EFFECT OF BORON FERTILIZATION ON BORON CONCENTRATIONS AND YIELD OF APPLE CULTIVARS GROWN ON DIFFERENT BORON CONTAINING SOILS

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Abstract

Study was carried to investigate the effect of soil, leaf and soil + leaf boron applications on leaf B concentration and fruit yield in three different boron containing soils. For this, 4 levels of soil application as 0,100, 300 and 500 g B da^{-1} and 2 levels of leaf application as 0 and 100 mg B l^{-1} were alone and as their combination. Leaf B concentrations and fruit yields in all individual districts increased with the soil and soil x leaf combination. Foliar application had an effect only in one district on leaf boron concentrations but in other districts foliar boron application did affect neither leaf boron concentration nor fruit yield. Depending on the means of soil applications, 12-23 % increase in leaf B concentrations and 11-57% increase in fruit yield were determined. The highest B and yield increases were determined from the lowest soil B containing district with the S3xL1.

Key words: Boron application, leaf B, fruit yield

Boron (B) with role of on sugar transport, cell wall synthesis, carbohydrate metabolism, RNA metabolism, respiration, IAA metabolism, phenol metabolism and etc. is one of the important nutrients and B deficiency can occur as different deficiency symptoms. Boron is immobile in phloem. So, B deficiency can result in different fruit disorders affecting fruit storability and quality. Under B deficiency, cell wall structure damage and denaturing, cracking, decaying and softening can be seen in the some fruits and tuber crops (Bergmann W., 1992; Marschner H., 1995). Apple trees require higher amount of B (Shorrocks V.M., 1997). Boron is required for pollen germination and pollen tube growth resulting in fruit setting. Therefore, B fertilization may increase yield, particularly when plants are grown on sandy soil with a low content of available B. The effect of B fertilization of apple trees on fruit quality can change with the several factors such as cultivar, orchard location, rainfall, air temperature. Both low and excessive concentrations of B in apple trees cause poor fruit quality. Apples with a low B concentration have a short storage life because of the high susceptibility to a break down. On the other hand, high B concentration in apples enhances the incidence of internal disorders, particularly water core and internal breakdown. Also, high B concentration in apples could result in increased decay and decreased fruit firmness (Bergmann W., 1992; Wójcik *et al*, 1999).

Boron uptake of the plants is in close relation with some soil, plant and environment factors. Even plants grown on a same soil there can have different characteristics for B using ability (Paull *et al*, 1992; Gupta U. C., 1979). Boron uptake by plants decreases with the increase of pH and lime (Bennet O.L., Mathias E.L., 1973). Soil texture and clay type are other factors effecting plant B nutrition and it is recorded that plants can uptake better B from the coarse texture soils (Singh *et al*, 1976). In regions having more rainfall, coarse texture with low organic matter containing soils don't have sufficient B. But increasing of organic matter in these soils contributes B nutrition of plants (Purves D., McKenzie E.J., 1974.).

In plant production, yield and quality have close relation with plant mineral nutrient concentrations. So it is required to know sufficient levels of nutrients for desired production. Boron is a nutrient that deficiency and toxicity levels are close in the soils. So, keeping the sufficient amount of soil B concentration needs close monitoring.

In this study, it was aimed to investigate the different B application methods on B nutrition and yield of apple grown on different B containing soil.

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MATERIAL AND METHODS

Study was conducted under 3 different districts (Isparta, Senirkent, Aglasun) having different soil B concentrations in Isparta region. In the region, 2.5 million tones apple production was made per year. The experiments were set up in 2014 using 6-7 years old Red Chief variety grafted on M-9 rootstocks.

Some soil and plant characteristics of experimental orchards in Isparta, Senirken and Aglasun were given in Table 1, Table 2 and Table 3, respectively.

Table 1

Some soil characteristics and leaf nutrient concentrations for previous year in Isparta orchard

Some soil characteristics			Previous year leaf nutrient concentrations	
pH (1/2.5)		8.1	N (%)	1.92
EC (1/2.5)		0.13	P (%)	0.13
OM (%)		2.5	K (%)	1.92
Texture		CL	Ca (%)	3.20
$CaCO_3$ (%)		10	Mg (%)	0.28
	B	1.1	B, ppm	30
	Fe	4.8	Fe, ppm	169
	Cu	1.6	Cu, ppm	12
	Zn	0.8	Zn, ppm	21
Extractable nutrients	Mn	10.6	Mn, ppm	56
	Ca	4019		
	Mg	423		
	K	163		
	P	9.58		

Table 2

Some soil characteristics and leaf nutrient concentrations for previous year in Senirken orchard

Some soil characteristics			Previous year leaf nutrient concentrations	
pH (1/2,5)		7.67	N (%)	2.3
EC (1/2,5)		0.24	P (%)	0.22
OM (%)		3,4	K (%)	2.38
Texture		C	Ca (%)	1.32
$CaCO_3$ (%)		14	Mg (%)	0.31
	B	0.84	B ppm	36.0
	Fe	2.18	Fe, ppm	71.4
	Cu	3.0	Cu, ppm	10.6
	Zn	2.0	Zn, ppm	43.6
Extractable nutrients	Mn	8.12	Mn, ppm	69.6
	Ca	5607		
	Mg	544		
	K	902		
	P	40		

Table 3

Some soil chacteristics and leaf nutrient concentrations for previous year in Aglasun orchard

Some soil characteristics			Previous year leaf nutrient concentrations	
pH (1/2,5)		7.88	N (%)	2.8
EC (1/2,5)		0.28	P (%)	0.14
OM (%)		2.4	K (%)	1.43
Texture		CL	Ca (%)	1.69
$CaCO_3$ (%)		20	Mg (%)	0.26
	B	0.46	B, ppm	42.0
	Fe	3.51	Fe, ppm	149
	Cu	2.41	Cu, ppm	12.5
	Zn	0.89	Zn, ppm	50.4
Extractable nutrients	Mn	3.38	Mn, ppm	57.8
	Ca	7813		
	Mg	243		
	K	626		
	P	21.6		

Boron fertilization

Boron fertilizations were made as soil, leaf and soil+leaf applications. For soil applications; 4 levels of B as S0=0, S1=100, S2=300 and S3= 500 g B da^{-1} were applied. For leaf applications, 2 levels of B as L0= 0 and L1= 100 mg B l^{-1} were used. Soil+leaf applications were the combination of soil and leaf (S+L) applications. As B source EDITOT-67 (B: 20.8 %) was used.

The experiments were planned according to randomized parcels with 5 replications and each replication contained 3 trees. All experiments were conducted on 120 trees (4 soil doses x 2 leaf dose x 5 replicates x 3 tree for each replicate). Soil B application was made on November as solution to the active root zone and mixed to the 20-30 cm depth. Foliar applications were made in 3 times as after the harvest, before flowering and fruit set.

Soil and plant analysis

In order to determine soil extractable B, 20 g of soil was weighted in to 250 ml flask and 40 ml of 0,01M $CaCl_2$ solution was added. Suspension was boiled for 5 minutes using re-circulated cooling system. Then, solution was cooled until room temperature and filtrated through the blue band filter paper. Boron concentration of filtrate was measured with ICP (Kacar B., 2009). Soil available P, exchangeable K, Ca, Mg and extractable micro elements were determined as described by Olsen *et al*, (1954), Jackson M. L., (1967) and Lindsay W. L., Norvell W.A., (1969). Soil texture was determined using hydrometer (Bouyoucos G.L., 1954) and $CaCO_3$ content was measured with calcimeter (Allison L.E., Moodie C.D. 1965). Soil organic matter was determined based on Walkley A., Black I.A., (1934). Soil pH was measured using pH mater in suspension of soil and water at the rates of 1/ 2.5.

For leaf analysis, leaf samples were collected in July (Jones *et al*, 1991) and brought to the lab. Then, samples were washed, dried at 65±5°C, grounded and wet digested with microwave oven and filled up to 50 ml with ultra-pure water. Boron concentrations in the filtrates were measured with ICP. Total nitrogen was analyzed according to Kjeldahl method. Phosphorus concentrations of samples were determined with a spectrophotometer (Shimadzu UV-1208) at 430 nm according to the vanadomolybdo phosphoric acid method. Potassium, Ca, Mg, Fe, Cu, Zn, and Mn concentrations were determined using atomic absorption spectrophotometer (Kacar B., İnal A., 2008).

For evaluating soil B level, 0.5 mg B kg^{-1} was accepted as critical concentration (Keren R., Bingham F.T., 1985). Sufficient leaf B concentration was accepted as 25-40 mg kg^{-1} (Jones *et al*, 1991). Other classifications were made using the classification chard given in Alpaslan *et al*, (1998) for the soils and given in Jones *et al*, (1991) for he leaves.

RESULTS AND DISCUSSION

Effect of B fertilization on leaf B concentrations

Effects of B fertilizations on leaf B concentrations of tree different experiments were given in Table 4. As seen from the mean values, soil applications significantly affected leaf B concentrations in all districts. Increases of leaf B with soil applications in Isparta, Senirkent and Aglasun were 22, 12 and 23 percent respectively.

Also mean B concentrations showed that leaf B fertilization resulted in B increase in Aglasun orchard but in other district, leaf applications did not affect leaf B concentrations. In Isparta district the highest leaf B concentration was measured from the S3xL1 treatment, in Senirkent and Aglasun the highest leaf B concentrations were reached S3xL0 and S3xL1, respectively.

Table 4

Effects of B applications on leaf B concentration of apple trees

Application	Leaf B concentrations (mg kg^{-1})		
	L0	L1	Mean
	Isparta experiment		
S0	31 b**	32 b	31 B*
S1	30 b	30 b	30 B
S2	35 ab	38 a	36 A
S3	37 a	39 a	38 A
Mean	33	35	
	Senirken Experiment		
S0	34 ab**	34 ab	34 B*
S1	34 ab	34 ab	34 B
S2	33 b	37 a	35 B
S3	38 a	37 a	38 A
Mean	35	36	
	Ağlasun experiment		
S0	42 c**	52 b	47 B*
S1	44 c	52 b	48 B
S2	44 c	56 ab	50 AB
S3	55 ab	61 a	58 A
Mean	46 *B****	55 *A*	

*S (P<0.01);**SxL (P<0.01); ***L (P<0.01)

Effect of B fertilization on yield

Soil application and soil x leaf interaction significantly affected apple fruit yield in all districts. In this increases, soil applications were more dominant comparing to leaf application. In all areas, the lowest yield was measured from the control treatments, but the dose that the highest yield values were obtained varied with the district. Yield increases from the Isparta, Senirkent and Aglasun were about the 52%, 11% and 57% respectively (*table 5*).

According to the soil analysis, B concentration of Aglasun orchard is under the sufficient level comparing to other orchards in Isparta and Senirkent (Keren R., Bingham F.T., 1985). However, leaf nutrient concentrations in all districts were at about sufficient levels (Jones *et al*, 1991). Looking at the experiment results, it can be seen that increases in leaf B concentration was higher in the orchard (Aglasun) with lower soil B than higher B containing orchards. Also, yield results reflected the same tendency with leaf B concentration and higher yield increase were measured from the orchard having higher leaf B increase. Similar results were found in previous studies implying the same findings (Ganie *et a*., 2013; Wang *et al*, 2012; Baysal G.D., Erdal I., 2015). Looking at the both application methods only in Aglasun experiment foliar B application had a significant effect, However but it was seen that leaf B fertilization did not affect both leaf B concentration and yield in other orchards. From this it can be said that soil application is more efficient (David *et al*, 2005; Meng *et a*., 2014). One of the important finding is that although soil of the Aglasun orchard is lower than other orchards, B concentrations measured in leaf of apples in Aglasun is higher. Looking at this result it can be said that there are some other factors effecting B availability for plant use (Bennet O.L., Mathias E.L., 1973; Purves D., Mc Kenzie E.J., 1974; Singh *et al*, 1976; Gupta U.C., 1976; Poul *et al*, 1992).

Table 5

Effects of B applications on fruit yield

Application	Yield, kg tree^{-1}		
	L0	L1	Mean
	Isparta experiment		
S0	42 c**	42 c	42 C*
S1	58 ab	70 a	64 A
S2	63 a	56 b	59 AB
S3	55 b	59 b	57 B
Mean	55	57	
	Senirken experiment		
S0	71 b**	72 b	71 B*
S1	74 ab	72 b	73 B
S2	78 a	81 a	80 A
S3	72 ab	74 ab	73 B
Mean	35	36	
	Ağlasun experiment		
S0	46 b**	48 b	47 B*
S1	60 a	50 b	55 AB
S2	75 a	57 b	66 A
S3	64 a	83 a	74 A
Mean	61	60	

*S (P<0.01);**SxL (P<0.01)

CONCLUSIONS

Soil, leaf and applications and their combination (soil+leaf) significantly increased the leaf B concentrations and fruit yields regardless of the regions. But the most effective application type and the application doses varied with the region.

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