RESPONSE OF APPLE CULTIVARS TO DIFFERENT BORON LEVELS UNDER THE AGRO-CLIMATIC CONDITION OF KALAM

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ABSTRACT

An experiment to study "Response of apple cultivars to different boron levels under the agro-climatic condition of Kalam" was conducted at Kalam Summer Station (KSS) Swat during the year 2016. The experiment was laid out in Randomized Complete Block Design (RCBD) with two factors. Apple cultivars (Golden Smoothee, Jonica, Royal Gala) were assigned as Factor A and Boron level (0, 0.5, 1.0, 1.5%) were considered as Factor B. The purpose of study was to improve the quality and yield of three different apple cultivars for agro-climatic condition of district Kalam. The three cultivars were treated with four different concentrations of boron at pink bud stage. Statistical analysis revealed that boron application at (1.5%) concentration significantly improved the fruit set (19.14%), TSS (11.72 ^{o}Brix), TSS Acid Ratio (22.32%), reducing sugars (11.03%) and non-reducing sugars (2.77%). While on the other hand fruit drop (7.44%) and titratable acidity (0.5%) were significantly reduced with 1.5% boron application. Royal Gala was found with minimum percent fruit drop, titratable acidity, Apple cultivar Jonica has maximum reducing sugars and non-reducing sugars. Apple cultivars Golden Smoothee has maximum TSS and TSS acid ratio. It was concluded from the experiment that boron at rate of 1.5% significantly increased fruit set, total soluble solids, sugar acid ratio and reducing sugars, while decrease in fruit drop, titratable acidity and non-reducing sugars.

Keywords: Boron, Apple, Cultivars, Agro climatic condition of Kalam

INTRODUCTION

Apple (*Malus domistica*) is a pome fruit belongs to family commonly known as "*Rosaceae*". Apple is unique and most famous fruit of genus *Malus* which is largely commercially cultivated all over the world. The origination of genus *Malus* is Eastern Turkey but progressively spread to Asia and Europe as well as Pakistan (Chuadhary and Malik, 1994). Apple is a rich source of water (84.7 %), Fiber (0.8 gram), Phosphorus (12 mg), Iodine (2 µ), Ash (0.3 gram), Carbohydrate (13.9 gram), Proteins (0.4 gram), Lipids (0.3 gram) and Iron (480 µg 100 g^{-1}) (Hussain, 2001). It has been used as a food and

for lowering down the cholesterol level and curing the disease like dysentery and diarrhea. (Considine, 1982).

Boron plays a vital role on flowering and fruiting. It maximizes fruit set, yield, fruit weight and total soluble solids. Boron showed their effect on all quality parameters. It has a key role in fruit set, maintaining integrity of cell, respiration rate, metabolic activities as well as nutrients uptake. (Naz *et al.,* 2012). Boron has a vital role in flowering and fruit formation (Nonnecke, 2003). As a micro nutrient boron has a major role in the development behavior of trees as well as in the yield. Boron maximize the germination of pollen grain and elongation of pollen tube thus increases the fruit set (%) and finally increase the yield (Abd.Allah, 2006). The foliar application of boron at fruit set significantly increased the fruit weight, fruit set, pulp seed ratio, total soluble solid, total sugars and seed hardness while fruit drop percent was significantly decreased Kumar *et al.* (2015). Boron also plays an important role in increasing the yield and quality (Magalhaes *et al.,* 2006). Boron helps in cell division, calcium uptake, nucleic acid synthesis, and transportation of carbohydrates (Bose and Tripathi, 1996). Deficiency of boron in plants affected the newly growing roots and leaves. The color of leaves converts to light green and become crumpled and frizzy. The translocation of phosphorus, starches, nitrogen and sugar also affected by boron deficiency. It also affects the synthesis of protein and amino acids (Stanley *et al.,* 2001). When leaves become thickened, curled or wilted and discoloration, cracking or decaying of fruits, tubers or roots is seem, so it is also the symptoms of boron deficiency (Tisdale *et al.,* 2003). When fruits are produce commercially it is particularly important to give sufficient level of boron for high yield formation, fruit quality, crop storability and stress tolerance (Wojcik *et al.,* 1999; Cakmak and Romheld, 1997; Khayyat *et al*., 2007).

Keeping in view the importance of boron in quality fruit production of apples the following objectives.

- To study the effect of boron on fruit quality of different apple cultivar under the agro-climatic condition of Kalam.
- To study the combined effect of Boron and different apple cultivars on fruit attributes.

MATERIALS AND METHODS

The experiment entitled 'Response of apple cultivars to varying concentrations of foliar application of boron under the agro-climatic condition of Kalam' was carried out at Kalam Swat, (Summer Station Kalam) in 2016. The research experiment was design according to the randomized complete block design (RCBD) with two factors that is replicated three times. Factor A contain four treatments of boron in which boric acid is taken as a source of boron which would be applied as a foliar spray on three apple cultivars which is taken as factor B.

The experiment details are given below:

FACTOR A: Apple Cultivars
C_1: Golden Smoothee.
C_2: Jonica.
C_3: Royal Gala

FACTOR 2: Boron Level
T1: Control
T2: 0.5%
T3:1.0%
T4: 1.5%

The experiment was conducted at (KSS) Kalam Summer Station. Kalam is located at an altitude of 2100 m, (North 35° 29' 15.8" East 72° 34' 26.6") above sea level. The area has a typical dry temperate zone climate. In winter the weather become very cold and temperature fall below 0° C. Summer start from June and ends in October.

Statistical Procedure

To Analysis of Variance (ANOVA) all the data will be added and used the procedure suitable for RCBD with two factors arrangement. Least Significance Differences (LSD) test for these analyses used to compare the means. Statistix 8.1 is used as statistical package (Jan *et al*., 2009).

RESULTS AND DISCUSSION

Fruit Set (%)

The statistical analysis of the data showed that Boron levels significantly affected the fruit set percent while apple cultivars and interaction was non-significant (Table 1).

Regarding the mean for boron treatments. Maximum fruit set (19.14%) was recorded with (1.5%) boron followed by fruit set (16.26%) and (12.92%) with (1.0%) and (0.5%) boron respectively, while minimum fruit set (10.47%) was recorded in control.

Mosa *et al*. (2015), stated that anna apple trees treated with Boric Acid significantly improved the anna apple fruit set, yield and quality. The same results of improving yield and quality of apple and pear trees as a results of Boron application were reported by Hans *et al*., (1997). Wojcik p *et al*., (2003) concluded that Boron application has a positive effect on increasing fruit set and fruit yield of mature pear as applied before full bloom or post bloom. The increase in fruit set and fruit yield might be due to the positive effect of Boron on pollen germination and growth of pollen tube. Ahmad *et al*. (2013), stated that apple cultivars contain different genetic make-up. Fruit set vary with change in apple cultivars. Marinda *et al,* (2015).

Fruit Drop (%)

The mean data showed there was significant variation among various apple cultivars. Maximum fruit drop (22.47%) was noted in apple cultivar Jonica followed by fruit drop (8.33%) was noted in apple cultivar Golden Smoothee, while minimum fruit drop (7.25%) was recorded in apple cultivar Royal Gala (Table 1).

The mean data revealed that maximum fruit drop (17.33%) was observed in control followed by frit drop (14.11%) and (11.77%) with (0.5%) and (1.0%) of boron respectively, however minimum fruit drop of (7.44%) was noted with (1.5%) of boron. Maximum fruit drop of (30%) was observed in cultivar Jonica with-out boron application. However, as the concentration of boron increased fruit drop was reduced. Foliar application of boron (0.5%) and (1.0%) fruit drop was (25.66%) and (20.66%) in apple cultivar Jonica while, minimum fruit drop (4%) was recorded in apple cultivar Royal Gala with (1.5%) of boron foliar application.

Our results are in lined with the findings of Bomeke *et al*. (1995), who found minimum fruit drop in cherry. Shahin *et al*. (2010), observed that Boron applied alone or in combination with GA_3 were effective in minimizing fruit drop before harvest in anna apple trees as compared to control and it was further stated that boron, zinc, copper, potassium, and iron are responsible for synthesizing and moving carbohydrates from leaves to fruit. Boron also had a key role in the biosynthesis and transportation of natural auxins indole acetic acid to the pedicle of fruit. Fruit drop vary with different apple cultivars. Ahmad *et al*. (2013), stated that the changes in inter cultivars is due to the genetic make-up of cultivars.

Total Soluble Solid (°Brix)

The analysis of the data revealed that boron treatments, apple cultivars was significantly affected total soluble solids (Table 1).

Maximum total soluble solids of (11.61°Brix) was noted in apple cultivar Golden Smoothee followed by total soluble solids (10.74°Brix) was recorded in apple cultivar Royal Gala while minimum total soluble solids (10.67°Brix) was observed in apple cultivar Jonica. Mean data exhibited that total soluble solids were significantly affected by boron treatments. Maximum total soluble solids of (11.72°Brix) was recorded with (1.5%) of boron followed by total soluble solids (11.20°Brix) and (10.77°Brix) with (1.0%) and (0.5%) of boron respectively. However minimum total soluble solids (10.35°Brix) was recorded without boron application. Maximum total soluble solids (12.10°Brix) was recorded in apple cultivar Golden Smoothee with (1.5%) of boron followed by total soluble solids (11.83°Brix) and (11.58°Brix) with (1.0%) and (1.5%) of boron respectively. While minimum total soluble solids (9.90°Brix) was noted in apple cultivar Royal Gala with no boron application.

Our findings can be co related to the results of Nagy *et al*. (2008), who found that boron foliar spray significantly increased total soluble solids as compared to control in sweet cherry fruit. Predieri *et al*. (2004), also noted the similar results of increase total soluble solids as a results of boron application. The previous study of Mousavi *et al*. (2011), confirms increase in total soluble solids in kinnov mandarin because of foliar spray of Boron and zinc combination. Gupta (1999) stated that the increase in total soluble solid as results of boron might be due to their effect on different enzymes which are involved in the formation of different proteins, acids and sugars.

Titratable Acidity (%)

The statistical analysis of data revealed that boron treatments and apple cultivars significantly affected the titratable acidity, while apple cultivars and boron treatments interaction had non-significant effect on titratable acidity (Table 1).

Regarding the mean for apple cultivars. Maximum titratable acidity (0.65%) was noted in apple cultivar Jonica which is closely related to apple cultivar Golden Smoothee. while minimum titratable acidity (0.60%) was noted in apple cultivar Royal Gala. According to the mean of boron treatments. Highest levels of titratable acidity (0.75%) was recorded in control followed by titratable acidity (0.65%) and (0.56%) with (0.5%)

and (1.5%) of boron respectively. While minimum titratable acidity (0.52%) was noted with (1.5%) of boron as the concentration of boron was increased titratable acidity was reduced.

Same results were obtained by Muhammad *et al*. (2012), in cherry fruit. The studies are also same with Nabel *etal*, (2010). Mosa *et al*. (2016), noted the same trend of decreased titratable acidity percent as a result of potassium sulfate 2% and boric acid 0.2% as applied in combination. Wojcik and Marzena (2008) noted non-significant effect on titratable acidity of sweet cherry as a results of boron foliar application. Dawarpana *et al*. (2016), also observed the decreased with increasing concentration of boron and zinc as applied in combination. Titratable acidity varies with different apple cultivars.

Table 1: Fruit Set (%), Fruit drop (%), Total Soluble Solids (°Bxix) and Titratable Acidity (%) of apple cultivars as affected by boron levels.

	Parameters			
(Factor A) Apple Cultivars	**Fruit Set (%)**	**Fruit drop (%)**	**Total Soluble Solids (°Bxix)**	**Titratable Acidity (%)**
Royal Gala	14.86 a	7.25 c	10.74 b	0.60 b
Jonica	14.30 a	22.47 a	10.67 b	0.65 a
Golden Smoothee	14.94 a	8.33 b	11.61 a	0.60 b
LSD (P≤0.05)	0.1383	0.5314	0.1587	0.0341
(Factor B) Boron Levels				
0	10.47 d	17.33 a	10.35 d	0.75 a
0.5%	12.92 c	14.11 b	10.77 c	0.65 b
1.0%	16.26 b	11.77 c	11.20 b	0.56 c
1.5%	19.14 a	7.44 d	11.72 a	0.52 d
LSD (P≤0.05)	0.7988	0.6136	0.1832	0.0394
Interaction at LSD (P≤0.05)				
Cultivars × Boron	---	---	---	---
Significance	NS	NS	NS	NS

Sugar Acid Ratio (mg 100ml^{-1})

The result of mean table showed maximum sugar acid ratio of (19.55%) was observed in apple cultivar Golden Smoothee followed by sugar acid ratio (18.14%) was noted in

apple cultivar Royal Gala. While minimum sugar acid ratio (16.78%) was recorded in apple cultivar Jonica (Table 2).

Maximum sugar acid ratio (22.32%) was noted with (1.5%) of boron followed by sugar acid ratio (19.82%) and (16.61%) with (1.0%) and (0.5%) of boron respectively, while the minimum sugar acid ratio of (13.88%) was recorded in control treatment.

Mosa *et al*. (2015), observed the similar results of improved sugar acid ratio of anna apple fruit as a results of boric acid application. Mosa *et al*., (2016) reported the similar results of significantly increased sugar acid ratio as a results of potassium sulfate and boric acid combination in peach fruit cultivar Cv Florida Prince. Gupta (1999) stated that increased levels of sugar acid ratio in boron treated fruit might be due to its effect on various enzymes involved in the formation of different protiens, acids and sugars. Ahmad *et al*., (2013) stated that sugar acid ratio changes with different apple cultivars. Different apple cultivars might be different genetic make-up. Marinda *et al*., (2015).

Reducing Sugar (%)

The statistical analysis showed that boron treatments and apple cultivars significantly affected the reducing sugar, while interaction was non-significant (Table 2).

Maximum reducing sugar (12.32%) was noted in apple cultivar Jonica followed reducing sugar (11.21%) in apple cultivar Golden Smoothee, while minimum reducing sugar (9.21%) was recorded in apple cultivar Royal Gala. Regarding mean for boron treatments. Maximum reducing sugar (11.03%) was noted with (1.5%) of boron followed by reducing sugar (10.97%) and (10.88%) with (1.5%) and (0.5%) of boron respectively. However minimum reducing sugar (10.97%) was recorded in control.

This increase in reducing sugars percentage might be because boron has a key role in various process like transportation of sugars and metabolism of carbohydrates. Sarwy *et al*, (2012). Our findings are in according with the study of Sarrwy *et al*. (2012), who noted increase in reducing sugar percentage as a results of boric acid application either alone or in combination with calcium nitrate. Ullah *et al*. (2012), also noted the highest reducing sugar percentage as a results of boric acid foliar application as compared to control. The study is also in line with the results of Kumar *et al.* (2015), who observed the significant increase in the reducing sugar percentage because of boron application.

Non-Reducing Sugar (%)

The statistical analysis of variance revealed that apple cultivars significantly affected non-reducing sugars while the interaction was non-significant (Table 2).

Regarding mean table of apple cultivar showed there was significant variation among various apple cultivars. Maximum non-reducing sugar (3.06%) was noted in apple cultivar Jonica followed by non-reducing sugar (2.86%) was noted in apple cultivar Golden Smoothee, however the minimum non-reducing sugar (1.84%) was noted in apple cultivar Royal Gala.

Our result are co related to the findings of Sarwy *et al*. (2012), who reported that boric acid sprayed in combination with calcium nitrate significantly increased the non- reducing sugar in date palm as compared to control. The studies are also in line with Ullah *et al.* (2012), who observed the increased in non-reducing sugar percentage because of 0.3 % boric acid foliar application. Our findings can also be verified from the results of Haq *et al*. (2013), who noted the significant increase in non-reducing sugars percentage because of borax applied in combination with calcium chloride in litchi fruit. Kumar *et al.* (2015), stated that this increase in non-reducing sugars percentage as a results of nutrients application is due to the conversion of complex sugars into simple sugars. Ahmad *et al.* (2013), noted that non-reducing sugar changes with different apple cultivars.

Table 2: Sugar acid ratio (mg 100 ml^{-1}), Reducing Sugar (%) and Non Reducing Sugar (%) of apple cultivars as affected by boron levels.

	Parameters		
(Factor A) Apple Cultivars	**Sugar acid ratio (mg 100 ml^{-1})**	**Reducing Sugar (%)**	**Non Reducing Sugar (%)**
Royal Gala	18.14 b	9.21 c	1.84 c
Jonica	16.78 c	12.32 a	3.06 a
Golden Smoothee	19.55 a	11.21 b	2.86 b
LSD (P≤0.05)	1.0792	0.0305	0.1662
(Factor B) Boron Levels			
0	13.88 d	10.79 d	2.48 b
0.5%	16.61 c	10.88 c	2.57 b
1.0%	19.82 b	10.97 b	2.53 b
1.5%	22.32 a	11.03 a	2.77a
LSD (P≤0.05)	1.2462	0.0352	0.9514
Interaction at LSD (P≤0.05)			

Cultivars × Boron	---	---	---
Significance	NS	NS	NS

Conclusion

On the basis of my study it is concluded that Boron foliar application at the rate of 1.5% significantly improve fruit set (%), TSS, sugar acid ratio, reducing sugars and non-reducing sugars while decreased fruit drop percentage and titratable acidity. While maximum reducing sugars and non-reducing sugars was recorded in apple cultivar Jonica, minimum fruit drop and titratable acidity was observed in apple cultivar Royal Gala. While cultivar Golden Smoothee has maximum TSS and sugar acid ratio.

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