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Plant growth characteristics of pomegranate cv. 'early bhagwa' as influenced by fertigation and micronutrient sprays

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Abstract
A field experiment was conducted during 2015-17 at research farm of RARI, Durgapura – Jaipur in split plot design on Pomegranate cv 'Early Bhagwa'. The experiment consisted 12 treatment combinations with three doses of fertigation (100, 75 and 50% of RDF) and four micronutrient sprays (M_1 to M_4). The pooled data showed that treatment F_3 showed maximum gain in plant height, gain in stem girth, gain in plant spread (E-W) and gain in plant spread (N-S) (0.76 m, 0.72 cm, 0.25 m and 0.35 m, respectively). Whereas the minimum values (0.52 m, 0.51 cm, 0.18 m and 0.26 m, respectively) were found with the application of treatment F_1. The micronutrient treatment M_4 had the maximum gain in plant height, gain in stem girth, gain in plant spread (E-W) and gain in plant spread (N-S) (0.67 m, 0.65 cm, 0.23 m and 0.34 m, respectively), while treatment M_1 showed the minimum value of gain in plant height and gain in plant spread (E-W) (0.62 m and 0.21 m, respectively) while treatment M_3 and M_2 showed minimum gain in stem girth and gain in plant spread (E-W) of 0.58 cm and 0.28 m, respectively.

Keywords: Pomegranate, fertigation, micronutrients

Introduction
Pomegranate (*Punica granatum* L.) belongs to Punicaceae family and is one of the oldest known edible fruits. Pomegranates are widely grown in many tropical and subtropical countries, especially in the moderate climate of the Mediterranean regions (Solaheddin and Kader, 1984) [24]. In addition, pomegranate trees have greater adaptability to adverse climatic conditions, such as drought tolerance and climate change (Sepulveda *et al*., 2000) [17].
In Rajasthan, pomegranate is commercially cultivated in Jaipur, Ajmer, Alwar, Tonk, Sriganganagar, Kota, Jodhpur, Pali, Jalore, Banswara, Sawai Madhopur, Bhilwara, Jhunjhunu, and Sirohi districts. In the state the area under pomegranate cultivation is 1.01 thousands hectares with production of 5.50 thousands MT and productivity of 5.4 MT/ ha. It contributes 0.7% of total production (Anonymous, 2013).
Area under this crop is increasing enormously in spite of higher cost of fertilizers, leaching and washing away of nutrients by run off, low fertilizer use efficiency and low productivity under conventional fertilizer application methods. Fertilizers are the most important inputs which directly affect the plant growth, development, yield and quality of produce. Application of fertlilizers to the growing crops along with irrigation water through drip system, provide nutrients to the active root zone at different time intervals in accordance to crop growth stages, thus preventing losses of expensive nutrients. Among micronutrients, Zn, B and Fe have much significance due to poor nutrient status of soil.
So looking to the importance of these micronutrients and fertigation in the plant growth characteristics of pomegranate this research experiment was conducted during the year 2015-16 and 2016-17 at the research farm of RARI, Durgapura, Jaipur to study the effect of different NPK doses under fertigation and foliar micronutrient spray of Zn, B and Fe on plant growth characteristics of pomegranate cv Early Bhagwa.

Materials and Methods
The present investigation was conducted at the research farm of Rajasthan Agricultural Research Institute, Durgapura – Jaipur. The experiment was laid out on 3 year old pomegranate cv. Early Bhagwa in the split plot design. The plants were planted under square system of planting at a spacing of 4 x 4 m. The experiment had twelve treatments and each treatment had four replications.
Three levels of fertigation viz., 50% (F_1), 75% (F_2) and 100% (F_3) of RDF was applied. The desired quantities of micronutrients were procured from different sources for the purpose of

experiment and required quantities of these micronutrients were applied as foliar spray on individual plant.

1. Spray of Zinc Sulphate ($ZnSO_4$) (containing 21% Zn) @ 0.4%
2. Spray of Boric acid (H_3BO_3) (containing 17.5% B) @ 0.4%
3. Spray of Ferrous Sulphate ($FeSO_4$) (containing 20% Fe) @ 0.4%

Before execution of trial, the tree height was measured with the help of a graded staff. The readings were again noted after the completion of the experiment. The average increase in tree height was computed by subtracting final and initial values and expressed in centimeters.

The stem girth was measured at 15 cm above the ground level for the three main stems immediately after first treatment application and harvesting stages.

The average increase in tree spread was measured with the help of a measuring tape and computed by subtracting final and initial values for tree spread and expressed in meters as done for tree height. Average of East-West and North-South direction was taken as tree spread.

Results and Discussion

The data pertaining to tree growth characters (Table 1 to 4) showed appreciable effect of fertigation. Maximum gain in plant height (0.71 m), stem girth (0.72 cm), tree spread E-W (0.25 cm) and N-S (0.35 cm) was recorded under treatment, F_3 (100% recommended dose of N, P and K through fertigation) followed by treatment F_2 (75% of recommended dose of N,P and K through fertigation). The better growth under fertigation may be due to beneficial effects of frequent split application of N, P, K fertilizers through drip. There was a continuous supply of nutrients in fertigation as the fertilizers were applied in split doses during the growth period of the tree, which might have helped in meeting the requirements of nutrients during the critical period of growth.

These results are in accordance with the findings of Dhakar *et al*. (2010) [7] who observed fertigation with 100% recommended dose of fertilizers in split doses to obtain significantly higher vegetative growth characters in pomegranate. Singh (2013) [20] reported 100% and 75% recommended dose of fertilizers to record highest growth parameters in nectarine cv. Snow Queen. Chauhan (2006) [5] also recorded highest vine growth characters with 100% recommended dose of fertilizer through fertigation in kiwi fruit. Raina *et al*. (2005) [13] reported that fertigation appreciably improved vegetative growth characters (i.e annual shoot growth, tree growth and canopy volume) of apricot as compared to conventional soil fertilization. Jeya Kumar *et al*. (2001) [10] and Shirgure *et al*. (2001) [19] also reported higher tree height, spread, trunk girth and canopy volume in fertigated trees with 100 per cent recommended dose of fertilizers in papaya and grapes, respectively.

Haneef (2012) [8] also recorded significant effect of fertigation on vegetative growth parameters with 100 per cent recommended dose of fertilizers in pomegranate. Singh *et al*. (2007) [21] who while studying the efficacy of NPK through fertigation on growth characteristics of apple cv. Red Chief reported highest vegetative growth of plants with full dose of NPK through drip irrigation. Jhakar (2010) [11] also recorded significant effect of 100 per cent recommended dose of fertilizers through fertigation on relative growth rate of shoots, plant spread and height in pomegranate. In acid lime, maximum increase in plant height, girth and canopy volume was recorded with 100 per cent recommended dose (Shirgure *et al*. 1999) [18].

Better vegetative growth characters can be explained from the fact that irrigation water and fertilizers are supplied by this method in optimum quantity and in split doses beneficial during active growth stages and applied directly at the active root zone and there by resulting in high efficiency of drip irrigation and fertigation and especially of the N fertilizer. The vegetative growth is correlated positively with the amount of nitrogen applied and also along with nitrogen; phosphorus and potassium are most indispensable of all mineral nutrients for growth and development of the plants as these are the basis of fundamental constituents of all the living matter (Shirgure *et al*., 2001) [19].

The absorbed nitrogen might have been utilized by the plant in the formation of complex substances like protein, amino acids which in turn helped to build up new tissues (Childers, 1966). The supply of nutrients in adequate doses would have increased the synthesis of IAA which in turn stimulate the cell elongation and increasing the plant height and stem girth.

It is evident from the results obtained, that the application of micronutrients had significantly influenced on various vegetative growth parameters like gain in plant height, gain in stem girth and gain in plant spread (East-West and North-South). In the present investigation, it was observed that foliar application of Zn, B and Fe significantly affected the vegetative growth parameters of pomegranate. The analysis of pooled data showed that treatment M4 (combination of Zn, Fe and B) had maximum gain in plant height (0.64 m) and stem girth (0.65 cm). Similarly the maximum East West (0.23 m) and North South (0.34 m) plant spread was observed with the treatment M_4.

This maximum increase in growth parameters might be due to the favourable influence of applied micronutrients (zinc + iron + boron) on vegetative characteristics because of their catalytic or stimulatory effect on most of the physiological and metabolic process of plants. Zinc and boron are essential components of enzymes responsible for nitrogen and carbohydrates metabolism respectively, thereby resulting into increase in uptake of nitrogen by the plant. Further, involvement of Zn in the synthesis of tryptophan which is a precursor of indole acetic acid synthesis, consequently it increased tissue growth and development. It has important role in starch metabolism, and acts as co-factor for many enzymes, affects photosynthesis reaction, nucleic acid metabolism and protein biosynthesis (Alloway, 2008). In case of boron, it increases the phenolic compounds which regulate polar auxin transport. The increased auxin activity results in increased vegetative growth characters. Iron plays an important role in the activation of chlorophyll and in the synthesis of many proteins such as different cytochrome, which participate in different functions in the plant metabolism (Al-Bamarny *et al*., 2010) [1]. The present results are supported by the finding of Ram and Bose (2000) [14] in mandarin, Ingle (2002) [9] in acid lime, Sarolia *et al*. (2007) [16] in guava, Pathak *et al*. (2011) [12] in banana Ullah *et al*. (2012) [25] in kinnow and Sohrab *et al*. (2013) [23] in pomegranate.

These finding are quite comparable to those of Banik and Sen (1997) [4] in mango, Balakrishanan (2001) [3] in guava, Saraswathy *et al*. (2004) [15] in sapota and Sohrab *et al*. (2013) [23] in pomegranate. Thus, combined application of micronutrients improved overall growth and development of plants. Singh *et al*. (2010) [22] also supported these result by reporting higher growth of papaya by application of borax (0.5%) and ZnSo4 (0.25%) and later on it was also supported by Modi *et al*. (2012) in papaya plant supplied with B (0.3%) and Zn (0.5%) exhibited better growth.

Table 1: Effect of fertigation and micronutrients on gain in plant height (m)

	2015-16	2016-17	Pooled
Fertigation			
F_1	0.51	0.53	0.52
F_2	0.64	0.66	0.65
F_3	0.73	0.78	0.76
CD (0.05)	0.03	0.06	**0.18**
Micronutrients			
M_1	0.60	0.64	0.62
M_2	0.63	0.66	0.65
M_3	0.62	0.64	0.63
M_4	0.65	0.69	0.67
CD (0.05)	0.03	0.03	**NS**
Interaction (FXM)			
$(T_1)F_1M_1$	0.48	0.50	0.49
$(T_2)F_1M_2$	0.52	0.54	0.53
$(T_3)F_1M_3$	0.50	0.52	0.51
$(T_4)F_1M_4$	0.53	0.55	0.54
$(T_5)F_2M_1$	0.61	0.65	0.63
$(T_6)F_2M_2$	0.64	0.66	0.65
$(T_7)F_2M_3$	0.63	0.64	0.64
$(T_8)F_2M_4$	0.67	0.70	0.69
$(T_9)F_3M_1$	0.71	0.77	0.74
$(T_{10})F_3M_2$	0.73	0.79	0.76
$(T_{11})F_3M_3$	0.72	0.75	0.74
$(T_{12})F_3M_4$	0.75	0.83	0.79
CD_1 (0.05)	NS	NS	**NS**
CD_2 (0.05)	NS	NS	**NS**

Table 2: Effect of fertigation and micronutrients on gain in stem girth (cm)

	2015-16	2016-17	Pooled
Fertigation			
F_1	0.50	0.52	0.51
F_2	0.60	0.63	0.61
F_3	0.70	0.73	0.72
CD (0.05)	0.05	0.05	0.18
Micronutrients			
M_1	0.59	0.61	0.60
M_2	0.61	0.64	0.63
M_3	0.58	0.59	0.58
M_4	0.63	0.66	0.65
CD (0.05)	0.03	0.03	NS
Interaction (FXM)			
(T_1) F_1M_1	0.49	0.52	0.51
$(T_2)F_1M_2$	0.51	0.53	0.53
$(T_3)F_1M_3$	0.48	0.48	0.48
$(T_4)F_1M_4$	0.54	0.55	0.54
$(T_5)F_2M_1$	0.58	0.61	0.60
$(T_6)F_2M_2$	0.61	0.63	0.62
$(T_7)F_2M_3$	0.58	0.60	0.59
$(T_8)F_2M_4$	0.63	0.67	0.65
$(T_9)F_3M_1$	0.69	0.71	0.70
$(T_{10})F_3M_2$	0.72	0.75	0.74
$(T_{11})F_3M_3$	0.68	0.70	0.69
$(T_{12})F_3M_4$	0.73	0.77	0.75
CD_1 (0.05)	NS	NS	NS
CD_2 (0.05)	NS	NS	NS

Table 3: Effect of fertigation and micronutrients on gain in plant spread (E-W) (m)

	2015-16	2016-17	Pooled
Fertigation			
F_1	0.18	0.18	0.18
F_2	0.22	0.23	0.22
F_3	0.24	0.26	0.25
CD (0.05)	0.03	0.04	0.12
Micronutrients			
M_1	0.21	0.22	0.21
M_2	0.20	0.21	0.21
M_3	0.22	0.23	0.22
M_4	0.22	0.24	0.23
CD (0.05)	0.01	0.01	NS
Interaction (FXM)			
(T_1) F_1M_1	0.17	0.18	0.18
$(T_2)F_1M_2$	0.16	0.17	0.17
$(T_3)F_1M_3$	0.18	0.19	0.19
$(T_4)F_1M_4$	0.19	0.20	0.20
$(T_5)F_2M_1$	0.21	0.22	0.22
$(T_6)F_2M_2$	0.20	0.22	0.21
$(T_7)F_2M_3$	0.22	0.23	0.23
$(T_8)F_2M_4$	0.23	0.24	0.23
$(T_9)F_3M_1$	0.24	0.26	0.25
$(T_{10})F_3M_2$	0.23	0.25	0.24
$(T_{11})F_3M_3$	0.25	0.26	0.25
$(T_{12})F_3M_4$	0.26	0.28	0.27
CD_1 (0.05)	NS	NS	NS
CD_2 (0.05)	NS	NS	NS

Table 4: Effect of fertigation and micronutrients on gain in plant spread (N-S) (m)

	2015-16	2016-17	Pooled
Fertigation			
F_1	0.25	0.27	0.26
F_2	0.31	0.33	0.32
F_3	0.34	0.36	0.35
CD (0.05)	NS	NS	NS
Micronutrients			
M_1	0.29	0.31	0.30
M_2	0.27	0.29	0.28
M_3	0.31	0.33	0.32
M_4	0.33	0.35	0.34
CD (0.05)	0.03	0.03	NS
Interaction (FXM)			
(T_1) F_1M_1	0.24	0.26	0.25
$(T_2)F_1M_2$	0.22	0.25	0.23
$(T_3)F_1M_3$	0.26	0.28	0.27
$(T_4)F_1M_4$	0.27	0.30	0.28
$(T_5)F_2M_1$	0.31	0.33	0.32
$(T_6)F_2M_2$	0.28	0.30	0.29
$(T_7)F_2M_3$	0.32	0.35	0.33
$(T_8)F_2M_4$	0.34	0.36	0.35
$(T_9)F_3M_1$	0.32	0.34	0.33
$(T_{10})F_3M_2$	0.30	0.32	0.31
$(T_{11})F_3M_3$	0.35	0.37	0.36
$(T_{12})F_3M_4$	0.38	0.41	0.40
CD_1 (0.05)	NS	NS	NS
CD_2 (0.05)	NS	NS	NS

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