Annals of Sri Lanka Department of Agriculture. 2006.8:29-34.

EFFECT OF ZINC AND BORON ON GROWTH, YIELD AND FRUIT QUALITY OF PAPAYA (*Carica papaya*) GROWN IN NON-CALCIC BROWN SOILS

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ABSTRACT

Micronutrients are generally not included when applying chemical fertilizers. Increased yields through intensive cropping and use of high yielding varieties have contributed towards accelerated depletion of micronutrients in soils. An experiment was conducted at Aralaganwila Research Station in 2004 in non-calcic brown soils to quantify the effects of zinc and boron on yield and bumpy fruit formation in papaya, a common problem in papaya cultivation in Sri Lanka. Zinc and boron applied separately at three levels (5, 10, 15 kg/ha) and together (10 kg/ha), were tested on growth, yield and fruit quality of papaya (var. Red lady). The highest crop growth and yield without bumpy fruit formation was observed in the zinc + boron treatment. High amount of bumpy fruits with low sugar content was observed in plants without boron treatment. However, significant growth and yield differences were not observed within different zinc and boron levels. Although significant differences on fruit quality were not observed under zinc deficient condition, zinc and boron are necessary to get high yields without the formation of bumpy fruits.

KEYWORDS: Boron, Bumpy fruits, Papaya, Zinc.

INTRODUCTION

Market demand for fruits has increased in the recent past due to increased income of farmers, urbanization, export demand, health and nutritional awareness etc. The export potential of fruits is very high and export market maintains a high standard in the quality of fruits; special attention is needed to ensure continuous supply of quality fruits. Efficient nutrient management is essential for obtaining optimum productivity of fruit crops. Unfortunately, nutrient management is the most neglected aspect of fruit crop production in Sri Lanka. Therefore, yields of the fruit crops are neither their optimum levels nor consistent in both quality and quantity. Even the improved varieties provide low quality fruits due to insufficient nutrient management. Nutrient imbalance in soils causes low fertilizer use efficiency, low yields and low farmer profit. It also results in further depletion of the most deficient nutrients in soil. Once a nutrient reaches the critical level, yields decline even when large amounts of other nutrients are applied (Anon., 2000). Hence the importance of balanced fertilization must be realized in increasing crop yields. At present, only N, P and K fertilizers are applied to fruit crops. Hence, plants depend on soil reserves for a number of micronutrients. However, soil cannot be considered as a source of continuous supply of plant nutrients forever. Furthermore, increased yields through intensive cropping and use of high yielding varieties, losses of micronutrients through leaching, application of decreasing proportion of farmyard manure compared with commercial fertilizers are the primary factors that contribute towards accelerated exhaustion of the supply of available micronutrients to soil.

It is apparent that micronutrient deficiencies are far more widespread than estimated. Micronutrient deficiencies which are only local, may become more serious in the future, occurring extensively over new areas and creating widespread and complicated production restrictions if they are not properly diagnosed and remediated in time and taken precautions to eliminate them.

In the recent past appearance of bumpy or lumpy fruit formation was commonly observed in many papaya cultivations, causing high economic loss to farmers. Bumpy fruit formation in papaya has been reported by several researchers (Munzos *et al.,* 1966; Wang and Ko, 1975; Atkinson, 1991) and most workers have demonstrated that this disorder is associated with B deficiency occurring in many papaya growing countries such as Australia, Malaysia, Taiwan and Hawaii. The problem has been overcome by application of B. It has also been reported that B availability is dependant on soil factors, climatic conditions and cultural practices.

Zinc also functions as the metal component of a series of enzymes in many fruit crops. The most important enzymes activated by this element are carbonic anhydrase and number of dehydrogenases. Zinc deficiency is thought to restrict RNA synthesis, which in turn inhibits protein synthesis. Zinc deficient plants are thus poor in growth (Tisdale *et al.*, 1985). Zinc is also involved in auxin production. Shoots and buds of Zn deficient plants contain very low auxin contents. This cause dwarfism and growth reduction. The net results are stunted plants and prolonged duration of growth. Zinc also plays a major role in yield and quality of fruits, especially flower initiation, fruit setting and fruit remaining. Zinc deficiency may depress plant yields by as much as 50 percent without producing any symptoms in fruit crops (Katyal and Randhawa, 1983). Therefore, the objective of this study was to quantify the effects of different levels of Zn and B on growth, yield and fruit quality of papaya in Non-Calcic Brown soils.

MATERIALS AND METHODS

The study was conducted from 2004 *yala* to end of 2005 *yala* season at the Regional Agriculture Research and Development Centre, Aralaganwila in the Low Country Dry Zone (DL_{2b}) in Non-Calcic Brown soils which is the major soil group of the Mahaweli system B area. The study area has a distinctly uni-modal rainfall pattern with an average annual rainfall of 1100mm (Panabokke, 1996).

Papaya (variety: Red lady, F-1 hybrid) one month old plants were planted at 3 x 3 m spacing on raised beds in April 2004. The experimental design was a Randomized Complete Block with four replicates and three plants per treatment within a replicate. One meter deep drains were constructed around the field to facilitate the draining of excess water. Insect pest control, weed management, fertilizer (except micronutrient) application and other crop management practices were done according to the recommendations of the Department of Agriculture (Anon., 1991). Zinc and B were applied in four equal doses at three months interval. Ammonium sulphate was used to supply part of the nitrogen requirement in each treatment to balance the S applied as zinc sulphate. Zinc and B were applied as borax and zinc sulphate respectively, tested separately at three rates (5, 10, 15 kg/ha) and in combination (10 kg/ha).

Plant growth parameters were recorded as number of leaves per plant, stem diameter, crown diameter and plant height at 50% flowering stage of the crop. Number of fruits per plant, fruit weight and fruit quality characteristics in each plant such as sugar content (Refractometer method), number of bumpy and normal fruits, fruit length and diameter were measured in randomly selected fruits in each and every plant.

RESULTS AND DISCUSSION

Table 1. Effects of B and Zn application on plant growth.

Treatment	*Plant height (cm)*	*No. of leaves*	*Crown diameter (cm)*	*Basal diameter difference (cm)*
NPK	35.96c	3.41b	28.3b	2.13e
NPK + B-5	79.39b	8.45a	129.6a	3.19d
NPK + B-10	81.12b	8.70a	130.3a	3.27d
NPK + B-15	86.40ab	9.41a	139.3a	3.38cd
NPK + Zn-5	88.32ab	9.50a	139.9a	3.57bc
NPK + Zn-10	91.57ab	9.79a	147.0a	3.61bc
NPK + Zn-15	101.70ab	10.58a	149.2a	3.62b
NPK + B-10 + Zn-10	117.20a	10.63a	150.0a	4.36a
CV %	26.62	24.11	13.6	4.46

Means with same letters are not significantly different at 5% probability level

The mean plant growth parameters for different treatments are shown in Table 1. The highest plant growth was observed in the NPK + B - 10 + Zn - 10 followed by NPK + Zn - 15 treatments. The lowest plant growth was recorded in NPK only (control) treatment (Table 1). Poor crop growth observed in the no Zn and no B treatments may be due to the retardation of growth functions, which may require sufficient supply of these nutrients. Cook (1964) reported the importance of boron in the development, growth and formation of new cells in the plant meristem.

Boron is also required for the development and differentiation of tissues. In its absence, abnormal formation and development of tissues were reported (Katyal and Randhawa, 1983). Tisdale *et al.* (1985) also reported the importance of Zn in the synthesis of tryptophane, a component of some protein and a compound needed for the production of growth hormone like indole acetic acid. Reduced growth hormone production in Zn deficient plants causes the shortening of internodes and small leaves (Tisdale *et al.*, 1985).

Table 2. Effects of Zn and B application on fruit quality and yield.

Treatment	*Fruits / plant*	*Fruit yield (kg/plant)*	*Sugar content (Brix value)*	*Fruit length (cm)*
NPK	5.41d	7.39c	5.6d	19.51d
NPK + B-5	11.60c	18.18b	7.8c	21.40c
NPK + B-10	16.30bc	18.70b	8.0c	21.74c
NPK + B-15	16.40bc	18.74b	8.1c	22.76b
NPK + Zn-5	18.00b	19.73b	8.1c	23.41b
NPK + Zn-10	18.40b	19.94b	9.8b	25.37a
NPK + Zn-15	20.23b	20.00b	10.3b	25.41a
NPK + B-10 + Zn-10	29.50a	37.98a	13.3a	25.81a
CV %	14.13	14.32	6.1	2.70

Means with same letters are not significantly different at 5% probability level

The highest fruit yield of 37.98 kg/ha was obtained in the B + Zn -10 treatment and this was significantly higher than the yields obtained when B and Zn were applied separately. There was no significant increase in fruit yields with increasing rates of either B or Zn application. Zinc and B levels already contained in the soil also may be a reason for the lack of sensitivity of plants to the higher doses of Zn and B.

The results of the present experiment also suggest the importance of Zn for the yield and fruit quality of papaya. Yield parameters (fruits per plant and fruit weight) were higher under no Zn treatments than no B treatments. But, the differences were not significant (Table 2). The requirement of B for the proper pollination and fruit set may be the reason for the low yield under B deficient condition (Romheld and Marscher, 1991). Katyal and Randhawa (1983) also reported that the sterility and malformation of reproductive organs under no B conditions cause low fruit yield.

The lowest crop growth and yield were observed in the control treatment where both Zn and B were not applied. Low Zn and B availability and high nutrient leaching in the light textured soils of the experimental site may be the reason for the lowest yield under control treatment. Tisdale *et al.* (1985) also reported lower availability of Zn and B in light textured soil.

Zinc and B availability is also highly pH dependent. It is higher in acid soils, whereas in alkaline soils the availability is very low. Severe Zn and B deficiencies are often noticed in high pH soils (Romheld, 1991).

The inability of increasing fruit yield may be the true reflection of Liebigs law of minimum factors. In many cases the significant increase of growth and yield parameters were observed only in the presence of both Zn and B. The lowest sugar content of fruits (brix value) was also observed in the B deficient condition (Table 2). Lack of translocation of sugars into the fruits from the leaves may be the reason for lower sugar content under the B deficient condition (Tisdale *et al.*, 1985). Katyal and Randwa (1983) also observed that if B deficiency occurs, there is assimilation of product accumulation in the leaves causing the lack of sugar content in fruits.

Table 3. Effects of Zn and B application on bumpy fruit formation.

Treatment	*% Bumpy fruits*	*% Normal fruits*
NPK	40	60
NPK + B-5	0	100
NPK + B-10	0	100
NPK + B-15	0	100
NPK + Zn-5	33	67
NPK + Zn-10	25	75
NPK + Zn-15	31	69
NPK + B-10 + Zn-10	0	100

The effects of Zn and B application on bumpy fruit formation are shown in Table 3. Formation of bumpy fruits was observed only under the B deficient condition (Table 3). Different levels of Zn application and treatment without Zn and B (control) showed the different levels of bumpy fruit formation. Thanthirige and Wijesundara (1999) also reported that the addition of 15 and 20g of borax per plant had significantly reduced the percentage of bumpy fruit formation under low country Wet Zone conditions. They also observed the reduction of bumpy fruit formation under application of B in the 20 g/plant than in the 10 g/plant. This finding contradicts the finding of the present experiment, where clear relationship with the different levels of B was not observed possibly due to the climatic differences between the two experimental sites. Clear relationship between the bumpiness and the rate of Zn application was also not observed possibly due to the insensitivity of papaya bumpy fruit formation to the Zn fertilization. Percentage of bumpy fruit formation under B deficient condition varies from 80.2 to 89.0 in low country Wet Zone (Thanthirige and Wijesundara, 1999). However according to the findings of present experiment, formation of bumpy fruits was only 40% even at B deficient condition (Table 3). The high percent of bumpy fruit formation under wet zone than dry zone may be due to the difference in climatic conditions prevailing in two regions. High amount of rainfall and poor drainage induce the B deficiency condition (Katyal and Randhawa, 1983). Although the precise role of B in plants is unknown, it is involved in regulation of carbohydrate metabolism, synthesis of amino acids and proteins, translocation of sugars, proper pollination and new cell development in meristematic tissues (Tisdale *et al.*, 1985).

CONCLUSIONS

The present study reveled that the lowest rate of Zn and B (5 kg/ha) is sufficient to increase the crop growth, yield and quality of Papaya to a satisfactory level. Although Zn had no effect on fruit quality, it had a significant effect on growth and yield of papaya. However, only the Zn and B combination increased the growth, yield and fruit quality of papaya.

REFERENCES

Anon., 1991. Crop recommendation technoguide. Department of Agriculture, Sri Lanka.

Anon., 2000. Balanced fertilizer use for sustainable agriculture in India. PPIC program, Gurgon - 122016, Haryana. Pp 4-6

Atkinson, I. 1991. Papaw growing. Agfat, H6.1.19 NSW. Agriculture and Forestry. Australia.

Cook, R.L. 1964. Hunger signs in crops. 3rd ed., David Mckay Co., New York. Pp 123-126.

Katyal, J.C. and N.S. Randhawa (1983). Micronutrients. FAO fertilizer and plant nutrition bulletin 7: 11-16

Munzos, S.M., G.F. Kocher and P.A Villalobos. 1966. Cultivation of papaya. Agric. Tech., Satigo 26: 106-113.

Panabokke, C. R. 1996. The great soil groups in Sri Lanka, their environmental setting, main characteristics and taxonomic placement. In Soils and Agro-ecological Environment in Sri Lanka, Natural Resources, Energy and Science Authority, Colombo, Sri Lanka. 30-40.

Romheld, V. and H. Marscher. 1991. Functions in micronutrients in plants. In Micronutrients in Agriculture. No 4. Soil Science Society of America, Madison, Wisconsin.

Thanthirige, M.K. and C. Wijesundara (1999). Bumpy fruit formation in papaya (*Carica papaya* L.) Proceeding of the Annual Symposium of the Department of Agriculture. Pp137-145.

Tisdale, S.L., W.L. Nelson, J.D. Deaton and J.L. Havlin (1985). Soil fertility and fertilizers. 5th edition, Macmillan Publishing Company, New York. Pp 71-72.

Wang, D.N. and W.H. Ko. 1975. Relationship between deformed fruit diseases of papaya and boron deficiency. Phytopathology 65: 445-447.