volumetric flask and volume was made up with distilled water. The made up solutions was filtered and the filtrate was titrated against 10ml boiling Fehling's solution mixture using methylene blue as indicator. Reducing sugar was determined with the following formula and expressed as percentage.

Reducing Sugar = mg of invert sugar × dilution × 100/ Titrate value × Weight of samples

V) Total sugar: From 250ml made up solution for reducing sugar estimation, 50ml of the solution was taken in a 250 ml conical flask and 5ml concentrated HCL was added and kept overnight. The solution was then neutralized with 1 N NaoH, made up to 150ml with distilled water and titrated against boiling Fehling's Solution.

From the titre value, percentage of total sugar was calculated out as following:

Total Sugar (%) = (Per cent sucrose + percent reducing sugar)

Percentage of sucrose= (Per cent total invert sugar – per cent reducing sugar originally present) × 0.95

Total invert sugar = mg of invert sugar ×First dilution × Second dilution × 100/Titre value × weight of sample taken Aliquat

VI) Non-reducing sugar: it was calculated as follows: Total sugar (%)- Reducing sugar(%) = Non-reducing sugar(%)

VII) TSS-acidity ratio: TSS-acidity ratio was calculated out by dividing the mean of the TSS by that for Titrable acidity.

VIII) Ascorbic acid: Ascorbic acid content was estimated by the visual titration method of Freed (1966) as described below.

Indophenol dye preparation: To 250ml of distilled water 42mg sodium bicarbonate and 52mg of 2, 6-dichlorophenol-indophenol were added and warmed gently to dissolve. This reagent was kept in a amber colour bottle and was stored in dark at $20^{o}C$ and used within a week of its preparation.

Standard ascorbic acid: 100mg of ascorbic acid was dissolved in 100ml of 4% oxalic acid. From this 10ml was taken in a 100ml volumetric flask and made up to the mark with 4% oxalic acid and titrated against indophenols dye until the solution changed to pink colour which persisted for atleast 15 seconds.

Estimation: Five ml of juice was taken with 25ml of 4% oxalic acid filtered through Whatman No. 42 filter paper and 5ml of filtrate was collected in 50 ml of volumetric flask .The volume was made up to 50ml with 4%oxalic acid. Five ml of the extract was taken with 5ml of oxalic acid and titrated against the standard indophenols dye. Amount of ascorbic acid and titrated against the standard indophenols dye. Amount of ascorbic acid was calculated using the dye factor and expressed as mg/100ml.

IX) Thickness of pulp: The thickness of pulp is measured by venier calliper and expressed in mm.

X) Weight of pulp: After taking the thickness the whole fruit without stone weight were weight separately and expressed in g.

XI) Stone weight: After removing the pulp the stone is weight separately.

XII) Pulp-Stone ratio = pulp weight(g)/ stone weight(g)

Statistical Analysis

Observations made during field experiment and data obtained from laboratory determinations relating to growth, yield and quality aspects were subjected to analysis of variance. Significance and non-significance of the variance due to the different concentrations of zinc were determined by calculating the respective 'F' values (Panse and Sukhatma, 1985).

III. Result

The results of the field experimentation and laboratory analysis are presented below .

Table 2. effect of zinc and non chelated zinc on growth attributing characters

Treatment	Leaf area(cm^2)	Leaf relative water content (%)	Leaf chlorophyll (mg/g)
T_0	9.05	76.84	0.78
T_1	10.04	80.33	0.83
T_2	11.76	83.33	0.83
T_3	12.76	84.80	0.97
T_4	14.33	85.70	1.07
T_5	16.02	87.67	1.09
T_6	18.06	89.85	1.24
SEd (±)	0.35	2.13	0.04
CD (0.05)	0.77	4.64	0.09

Table 3. Effect of zinc and non chelated zinc on nitrogen and zinc content in leaves at the time of harvest

Treatment	N content on leaves (%)	Zn content on leaves(ppm)
T_0	2.21	15.24
T_1	2.54	15.63
T_2	2.56	20.63
T_3	2.73	24.70
T_4	2.84	24.76
T_5	3.03	25.80
T_6	3.12	28.80
SEd (±)	0.08	0.30
CD (0.05)	0.18	0.65

Table .4 effect of zinc and non chelated zinc on yield attributing characters and yield

Treatment	Number of flower $Plant^{-1}$	Flowering to harvesting interval (days)	Number of fruit $Plant^{-1}$	Fruit volume at harvest(cc)	Fruit Weight (g)	Yield (Kg $Plant^{-1}$)	Length of fruit (cm)	Girth of the fruits(cm)	Fruit drop (%)
T_0	2512.02	117.00	123.82	55.03	58.12	7.22	5.00	5.58	9.04
T_1	6832.03	114.66	187.28	55.04	58.74	11.01	5.01	5.59	6.97
T_2	8772.00	107.00	238.76	59.02	59.34	14.26	5.12	5.65	6.75
T_3	10009.00	106.00	337.06	60.03	59.69	19.98	5.29	5.79	5.87
T_4	13575.03	98.33	338.59	62.02	63.34	21.33	5.48	5.82	5.67
T_5	16625.07	98.33	370.18	62.02	67.54	25.03	5.76	5.97	4.48
T_6	18277.02	92.66	441.29	75.05	70.53	31.22	6.07	6.08	3.69
SEd (±)	271.81	2.11	8.51	1.58	1.80	0.35	0.14	0.16	0.18
CD (0.05)	592.22	4.59	18.53	3.43	3.92	0.76	0.30	N.S	0.39

Table.5 effect of zinc and non chelated zinc on Quality attributing characters

Treatment	Fruit juice per volume (cc)	Total sugar (%)	Ascorbic acid (mg/100g)	Reducing sugar (%)	Non reducing sugar (%)	TSS content (%)	Titrable acidity (%)	TSS/Acid ratio	Weight of the pulp (g)	Thickness of pulp (mm)
T_0	31.62	0.72	74.61	0.35	0.53	9.93	0.55	18.09	54.42	16.40
T_1	38.03	1.59	68.22	0.53	1.14	10.41	0.44	23.68	54.86	17.36
T_2	45.73	3.00	64.02	2.45	1.54	10.74	0.43	24.98	56.23	17.56
T_3	47.70	5.88	62.44	2.93	3.01	11.32	0.35	32.35	56.03	18.40
T_4	48.53	7.60	59.96	3.63	3.78	11.42	0.33	34.35	60.36	19.36
T_5	50.09	9.43	58.33	4.27	5.46	11.09	0.25	44.31	66.06	21.06
T_6	52.52	11.04	55.42	4.84	6.23	11.73	0.23	52.63	66.51	23.60
SEd (±)	1.15	0.11	0.68	0.09	0.10	0.22	0.22	0.77	1.58	0.44
CD (0.05)	2.51	0.23	1.49	0.19	0.23	0.48	0.48	1.68	3.44	0.95

IV. Discussion

The productivity of a ber plantation depends on a variety of factors like climate, site, varieties and rootstocks, fertilization, irrigation, soil management practices, pest and disease control etc. Among these factors, adequate supply of macro and micro nutrients seems to be a very important in regulating cropping and influencing the quality of fruits. Ber requires generous supply of nutrients not only for development of vegetative structures and flowers, but also to give regular harvest of high quality fruits. Among the various micronutrient, zinc plays an important role in growth and development of the fruit plant and brings many vital changes in plants (Wallace, 1925). The most prominent role of zinc in plants is the biosynthesis of plant auxin-Indole-3- Acetic acid and the manufacturing of nuclic acid and proteins (Tsui, 1948; Gupta and Jawanda, 1988). Zinc acts as an oxidation reduction catalyst (Chandler, *et al*., 1934) and improved several enzyme reactions affecting translocation of carbohydrates (Hoagland, 1944) particularly the activity of hexokinase enzymes (Reed, 1946). Singh (1969) observed that zinc influences and controls many physiological activities in the plants. Maximum fruit set (9.70 and 9.58%) and fruit yield (119.2 and 103.5kg/tree) were obtained with foliar application of 0.5% zinc sulphate, closely followed by 20ppm NAA treatment during 2002 and 2003, respectively.

The climatic condition of Assam is suitable for commercial cultivation of ber. However, heavy rainfall during summer season in Assam causes leaching losses and non-availability to the plant may occur, especially of iron, zinc, manganese and copper compounds. Randhawa and Srivastava (1986) are of the opinion that due to slow response to micronutrient application and treatment in soils, their addition as a spray on the foliage offers a practical device for avoiding their deficiencies and resultant crop losses before the deficiency symptoms actually set in or give a clue of their emergence.

In the present instance, the two sources of zinc, zinc sulphate and chelamin were used as foliar sprays on Ber. Zinc sulphate is an inorganic non chelated salt while chelamin is a chelated (Zn-EDTA) form of zinc. Chelated form of zinc has some advantage over zinc sulphate. Chelated form of zinc prevents formation of zinc complexes with certain chemicals in soil. Moreover, chelated zinc is water soluble and can be taken by the plants when it is applied as spray. However, the information on the use of chelated and non chelated zinc in ber plantation is not well documented. Therefore, the present study was programmed to standardise the suitable concentration of zinc and sources of zinc for growth and development of ber. The results of the study are discussed below.

Effect of Zinc on Vegetative Growth

The finding of the study revealed that zinc is indispensable for normal growth of Ber. Zinc sprays significantly increased leaf area indicating the better vegetative growth over control. Leaf relative water content (RWC) and leaf chlorophyll concentration are considered good indices of vegetative growth rate of plant. Both leaf RWC and chlorophyll content have been shown to be favourably by the foliar application of zinc. The highest leaf area (18.06cm^2), leaf RWC (89.85%) and chlorophyll content (1.24mg/g) were recorded in 0.5% chelated zinc treatment. The beneficial influence of zinc on the vegetative growth could be attributed to the existence of interrelationship between zinc and auxin where zinc might have enhanced the synthesis of auxin in the plants. The chelates are the complex compounds in which certain cation are complexed or bound to an organic molecule in complex form. The cations are protected from reactions with inorganic soil constituents that would make them unavailable for uptake by plants. Chelates also provide a continuous supply of nutrient without any danger of toxicity (Tisdale *et al*., 1985). Aiyappa *et al.* (1968) had also reported the significant response of zinc sprays on vegetative growth of fruit crops. Perhaps zinc tissues had a characteristic effect in improving the capacity of cells and tissues of the plants to retain more moisture as was proffered by Srivastava (1967).

Nitrogen and Zinc content on leaves

The analysis of leaf samples at harvest in the present instance, indicated the increase in the content of nitrogen in the leaves. With the increase in the concentration of zinc, there was increase in the levels of nitrogen .This situation happened due to the synergestic effects between nitrogen and zinc. The increase in leaf nitrogen in the present instance could be attributed to the fact that zinc sprays helped in better utilization of soil nitrogen which is in conformity with the work of Manchanda, *et al*. (1974). Lal *et al.* (2003) reported 500g N, 500g P_2O_5 and 50g K_2O/plant was found to be the best for obtaining the highest fruit yield in Rajasthan soils.

Effect of Zinc on yield Attributing Characters and Yield

The foliar spray of zinc showed a profound beneficial influence on attributing characters *viz.*, number of flowers per plant, flowering to harvesting interval, length, girth and volume of individual fruit. The highest number of flowers (18277.02) per plant was recorded in 0.5% chelated zinc treatments. All the concentration of zinc significantly increased the number of flower over control. The enhanced flower production observed in the treatment might be due to the synthesis of protein in plants in presence of zinc which in turn influence the flower production. This view is in tune with that of Yamdagini *et al*. (1979) who substanciated the influence of zinc in the formation of floral primordial in grape vines. That the percentage of fruit set in ber could be augmented to a highly significant extent with the increasing concentration of zinc spray became evident from the present study . That the number of fruit in ber could be augmented to a highly significant extent with the increasing concentrations of zinc spray became evident from the present study. The highest number of fruit (441.29) was recorded in 0.5% chelated zinc spray while the control recorded the lowest (123.82) number of fruit per plant .The influence of zinc in increasing the number of fruit which became evident from the present study could be traced to its profound inhibitory influence on embryo abortion and thereby preventing flower drops (Daulta *et al*., 1986).

The flowering-harvesting interval in the present instance was drastically reduced with the increasing concentration of zinc. The control recorded the longest (117 days) flowering-harvesting interval as compared to the shortest interval (92 days) in 0.5 chelated zinc treatment. The profound beneficial influence of zinc in reducing the flowering-harvesting interval could be attributed to the enhancing effect of zinc in enzymatic reaction, cell division as well as in growth. Working on the effects of micronutrients on 'Kew' pineapple, Bhattacharyya (1988) also drew similar conclusions.

Current efforts to increase yield of ber with limited expensive orchard soil and plant management practices, have focussed attention on the possibility of using the efficient method of feeding plant nutrients through foliage. Foliar application of zinc in the present study had considerably increased the number of fruits in ber. The increased fruit production due to the foliar application of zinc observed in the present study could be attributed to the role of zinc in the retardation of formation of abscission layer in fruit pedicels leading to the prevention of premature fruit drop. The fruit retention capacity of zinc by preventing premature drop of fruits observed by Gopalkrishnna and Ekbote (1962) has considerable relevance in this context.

The result of the present study clearly revealed that foliar application of zinc considerably increased the volume, length, girth and weight of individual fruit. The highest fruit volume (75.05cc), length (6.07cm), girth (6.08cm) and fruit weight (70.53g) were recorded in 0.5% chelated zinc spray. It is well understood that zinc involves in cell division and cell elongation processes which helps in increasing size of the fruits. Navjot *et al*. (2007) recorded fruit yield was in Muria murhera (60.8kg/tree) followed by Umran (59.8kg /tree). The fruit weight was maximum in umran (27.3gm). Fruit length and fruit breadth varied from 3.3 to 5.5 and 2.2 to 3.6cm. The present finding is in confirmity with the work of Rajput and Chand (1975) on guava and Babu *et al*. (1984) on Kagzi lime fruits. Thus the increase in the fruit size and number of fruits due to the application of zinc ultimately increased the yield of ber. In this context it is pertinent to point out that the increase in leaf area, relative water content as well as chlorophyll contents of leaves observed in the present instance might have enabled the plants to produce more amount of assimilates resulting in higher fruit production.

Effect of Zinc on Fruit Quality

The fruit quality in terms of juice content, TSS, titrable acidity, total sugar, reducing and non-reducing sugars, ascorbic acid, TSS-acidity ratio, pulp weight, stone weight and their ratio was found to be influenced significantly by the foliar application of zinc. The highest fruit juice content (52.52cc) was recorded in 0.5% chalated zinc content. It might be attributed to the action of zinc on cells and tissues of the plants to retain more moisture. The highest TSS (11.73%) was recorded in 0.5% chelated zinc and the lowest was recorded in control (9.93%). The highest total sugar content (11.04%) was recorded in 0.5% chelated zinc spray and the lowest (0.72%) in the control. Increase in the sugar content of zinc treated fruits could possibly be due to the increased photosynthetic activity in zinc treated plants resulting more production of sugar. Working on grape Kumar and Bhushan (1980) drew similar conclusions.

In the present study, zinc spray significantly increased the TSS- acidity ratio in fruits over control. The highest ratio (52.63) was recorded in 0.5 % chelated treatment against the lowest (18.09) recorded in control. This was due to the increased TSS contents and decreased in acidity under zinc treated plants. The present finding gets support from the works of Kumar and Bhushan (1980) in grapes and Bhuller *et al*. (1981) in Kinnow mandarin.

Foliar application of zinc significantly increased reducing sugar and ascorbic acid content in fruits. With the increase in concentration of zinc there is increase in reducing sugar (4.84%) was recorded in 0.5% chelated zinc treatment and the lowest (0.35 %) in control indicating the involvement of zinc in carbohydrate metabolism and thereby increasing the production of sugar. Working on grapes, Kumar and Bhushan (1980) drew similar conclusions. The highest (74.61mg/100g) and the lowest (55.42mg/100g) ascorbic acid contents were recorded in 0.5% chelated zinc and control, respectively. Dobrolyuskii and Reshetriyark (1974) explained the increase of ascorbic acid content as the involvement of zinc in organic acid metabolism. Such a view was also supported by Labanauskas et al. (1963).

In the present study, zinc spray also significantly increased the pulp thickness, pulp weight and reduced stone weight, pulp stone ratio of ber. The thickest pulp (23.60mm) was recorded in 0.5% chelated zinc treatment. This could very well be explained to the enhancement of cell division and growth subsequent to zinc spray. The highest pulp weight (66.51g) was recorded in 0.5% chelated zinc against the lowest of (54.42g) in control. The highest stone weight (4.37g) was recorded in control and the lowest was in 0.5% chelated zinc (2.55g). The increase in the pulp weight under zinc treated fruits might possibly be due to the production of large size fruits with increased juice content. The increase in pulp weight while decrease in stone weight had contributed largely in increasing the pulp-stone ratio. The highest pulp-stone ratio (26.08) was observed in 0.5% chelated zinc treatment while the lowest (12.49) in the control.

From the foregoing discussion it became clear that foliar application of both the chelated (Chelamin) and non-chelated (zinc sulphate). Zinc sources at higher concentration more particularly at the concentration of

0.5% chelated zinc had produced profound beneficial influence on the vegetative growth, yield and yield attributing characters of Ber cv. Thailand Apple. However, the comparison of the relative efficacy of the sources of the zinc would clearly demonstrate that chelated form of zinc has more pronounced beneficial influence over the non-chelated form. The relatively high efficiency of the chelated zinc 'Chelamin' as foliar application might obviously be due to its high solubility in water and thus making the plants to absorb it efficiently. Besides, chelamin does not make any phytotoxic effect if it is applied as foliar sprays.

V. Summary And Conclusion

The results of the investigation are summarised below.

1. Different concentrations of zinc favourably influenced leaf area, the highest leaf area (18.06cm^2) was recorded in 0.5% chelated zinc spray.
2. Estimation of leaf RWC revealed that the 0.5% chelated zinc increased leaf RWC to maximum (89.85%) level while control recorded the lowest (76.84%).
3. Among the treatments, 0.5% chelated zinc increased the total chlorophyll content of leaves. The highest chlorophyll (1.24mg/g) and the lowest was recorded in control (0.78mg/g).
4. N and Zn concentrations of leaves recorded at harvest were highly significant due to zinc spray. The highest nitrogen content (3.12%) was recorded in 0.5% chelated zinc spray. The highest zinc content was recorded in (28.80ppm) 0.5% chelated zinc.
5. The results of the investigation revealed that different concentrations of zinc of either source significantly increased the number of flower and number of fruit. The highest number of flower per plant was recorded in 0.5% chelated zinc sprays (18277.02) while the lowest (2512.02) was recorded in control. The highest number of fruit was recorded in 0.5% chelated zinc spray (441.29) and the control recorded the lowest (123.82).
6. Zinc spray significantly reduced the flowering-harvesting interval. The longest flowering-harvesting interval (117 days) was recorded in control and the shortest flowering-harvesting interval (92 days) was recorded in 0.5% chelated zinc spray.
7. Zinc spray also significantly increased the fruit volume and weight over control. The highest (75.05cc) volume was recorded in 0.5% chelated zinc and the lowest being recorded in control (55.03cc). The maximum fruit weight (70.53g) was recorded in 0.5% chelated zinc and the lowest (58.12g) was recorded in control.
8. Fruit yield significantly increased due to zinc spray, Maximum fruit yield (31.22kg /plant) was obtained in 0.5% chelated zinc and the lowest yield (7.22kg /plant) was recorded in control.
9. The fruit length, girth recorded at harvest was found to be significant in case of fruit length but not in girth. The highest length (6.07cm) was recorded in 0.5% chelated zinc and girth (6.08cm) were also recorded to be the highest in 0.5% chelated zinc. The lowest was recorded in control.
10. Fruit growth pattern showed double simple sigmoid curve. At early stage, there was no significant increase in fruit growth due to zinc spray while at later stage zinc spray significantly increased the growth in terms of length, and girth.
11. The fruit quality in terms of fruit juice, TSS, TSS-acidity ratio, total sugar, reducing sugar, pulp thickness and pulp weight were significantly increased due to zinc spray over control. Ascorbic acid content was reduced in case of zinc sprays. The highest fruit juice (52.52cc), TSS (11.73%), TSS- acidity ratio (52.63) total sugar (11.04%), reducing sugar (4.84%), pulp thickness (23.60mm) and pulp weight (66.51g) were recorded in 0.5% chelated zinc .The lowest was recorded in control. In case of ascorbic acid content (74.61mg/100g) and Titrable acidity lowest was recorded in 0.5% chelated zinc and the highest was recorded in control (0.55%).
12. In general, zinc form of chelamin- a chelated source of zinc, when applied at the rate of 0.5% increased the vegetative growth and yield as well as improved the quality of Ber cv. Thailand apple.

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