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Effect of fertigation and micronutrients spray on chlorophyll content of Early Bhagwa pomegranate under semi-arid conditions of Rajasthan

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ABSTRACT

A field experiment was conducted during 2015-17 at research farm of Rajasthan Agricultural Research Institute, Durgapura, Jaipur, Rajasthan in split plot design. The experiment consisted of 12 treatment combinations with three doses of fertigation [100, 75 and 50% of recommended dose of fertilizers (RDF)] and four micronutrient sprays (M_1 to M_4). The pooled data showed that treatment F_3 exhibited maximum total chlorophyll content at vegetative, flowering and harvesting stages of 1.37, 1.30 and 1.16 mg respectively whereas the minimum values (0.87, 0.80 and 0.70 mg respectively) were recorded under application of treatment F_1. The micronutrient treatment M_4 had the maximum total chlorophyll content (1.19, 1.11 and 1.01 mg) at all stages of growth viz vegetative, flowering and harvesting respectively while treatment M_1 showed the minimum value of 1.02, 0.95 and 0.84 mg at three growth stages respectively.

Keywords: Fertigation; micronutrients; chlorophyll; pomegranate; stages

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 region (Solaheddin and Kader 1984). In addition pomegranate trees have greater adaptability to adverse climatic conditions such as drought tolerance and changing climate (Sepulveda et al 2000). The fruit is increasingly recognized as a highly beneficial fruit with a unique combination of appealing appearance, good taste and high content of healthy metabolites (Seeram et al 2006).

In India pomegranate is commercially cultivated in Maharashtra, Karnataka, Gujarat, Andhra Pradesh, Madhya Pradesh, Tamil Nadu and Rajasthan. Maharashtra is the leading state with 78 thousand hectare area with annual production of 408 thousand MT and productivity of 6 MT/ha. In Rajasthan pomegranate is commercially cultivated in Jaipur, Ajmer, Alwar, Tonk, Sriganganagar, Kota, Jodhpur, Pali, Jalore, Banswara, Sawai Madhopur, Bhilwara, Jhunjhunu and Sirohi disticts. In the state the area under pomegranate cultivation is 1.01 thousand hectares with production of 5.50 thousand MT and productivity of 5.4 MT/ha. It contributes 0.7 per cent of total production (Anon 2013).

Fertigation ensures higher fruit yield by 50-75 per cent along with saving of water and fertilizers by 40-50 per cent besides reducing soil loss up to 20 per cent under fruit-based land use systems and save time and labour which makes fertigation economically viable (Sharda 2011). Fertigation allows to adopt the amount and concentration of the applied nutrients in order to meet the actual nutritional requirement of the crop throughout the growing season.

In recent years increasing productivity coupled with quality is becoming very essential to get more returns per unit area. The farmers become aware of the value of quality production as quality fruits fetch higher price in the market. To achieve the best quality pomegranate many factors are responsible viz size,

weight, sugar content, color, flavor etc. Foliar application of different micronutrients at proper stage helps in improving fruit yield, quality and physico-chemical characteristics of pomegranate. It also helps in correcting micronutrients' deficiency. The important tools used in quality production provide balanced nutrition, control of pests and diseases and maintain the optimum crop load on the tree.

The foliar application of nutrients for quality production of fruits is becoming very popular among the pomegranate growers. 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 qualitative production of pomegranate experiment was conducted during the year 2015-16 and 2016-17.

MATERIAL and METHODS

The present investigations were conducted at the research farm of Rajasthan Agricultural Research Institute, Durgapura, Jaipur, Rajasthan. 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 per cent (F_3) of recommended dose of fertilizers (RDF) were 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. The zinc sulphate ($ZnSO_4$) containing 21 per cent Zn, boric acid (H_3BO_3) containing 17.5 per cent B and ferrous sulphate ($FeSO_4$) containing 20 per cent Fe were applied @ 0.4 per cent each.

Chlorophyll 'a', 'b' and total contents were determined in fresh leaves at three stages viz vegetative, flowering and harvesting by following the method of Yoshida et al (1971).

Chorophyll 'a'

$$=(12.7 \times \text{OD at } 663) - (2.69 \times \text{OD at } 645) \times \frac{V}{1000 \times W}$$

Chorophyll 'b'

$$=(22.9 \times \text{OD at } 645) - (4.68 \times \text{OD at } 663) \times \frac{V}{1000 \times W}$$

$$\text{Total chlorophyll} = \frac{(\text{OD at } 652) \times 1000}{34.5} \times \frac{V}{1000 \times W}$$

where OD= Optical density, V= Final volume of supernatant (25 ml) W= Weight of leaf sample taken in gram; the chlorophyll content of the samples expressed as mg/g of fresh leaf

The data were subjected to statistical analysis as per Gomez and Gomez (1984).

RESULTS and DISCUSSION

The observations on leaf chlorophyll content at vegetative, flowering and harvesting stages are presented in Tables 1 to 3. The analysis of pooled data show that total chlorophyll content was significantly affected by fertigation levels. The pooled data depict that treatment F_3 showed maximum total chlorophyll content at vegetative, flowering and harvesting stages (1.37, 1.30 and 1.16 mg respectively) whereas the minimum values (0.87, 0.80 and 0.70 mg respectively) were found under F_1.

The chlorophyll content was found to be significantly affected with the application of different micronutrients. The pooled data showed that treatment M_4 resulted in maximum total chlorophyll content (1.19, 1.11 and 1.01 mg) at vegetative, flowering and harvesting while treatment M_1 showed the minimum values of 1.02 and 0.95 mg at vegetative and flowering stages respectively. In the harvesting stage the treatments M_1 to M_3 were found at par. The interaction effect of fertigation and micronutrients was non-significant for the pooled data of total chlorophyll content at all growth stages.

The physiological attributes are closely related to yield and quality parameters. The leaf chlorophyll content which is the key factor in determining the rate of photosynthesis is also considered as an index of the metabolic efficiency of plants. This pigment responsible for harnessing solar energy and converting it into chemical energy exhibits a differential pattern in its accumulation in response to nutrients applied through fertigation. Fertigation with 100 per cent recommended NPK as water soluble fertilizers (WSF) through fertigation showed a profound influence on chlorophyll

Table 1. Effect of fertigation and micronutrients on chlorophyll content (vegetative stage) (mg/g)

Treatment	2015-16			2016-17			Pooled		
	a	b	Total	a	b	Total	a	b	Total
Fertigation (F)									
F_1	0.61	0.24	0.85	0.64	0.25	0.89	0.63	0.25	0.87
F_2	0.71	0.30	1.01	0.73	0.31	1.04	0.72	0.31	1.03
F_3	0.98	0.37	1.35	1.01	0.38	1.39	1.00	0.37	1.37
$CD_{0.05}$	0.05	0.05	0.08	0.03	0.05	0.06	0.04	0.05	0.07
Micronutrients (M)									
M_1	0.72	0.28	1.00	0.75	0.29	1.03	0.73	0.28	1.02
M_2	0.76	0.30	1.06	0.79	0.32	1.10	0.78	0.31	1.08
M_3	0.75	0.30	1.05	0.77	0.31	1.08	0.76	0.30	1.07
M_4	0.84	0.33	1.17	0.86	0.34	1.21	0.85	0.34	1.19
$CD_{0.05}$	0.04	0.03	0.05	0.03	0.03	0.04	0.03	0.03	0.04
Interaction (F x M)									
(T_1) F_1M_1	0.58	0.21	0.78	0.60	0.22	0.82	0.59	0.21	0.80
(T_2) F_1M_2	0.62	0.23	0.85	0.66	0.24	0.89	0.64	0.23	0.87
(T_3) F_1M_3	0.59	0.25	0.83	0.61	0.26	0.87	0.60	0.25	0.85
(T_4) F_1M_4	0.67	0.27	0.94	0.69	0.29	0.98	0.68	0.28	0.96
(T_5) F_2M_1	0.69	0.28	0.96	0.71	0.29	1.00	0.70	0.28	0.98
(T_6) F_2M_2	0.71	0.31	1.02	0.73	0.33	1.05	0.72	0.32	1.04
(T_7) F_2M_3	0.69	0.29	0.98	0.71	0.30	1.00	0.70	0.30	0.99
(T_8) F_2M_4	0.76	0.33	1.09	0.78	0.35	1.13	0.77	0.34	1.11
(T_9) F_3M_1	0.91	0.35	1.25	0.93	0.36	1.29	0.92	0.35	1.27
(T_{10}) F_3M_2	0.95	0.37	1.32	0.98	0.38	1.36	0.96	0.38	1.34
(T_{11}) F_3M_3	0.99	0.36	1.34	1.01	0.37	1.38	1.00	0.36	1.36
(T_{12}) F_3M_4	1.09	0.39	1.48	1.12	0.40	1.52	1.11	0.40	1.50
$CD_{0.05}$ (1)	NS	NS	NS	0.05	NS	NS	0.06	NS	NS
$CD_{0.05}$ (2)	NS	NS	NS	0.05	NS	NS	0.06	NS	NS

Table 2. Effect of fertigation and micronutrients on chlorophyll content (flowering stage) (mg/g)

Treatment	2015-16			2016-17			Pooled		
	a	b	Total	a	b	Total	a	b	Total
Fertigation (F)									
F_1	0.56	0.22	0.78	0.58	0.23	0.82	0.57	0.23	0.80
F_2	0.67	0.28	0.96	0.69	0.29	0.99	0.68	0.29	0.97
F_3	0.93	0.35	1.28	0.95	0.36	1.31	0.94	0.36	1.30
$CD_{0.05}$	0.04	0.03	0.04	0.05	0.03	0.05	0.04	0.03	0.05
Micronutrients (M)									
M_1	0.67	0.26	0.93	0.69	0.27	0.96	0.68	0.27	0.95
M_2	0.72	0.28	1.00	0.74	0.29	1.04	0.73	0.29	1.02
M_3	0.72	0.28	1.00	0.73	0.30	1.03	0.73	0.29	1.02
M_4	0.78	0.31	1.09	0.80	0.32	1.12	0.79	0.32	1.11
$CD_{0.05}$	0.02	0.03	0.03	0.02	0.03	NS	0.02	0.03	0.03
Interaction (F x M)									
(T_1) F_1M_1	0.51	0.19	0.71	0.54	0.21	0.75	0.53	0.20	0.73
(T_2) F_1M_2	0.57	0.20	0.77	0.59	0.22	0.81	0.58	0.21	0.79
(T_3) F_1M_3	0.54	0.23	0.77	0.56	0.24	0.81	0.55	0.24	0.79
(T_4) F_1M_4	0.61	0.25	0.86	0.63	0.27	0.90	0.62	0.26	0.88
(T_5) F_2M_1	0.64	0.26	0.90	0.67	0.27	0.93	0.65	0.26	0.91
(T_6) F_2M_2	0.68	0.29	0.97	0.70	0.30	1.00	0.69	0.29	0.98
(T_7) F_2M_3	0.66	0.28	0.94	0.68	0.29	0.97	0.67	0.28	0.96
(T_8) F_2M_4	0.71	0.31	1.02	0.73	0.32	1.05	0.72	0.32	1.04
(T_9) F_3M_1	0.85	0.33	1.18	0.86	0.35	1.21	0.85	0.34	1.19
(T_{10}) F_3M_2	0.92	0.35	1.27	0.94	0.36	1.30	0.93	0.36	1.29
(T_{11}) F_3M_3	0.95	0.35	1.29	0.96	0.36	1.32	0.95	0.35	1.31
(T_{12}) F_3M_4	1.01	0.37	1.39	1.04	0.39	1.42	1.02	0.38	1.40
$CD_{0.05}$ (1)	0.04	NS	NS	0.05	NS	NS	0.04	NS	NS
$CD_{0.05}$ (2)	0.05	NS	NS	0.06	NS	NS	0.06	NS	NS

Table 3. Effect of fertigation and micronutrients on chlorophyll content (harvesting stage) (mg/g)

Treatment	2015-16			2016-17			Pooled		
	a	b	Total	a	b	Total	a	b	Total
Fertigation (F)									
F_1	0.46	0.22	0.68	0.49	0.23	0.72	0.48	0.23	0.70
F_2	0.58	0.29	0.86	0.59	0.30	0.89	0.59	0.29	0.88
F_3	0.78	0.36	1.14	0.80	0.38	1.18	0.79	0.37	1.16
$CD_{0.05}$	0.03	0.03	0.05	0.03	0.03	0.03	0.03	0.03	0.04
Micronutrients (M)									
M_1	0.56	0.26	0.83	0.58	0.28	0.86	0.57	0.27	0.84
M_2	0.61	0.29	0.90	0.64	0.30	0.94	0.63	0.29	0.92
M_3	0.58	0.28	0.86	0.60	0.30	0.89	0.59	0.29	0.88
M_4	0.67	0.33	1.00	0.69	0.34	1.03	0.68	0.33	1.01
$CD_{0.05}$	0.04	0.03	0.04	0.04	0.03	0.04	0.04	0.03	0.04
Interaction (F x M)									
(T_1) F_1M_1	0.41	0.18	0.59	0.44	0.19	0.63	0.42	0.18	0.61
(T_2) F_1M_2	0.48	0.21	0.69	0.50	0.23	0.73	0.49	0.22	0.71
(T_3) F_1M_3	0.45	0.23	0.68	0.47	0.24	0.72	0.46	0.24	0.70
(T_4) F_1M_4	0.51	0.26	0.78	0.54	0.28	0.81	0.52	0.27	0.79
(T_5) F_2M_1	0.55	0.27	0.82	0.57	0.28	0.85	0.56	0.27	0.83
(T_6) F_2M_2	0.59	0.28	0.87	0.61	0.29	0.90	0.60	0.28	0.88
(T_7) F_2M_3	0.53	0.26	0.80	0.55	0.27	0.83	0.54	0.27	0.81
(T_8) F_2M_4	0.63	0.33	0.96	0.65	0.35	0.99	0.64	0.34	0.98
(T_9) F_3M_1	0.72	0.35	1.07	0.74	0.36	1.10	0.73	0.35	1.09
(T_{10}) F_3M_2	0.78	0.37	1.15	0.79	0.39	1.18	0.78	0.38	1.16
(T_{11}) F_3M_3	0.75	0.36	1.11	0.77	0.37	1.14	0.76	0.36	1.13
(T_{12}) F_3M_4	0.87	0.38	1.25	0.89	0.39	1.28	0.88	0.39	1.27
$CD_{0.05}$ (1)	NS	NS	NS	NS	NS	NS	NS	NS	NS
$CD_{0.05}$ (2)	NS	NS	NS	NS	NS	NS	NS	NS	NS

content of leaves. The concentration of chlorophyll at vegetative stage was more as compared to other stages and this increase might be due to improved vegetative growth as a result of better water absorption and uptake of nutrients which have close association with chlorophyll biosynthesis. This finding is in accordance with the reports of Dhakar et al (2010) and Karthik (2011) in mango.

Increased photosynthetic rate as a result of more absorption of available nutrients could have caused an increase in growth and photosynthetic efficiency as opined by Abdel-Nazeer and El-Shazly (2001). The phenomenon of increased chlorophyll content with increased nutrition as observed in the present study is also supported by Josefina et al (2003) in citrus and Sivakumar (2007) and Karthik (2011) in mango.

The chlorophyll content was found to be significantly affected due to different micronutrients. The increase in chlorophyll content might be due to the favourable influence of applied micronutrients (zinc + boron + iron) on vegetative characteristics because of their catalytic or stimulatory effect on most of the physiological and metabolic processes of plants. Zinc and boron are essential components of enzymes responsible for nitrogen and carbohydrate metabolism respectively thereby resulting into increase in uptake of nitrogen by the plants. Involvement of Zn in the synthesis of tryptophan is a precursor of indole acetic acid synthesis and it increases 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). Iron plays an important role in the activation of chlorophyll and in the synthesis of many proteins such as different cytochromes which participate in different functions in the plant metabolism (Al-Bamarny et al 2010).

The present results are supported by the findings of Ram and Bose (2000) in mandarin, Ingle et al (2002) in acid lime, Rathore and Chandra (2003) in ber, Cifu et al (2007) in red bayberry, Sarolia et al (2007) in guava, Pathak et al (2011) in banana and Ullah et al (2012) in kinnow.

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