Original Research Article

Influence of irrigation scheduling and Fertigation on quality of Bhagwa cultivar of pomegranate under semi-arid conditions of Rajasthan

ABSTRACT : The field experiment was conducted at Horticulture farm, Rajasthan Agricultural Research Institute, Durgapura (Jaipur-Rajasthan) during 2019-20 and 2020-21. The experiment comprised of 12 treatment combinations consisting of 3 drip irrigation levels (50%, 75% and 100% at PE level) and 4 fertigation levels (100%, 75%, 50% of recommended dose of fertilizers through drip and 100% of RDF as basal dose). The experiment was laid out in factorial Randomized Block design. The experimental results revealed that among different treatment combinations highest fruit quality characters such as TSS (B^0), TSS:Acid, reducing sugar (%), total sugar (%) and lowest value for acidity (%) and non-reducing sugar (%) of pomegranate fruit was found under treatment I_2F_3 (75% irrigation at PE level + 75 % RDF through drip).

Keywords: Irrigation, Fertigation, Pomegranate, Bhagwa, Qualitative parameters

INTRODUCTION:

Irrigation water and nutrients are the most crucial inputs which directly affect the plant vegetative growth, development, yield and quality of product. Application of irrigation water and fertilizers together through drip is the most efficient way of applying water and nutrient to the plant root zone. These inputs are efficiently harnessed by plants as these are placed near root zone of the plant. For proper water management, scheduling of water is beneficial (Tan, 1980). Scheduling of irrigation is the process which helps an irrigator to determine the timing, frequency and quantity of water that is to be applied to the crop. The main task is to estimate crop water requirement in the perspective of growth stages of plant and climate (Tan and Layne, 1981). Pomegranate needs supplemental irrigation for proper growth and for commercial cultivation of pomegranate in dry and arid region, water itself is a limiting factor (Prasad *et al*., 1997).Through fertigation both water and fertilizer can be applied more precisely, in controlled quantity and at appropriate time and frequency directly to the root zone with drip irrigation as per the crop requirements at different growth stages (Yadav *et al*., 1998). Fertigation through drip can minimize the fertilizer usage up to 25-40 per cent (Kale, 1995; Hasan *et al.*, 2007; Thakur *et al*., 2012) and increased fertilizer use efficiency (Ranghaswami *et al*., 2006).

MATERIALS AND METHODS:

The present study was conducted on five-year-old pomegranate plants *cv.* Bhagwa growing under high density planting system (3 m×3 m spacing), at the Horticulture Farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur. The experiment was conducted on 36 plants in randomized block design. The experiment comprised of 12 treatment combinations consisting of 4 fertigation levels (100%, 75%, 50% of recommended dose of fertilizers through drip and 100% of RDF as basal dose) and 3 drip irrigation levels (50%, 75% and 100% at PE level). The **"*Mrig Bahar* "** (June-July) crop had been chosen for the present experiment. Recommended dose of N,P and K used were applied @ 625, 250 and 250 g per plant respectively. Water soluble fertilizers were applied through drip irrigation system (fertigation). Amount of water soluble fertilizes were determined by calculating the amount of nitrogen, phosphorus and potassium in recommended dose. All fertilizers were applied in ten equal split doses at weekly interval (from 16 August to 30 October in both the years). Weighed quantity of water soluble fertilizers (19:19:19) along with urea as per treatment requirement were mixed in water and injected through venturi meter. Pan Evaporation method was used for estimating crop water requirement (Mane *et al*., 3).

OBSERVATIONS:

1. **TSS (^{0}Brix) :** Total soluble solids of juice was recorded with the help of "Digital Refractometer" (Brix: 0.0 to 53.0 %) by taking a drop of juice of composite sample on prism of the refractometer and observing it against the light as it works on the principle of refraction of light.
2. **Acidity (%) :** The titrable acidity of the fruit juice was determined by the method given by Ranganna, 1986. For this 10 ml of juice was titrated against 0.1N NaOH using phenolphthalein as an indicator. The percentage acidity of the juice was expressed as citric acid in grams in 100 ml of fruit juice.

0.0064 x Volume of NaOH used

$$\text{Acidity (\%)} = \frac{\qquad\qquad}{\text{Volume of sample taken}} \times 100$$

3. **TSS: Acid ratio :** From T.S.S. and acidity of fruit juice, T.S.S.: Acid ratio was worked out by dividing T.S.S.(^{0}B) by acidity(%).

4. **Sugars:**

Reducing sugar (%): The reducing sugar was estimated by DNS method (Miller, 1959).

Reagents:

(i) Dinitro salicyclic acid (DNS) reagent:

Dinitro salicyclic acid	=	1g
Crystalline phenol	=	200mg
Sodium sulphite	=	50mg
1 per cent NaOH	=	100 ml

(ii) Rochelle salt :

Na-K tartrate	=	40g
Volume	=	100 ml

(iii) Standard glucose solution: (1mg/ml)

Dissolve 100 mg glucose in 100 ml of distilled water.

(iv) Working standard solution: (100µg/ml)

10 ml standard solution make up to 100 ml with distilled water.

Estimation: Reducing sugar was estimated by using DNS reagent and Rochelle salt. Pulp (0.5ml) (100 times diluted) was added with 2.5ml D.W., 3ml DNS reagent and heated in boiling water bath, cooled and 1 ml of Rochelle salt was added. The absorbance was measured at 510 nm on spectrophotometer, model Spectronic–20. The value was plotted against a standard curve prepared from glucose. The figure was expressed on percentage basis.

Total sugar (%): Total sugar was estimated by Anthrone reagent method (Dubois *et al.,* 1951).

Reagent:

A.	Anthrone reagent	=	2 mg/ml in conc. H2SO4
B.	Standard glucose solution	=	1mg/ml

100 mg glucose was dissolved in 100 ml distilled water.

C. Working Standard Solution = 100 µg/ml

10 ml standard solution was dissolved in 100 ml distilled water.

Estimation: Total sugar content was determined by using Anthrone reagent method (Dubois *et al.,* 1951). 0.5ml of diluted pulp (100 times) was taken. 0.5 ml of diluted H2O and 4ml Anthrone reagent was put in chilled water for 5-10 times and absorbance was measured at 630 nm on Spectronic-20.

The amount of sugar present in the pulp was plotted against standard curve prepared from glucose. The content was expressed on per cent basis.

Non-reducing sugar (%): The amount of non-reducing sugar was obtained by dividing the total sugar by factor 0.95 and subtracting the reducing sugar from the resultant.

Non-reducing sugar (%) = (Total Sugar (%) × 0.95) – Reducing Sugar (%)

RESULTS:

Total Soluble Solids (^{0}Brix) :

The data on T.S.S. (^{0}B) of pomegranate as affected by drip irrigation levels, fertigation and their interaction are presented in the table. The results are presented as pooled value for both the years of experiments.

As obvious from the table that irrigation levels significantly affected the T.S.S. (^{0}B) in pomegranate. Pooled data of both the years presented showed that the maximum and minimum T.S.S. (^{0}B) (14.24 and 12.59) was found under treatments I_2 and I_1 respectively. Among fertigation levels, the maximum and minimum T.S.S. (^{0}B) (14.21 and 12.86) was found under treatments F_3 and F_4 respectively.

Interaction effect (I x F): Interaction effect of drip irrigation levels and fertigation presented in the table showed significant effect on T.S.S. (^{0}B). Based on the found data, Pooled data for both the years showed that maximum T.S.S. (^{0}B) (14.92) was recorded in the treatment I_2F_3 and minimum T.S.S. (^{0}B) (11.94) was recorded in the treatment I_1F_4.

Acidity (%) :

The data regarding acidity (%) of pomegranate as affected by drip irrigation levels and fertigation and their interaction are presented in Table 1.The data reveal that the different irrigation levels significantly affected the acidity (%), where Pooled data for both the years showed that the mean minimum (0.46 %) and mean maximum acidity (%) (0.54 %) was observed in treatment I_2 and I_1 respectively. Similarly, different fertigation levels significantly affected the acidity (%), where pooled data for both the years showed that the mean minimum (0.48 %) and mean maximum acidity (%) (0.52 %) was observed in treatment F_2 and F_4 respectively.

Interaction effect (I x F): Interaction effect of drip irrigation levels and fertigation presented in the table showed significant effect on acidity (%). Based on the found data, pooled data for both the years showed that minimum acidity (%) (0.45 %) was recorded in the treatment I_2F_2 and maximum acidity (%) (0.56) was recorded in the treatment I_1F_4.

TSS: acid ratio :

The data on TSS: acid of pomegranate as affected by drip irrigation levels, fertigation and their interaction are presented in Table 1. As obvious from the table that irrigation levels significantly affected the TSS: acid in pomegranate.. Pooled data of both the years showed that the maximum and minimum TSS: acid (30.17 and 24.23) was found under treatments I_2 and I_1 respectively. Similarly, fertigation levels significantly affected the TSS: acid in pomegranate.. Pooled data of both the years showed that the maximum and minimum TSS: acid (30.28 and 25.77) was found under treatments F_3 and F_1 respectively.

Interaction effect (I x F): Interaction effect of drip irrigation levels and fertigation presented in the table showed significant effect on TSS: acid. Based on the found data, Pooled data for both the years showed that maximum TSS: acid (32.94) was recorded in the treatment I_2F_3 and minimum TSS: acid (22.93) was recorded in the treatment I_1F_1.

Sugars (reducing sugar, non-reducing sugar, total sugar) :

Reducing sugar:

The data on reducing sugar (%) of pomegranate as affected by drip irrigation levels, fertigation and their interaction are presented in Table 1. As obvious from the table that irrigation levels significantly affected the reducing sugar (%) in pomegranate. Pooled data of both the years showed that the maximum and minimum reducing sugar (%) (8.45 and 7.24) was found under treatments I_2 and I_1 respectively. As presented in the table that fertigation levels significantly affected the reducing sugar (%) in pomegranate. Pooled data of both the years showed that the maximum and minimum reducing sugar (%) (8.36 and 7.70) was found under treatments F_3 and F_4 respectively.

Interaction effect (I x F): Interaction effect of drip irrigation levels and fertigation presented in the table showed significant effect on reducing sugar (%). Based on the pooled data for both the years the maximum reducing sugar (%) (8.81) was recorded in the treatment I_2F_3 and minimum reducing sugar (%) (6.95) was recorded in the treatment I_1F_4.

Total Sugar (%) :

The data on total sugar (%) of pomegranate as affected by drip irrigation levels, fertigation and their interaction are presented in Table 1. As obvious from the table that irrigation levels significantly affected the total sugar (%) in pomegranate. Pooled data of both the years showed that the maximum and minimum total sugar (%) (8.93 and 8.09) was found under treatments I_2 and I_1 respectively. As presented in the table that fertigation levels significantly affected the total sugar (%) in pomegranate.. Pooled data of both the years showed that the maximum and minimum total sugar (%) (8.94 and 8.30) was found under treatments F_3 and F_4 respectively.

Interaction effect (I x F): Interaction effect of drip irrigation levels and fertigation presented in the table showed significant effect on total sugar (%). Based on the found data, Pooled data for both the years showed that maximum total sugar (%) (9.26) was recorded in the treatment I_2F_3 and minimum total sugar (%) (7.79) was recorded in the treatment I_1F_4.

Non-reducing sugar (%):

The data regarding non-reducing sugar (%) of pomegranate as affected by drip irrigation levels and fertigation and their interaction are presented in Table 1. The data revealed that the different irrigation levels significantly affected the non-reducing sugar (%), where pooled data for both the years showed that the mean minimum (0.93 %) and mean maximum non-reducing sugar (%) (1.25 %) was observed in treatment I_3 and I_1 respectively. Similarly, different fertigation levels significantly affected the non-reducing sugar (%), where pooled data for both the years showed that the mean minimum (1.00 %) non-reducing sugar (%) was observed in treatment F_3 and mean maximum non-reducing sugar (%) (1.07 %) was observed in treatment F_4 which was found statistically at par with F_2.

Interaction effect (I x F): Interaction effect of drip irrigation levels and fertigation presented in the table showed significant effect on non-reducing sugar (%). Based on the found data, pooled data for both the years showed that minimum non-reducing sugar (%) (0.89 %) was recorded in the treatment I_3F_3 and maximum non-reducing sugar (%) (1.27 %) was recorded in the treatment I_1F_4 which was statistically at par with I_1F_2 treatment.

Table:1 - Effect of drip irrigation levels and fertigation on Qualitative parameters

Treatments	TSS (^{0}Brix)	Acidity (%)	TSS : acid ratio	Reducing sugar (%)	Total sugar (%)	Non-reducing sugar (%)
Irrigation Levels (I)						
I_1	12.59	0.54	24.23	7.24	8.09	1.25
I_2	14.24	0.46	30.17	8.45	8.93	0.96
I_3	13.83	0.48	28.79	8.36	8.82	0.93
SEm±	0.22	0.01	0.45	0.13	0.14	0.02
CD (5 %)	0.62	0.02	1.28	0.36	0.39	0.05
Fertigation Levels (F)						
F_1	13.37	0.51	25.77	7.92	8.51	1.05
F_2	13.79	0.48	29.05	8.11	8.72	1.07
F_3	14.21	0.48	30.28	8.36	8.94	1.00
F_4	12.86	0.52	25.84	7.70	8.30	1.07
SEm±	0.25	0.01	0.52	0.15	0.16	0.02
CD (5 %)	0.71	0.03	1.48	0.42	0.45	0.06
Interaction (IxF)						
I_1F_1	12.42	0.55	22.52	7.15	8.00	1.26
I_1F_2	12.80	0.52	25.38	7.33	8.19	1.27
I_1F_3	13.19	0.52	26.45	7.55	8.40	1.20

I_1F_4	11.94	0.56	22.58	6.95	7.79	1.27
I_2F_1	14.05	0.48	28.03	8.34	8.82	0.96
I_2F_2	14.48	0.45	31.61	8.55	9.03	0.97
I_2F_3	14.92	0.45	32.94	8.81	9.26	0.91
I_2F_4	13.51	0.48	28.11	8.11	8.60	0.97
I_3F_1	13.65	0.50	26.75	8.25	8.71	0.93
I_3F_2	14.07	0.47	30.16	8.45	8.92	0.95
I_3F_3	14.50	0.47	31.44	8.71	9.15	0.89
I_3F_4	13.13	0.50	26.83	8.02	8.49	0.95
SEm±	0.43	0.02	0.90	0.25	0.27	0.03
CD (5 %)	1.24	0.04	2.56	0.72	0.78	0.10

I1 - 50% irrigation at PE
I2 - .75% irrigation of PE
I3 - 100% irrigation of PE
F1 - 100 % RDF as basal dose plant^{-1}
F2 - 100 % RDF at weekly interval plant^{-1}
F3 - 75 % RDF at weekly interval plant^{-1}
F4 - 50 % RDF at weekly interval plant^{-1}

DISCUSSION:

It is clear from the results presented in the table obtained that irrigation and fertigation levels significantly enhanced the fruit quality parameters (,TSS, acidity, TSS: acid, sugars) of pomegranate.

The maximum TSS, TSS: acid and juice content, were recorded in plants that received higher RDF through fertigation. It might be possibly due to higher levels of fertigation maximizing the growth of the plant and facilitating the accumulation of more carbohydrates into the fruit. During subsequent fruit development, such metabolites (starch) will hydrolyse in to sugars (Hulme, 1970) which increases the TSS and decreases the acidity. The lesser TSS content under low N fertilization conditions can be elucidated by less transport of photosynthates from the leaves to the fruit. Higher qualitative attributes under fertigation might be due to the prevalence of low temperature at the time of fruit ripening, which not only prevented the excessive loss of respiratory substances but also promoted the translocation of photosynthates from leaves to the fruits (Singh and Dhaliwal, 2004). Better accumulation of metabolites improved the fruit quality of winter crop due to diversion of synthesized food materials of spring flushed crop to monsoon flushed crop (Chandra and Govind, 1995). The similar findings were observed by Ramniwas *et al.,* (2012b), Ramniwas *et al.,* (2013), Kumawat *et al.,* (2017), Mahadevan *et al.,* (2017b) in guava and Shanmugasundaram and Balakrishnamurthy (2013), Haneef *et* *al.,* (2014), Tanari *et al.,* (2019), Suman and Jain (2020), Pawar and Dingre (2020) in pomegranate.

Drip irrigation improved the fruit quality parameters by providing constant moisture regime in the soil due to which root remains active throughout the season resulting in optimum supply of nutrient and proper translocation of food which promoted the fruit growth and improved the fruit quality. Such results are also in conformity with the findings of Athani *et al*. (2005a) and Athani *et al*. (2005b) in guava *cv.* 'Sardar' , Sarolia *et al*., (2010) and Kumawat *et al*., 2017 in guava.

REFERENCES:

Athani, S.I., Prabhuraj, H.S., Ustad, A.I., Swamy, G.S.K., Patil, P.B. and Kotikal, Y.K. 2005a. Effect of organic and inorganic fertilizers on vegetative growth parameters, fruit characters, quality and yield of 'Sardar' guava. *1st International Guava Symposium*, Dec. 5-8, CISH, Lucknow, Pp. 70.

Athani, S.I., Ustad, A.I., Kotikal, Y.K., Prabhuraj. H.S. Swamy, G.S.K. and Patil, P.B. 2005b. Variation in growth parameters, fruit characters, quality and yield of 'Sardar' guava as influenced by vermicompost. *Ist International Guava Symposium*, Dec. 5-8, CISH, Lucknow, Pp. 71.

Chandra, R. and Govind, S. 1995. Influence of time and intensity of pruning on growth, yield and fruit quality of guava under high density planting. *Tropical Agriculture,* **72**: 110-113.

Dubois, M., Gilles, K., Hamilton, J. 1951. A Colorimetric Method for the Determination of Sugars. Nature. Pp :168

Haneef, M., Kaushik, R.A., Sarolia, D.K., Mordia, A. and Dhakar, M. 2014. Irrigation scheduling and fertigation in pomegranate *cv.* Bhagwa under high density planting system. *Indian Journal of Horticulture*, 71**(1)**: 45-48.

Hasan, M., Sirohi, N.P.S., Kumar, V., Sharma, M.K. and Singh, A.K. 2007.

Performance evaluation of different irrigation scheduling methods for peach through efficient fertigation system network. *VII International Symposium on Temperate Zone fruit in the Tropics and Subtropics*, *Acta Horticulture*, **662**.

Hulme, A.C. 1970. The biochemistry of fruits and their products. Academic Press, New York, Vol.**1**& **2**.

Kale, S.S. 1995. Irrigation water and N fertilizer management through drip irrigation for brinjal in Entisol. *M.Sc. (Ag.) Thesis*, Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.).

Kumawat, K.L., Sarolia, D.K., Kaushik, R.A. and Jodha, A.S. 2017. Effect of irrigation and fertigation scheduling on growth, flowering, yield and economics of guava *cv*. Lalit under ultra high density planting system. Indian Journal of Horticulture, **74**(3) : 362-368.

Mahadevan, A., Kumar, S., Swaminathan, V., Gurusamy, A. and Sivakumar T. 2017b. Effect of Crop Regulation and Fertigation on Quality Characters of Guava (*Psidium guajava*) *cv.* Sardar. *International Journal of Current Microbiology and Applied Sciences,* **6** (11): 2137-2141.

Miller, G.L. 1959. Use of Dinitrosalicylic Acid Reagent for Determination of Reducing Sugar. *Journal of Analytical Chemistry,* **31**: 426-428.

Pawar, D. D. and Dingre, S. K. 2020. Productivity, Water Use, Quality and Economics of Pomegranate Fertigation in Semiarid Conditions of India. *International Journal of Current Microbiology and Applied Sciences,* **9**(6): 2503-2510.

Prasad, R.N., Bankar, G.J. and Vaishishtha, B.B. 1997. Problems and prospects of pomegranate cultivation in arid region. *Symposium on Recent Advances in Management of Arid Ecosystems*, Jodhpur, March 3-5.

Ramniwas, Kaushik, R.A., Sarolia, D.K., Pareek, S. and Singh, V. 2012b. Effect of irrigation and fertigation scheduling on growth and yield of guava (Psidium guajava L.) under meadow orcharding. *African Journal of Agricultural*

Research, **7**(47) : 6350-6356.

Ramniwas., Kaushik, R.A., Pareek, S., Sarolia, D.K. and Singh, V. 2013. Effect of drip fertigation scheduling on fertilizer use efficiency, leaf nutrient status, yield and quality of 'Shweta' guava (*Psidium guajava* l.) under meadow orcharding. *National Academy of Science Letters*, **36**(5):483–488.

Ranganna, S. 1986. Hand Book of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw-Hill Publishing Co.New Delhi.

Sarolia, D.K., Singh, V., Kaushik, R.A., Ameta, K.D. and Pareek, S. 2010. Effect of micro irrigation on growth, yield and quality of Sardar guava under semi arid conditions of Rajasthan. Book of Abstracts, *4th Indian Horticulture Congress*, Nov. 18-21, New Delhi, pp. 158-59.

Shanmugasundaram, T. and Balakrishnamurthy, G. (2013). Effect of fertigation on flowering and yield of tissue culture pomegranate (*Punica granatum* L.) cv. Mridula grown under ultra high density planting (UHDP). *Asian Journal of Horticulture*, **8**(2) : 601-604.

Singh, A. and Dhaliwal, G.S. 2004. Influence of radiation interception and canopy temperature on fruit quality of Sardar guava at different planting distance. *Indian Journal of Horticulture,* 61: 118-121.

Suman, M. and Jain, M.C. 2020. Influence of plant growth regulators and fertigation on yield and economic feasibility of pomegranate (*Punica granatum* L.) *cv.* Sinduri under high density planting system. *Journal of Entomology and Zoology Studies*, **8**(5): 192-196.

Tan, C.S. 1980. Estimating crop evapotranspiration for irrigation scheduling. *Agriculture Canada*, **25** (4): 26-29.

Tan, C.S. and Layne, R.E.C. 1981. Application of a simplified evapotranspiration model for predicting irrigation requirements of peach. *Horticultural Science*, **16**(2): 172-173.

Tanari, N., Ramegowda, S., Thottan, A. and Girigowda, M. 2019. Effect of fertigation of primary nutrients on pomegranate (*Punica granatum* L.) fruit productivity and quality. Tropical Plant Research, **6**(3): 424–432.

Thakur, N., Sharma, Y. and Singh, S.K. 2012. Drip irrigation and fertigation in fruits crops. *Book of Abstracts, 5th Indian Horticulture Congress*, November 6-9, 2012 held at, Ludhiana. Pp. 218.

Yadav, J.S.P., Singh, A.K. and Rattan, R.K. 1998. Water and nutrient management in sustainable agriculture, *Fertilizer News*, **43**(12): 103-117.