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Effect of partial root drying technique and fertigation on leaf nutrient status of pomegranate (*Punica granatum* L.) *Cv*. Bhagwa

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Abstract
A field experiment was conducted to study the effect of partial root drying technique and fertigation on leaf nutrient status of pomegranate (*Punica granatum* L.) Cv. Bhagwa. The experiment comprising of 8 treatments, T_1: Partial root drying technique (100% water requirement) + 100% nutrition (NPK), T_2: Partial root drying technique (100% water requirement) + 75% nutrition (NPK), T_3: Partial root drying technique (75% water requirement) + 100% nutrition by fertigation with 100% RDF of NPK, T_4: Partial root drying technique (75% water requirement) + 75% nutrition by fertigation with 75% RDF of NPK, T_5: Partial root drying technique (50% water requirement) + 100% nutrition by fertigation with 100% RDF of NPK, T_6: Partial root drying technique (50% water requirement) + 75% nutrition by fertigation with 75% RDF of NPK, T_7: Control *i.e.* normal drip irrigation (100% water requirement) + 100% nutrition by fertigation with 100% RDF of NPK, T_8: Control *i.e.* normal drip irrigation on both sides of the plant (100% water requirement) + 75% nutrition by fertigation with 75% RDF of NPK. During flowering stage, the maximum nitrogen (1.95%), potassium (1.95%), calcium (2.10%) and magnesium content (0.57%) was recorded in I_2N_1 treatment. Coming to harvest stage, maximum nitrogen content (1.53%), maximum potassium of 1.40% (I4N2 treatment also). Whereas, maximum calcium (0.49%) was observed in I_2N_2 treatment.

Keywords: Pomegranate, PRD, bhagwa, soil nutrients, drought, evapotranspiration

Introduction

Material and Methods

The present investigation on the effect of partial root drying technique and fertigation on soil nutrients of pomegranate (*Punica granatum* L.) Cv. Bhagwa was carried out at pomegranate orchard at Fruit orchard, Sector 70, UHS, Bagalkot during 2019-2020 and 2020-2021. The location comes under Northern dry zone (Zone-3) of Karnataka and situated at 16. 10° N latitude and 75.42° E longitude at an altitude of 542.00 m above Mean Sea Level (MSL). The experiment was laid out in Two Factorial RCBD, first factor with four different irrigation treatment and second factor with two different fertigation treatments replicated three times comprising of 24 plots. The treatment details include**.**

Main treatments

1. **I_1:** Partial root zone irrigation technique to replenish 100% CP_E (100% water requirement)
2. **I_2:** Partial root zone irrigation technique to replenish 75% CP_E (75% water requirement)
3. **I_3:** Partial root zone irrigation technique to replenish 50% CP_E (50% water requirement)
4. **I_4:** Control *i.e.* normal drip irrigation on both sides of the plant to replenish 100% CP_E (100% water requirement)

Sub treatments

1. **N_1:** 100% nutrition by fertigation with 100% RDF of NPK (400:200:200 g /plant)
2. **N_2:** 75% nutrition by fertigation with 75% RDF of NPK (300: 150:150 g /plant)

Calculation of water requirement of the crop

Based on CPE, using FAO Penman- Monteith method (http://wwww.fao.org or https://aggiehorticulture.tamu.edu).

The index tissue identified for pomegranate plant tissue analysis *i.e.* eighth pair leaf from non-bearing shoot (Raghupathi and Bhargawa, 1998) [7] was collected from all plants in each replication separately at three stages *viz*., before pruning, flowering and at harvest of the fruit and subjected to acid digestion of leaf samples with di-acid (HNO_3: $HClO_4$-10:4) mixture on sand bath for the nutrient content in the plant sample except nitrogen. For nitrogen, acid digestion with concentrated sulfuric acid along with digestion mixture was carried out. For determining the nutrient content in the pomegranate leaf sample. A known weight (0.5 g) of powdered sample was digested with conc. H_2SO_4 in presence of digestion mixture ($CuSO_4$: K_2SO_4: Se 100:40:1). The digested sample was distilled in an alkaline environment (with a 40% NaOH solution) and the distilled ammonia was trapped in boric acid. The ammonia in the boric acid was titrated against 0.1 N H_2SO_4 for nitrogen measurement (Piper, 1966) [5]. The amount of phosphorus in the leaf sample was calculated using the phospho-vanado-molybdate technique. Using a spectrophotometer, the intensity of yellow colour was measured at 430 nm. The phosphorus content was calculated using the P standard curve as a guide (Piper, 1966) [5]. The di-acid digested sample was fed to flame photometer directly, with proper dilution if it is required. The reading was used along with the standard curve to estimate potassium content in the plant sample (Piper, 1966) [5]. The complexometric titration method was used to determine the Ca and Mg content of the plant sample. Calcium and magnesium (Ca +, Mg+) concentrations were assessed using an EDTA titration at pH 10.00 in the presence of an EBT indicator. Calcium was determined by EDTA titration with NaOH solution at pH 12.00 in the presence of Patton and Reader indicators (Jackson, 1973) [4].

Results and Discussion

The interpretation of pooled mean values pointed out that among the irrigation treatments, the maximum nitrogen content in leaves was recorded in I_2 treatment (PRD_{75}) followed by I_1 (PRD_{100} treatment). Whereas, minimum nitrogen content in leaves was observed in I_3 (PRD_{50}) treatment during before pruning and at flowering stage (Table 1). The increased nitrogen content in PRD_{75} and PRD_{100} irrigation treatments could be attributed to Birch effect due to alternate wetting and drying of rootzone by improving microbial and enzymatic activity of soil enables faster conversion of complex into simpler form to be ready for uptake, similar results were revealed by earlier works of Wang *et al.* (2010) [9] in tomato. Among the fertigation treatments, N_1 (RDF_{100}) recorded significantly maximum nitrogen content in leaves during both the years. The relatively higher amounts of inorganic N application in this treatment might have triggered higher accumulation in succulent levels at early stages of crop growth, and its owing to higher availability of N in soil (Sheikh and Rao, 2005) [6].

During harvest stage, significantly maximum nitrogen content in leaves was recorded in I_3 treatment (PRD_{50}) followed by I_4 treatment (CDI_{100}). Whereas, minimum nitrogen content in leaves was observed in I_2 treatment (PRD_{75}). The decreased nitrogen content in PRD_{75} and PRD_{100} irrigation treatments could be attributed to Birch effect due to alternate wetting and drying of rootzone by improving microbial and enzymatic activity of soil and greater increase in volume of root system with higher activity of feeder roots, which enables faster uptake and absorption of nutrients from plants resulted in decreased quantity of nutrients. Similar results were revealed by earlier works of Dry *et al.* (2000) [1] in grape, Songsri *et al*, (2008) [8] in peanut, and Wang *et al.* (2010) [9] in tomato. In fertigation, again N_2 recorded higher leaves nitrogen content than that of N_2. This decreased nitrogen content during harvest stage than that during vegetative growth attributed to utilisation of nitrogen by fruits for its growth with the advancement of crop growth resulted in reduction in leaf N concentration.

Before pruning and at flowering stage, among four different irrigation treatments, the highest phosphorous content in leaves was recorded in I_2 treatment (PRD_{75}) followed by I_1 treatment (PRD_{100}). Whereas, minimum phosphorous content in leaves was observed in I_3 treatment (PRD_{50}) at flowering stage (Table. 2). The increased quantity of phosphorous content in mild and even zero water stress treatment in PRD irrigation regime might be due to enlarged root system due to negative effect of PRD irrigation on excess shoot growth and diversion of carbohydrates into root growth. Further, phosphorous is having higher fixation property under drought condition resulted in lesser conversion from complex form to simpler form leads to lesser mobilization in soil and plant system. Among the fertigation treatments, N_1 (RDF_{100}) recorded significantly maximum phosphorous content during both the years, this higher amount of P in this treatment could be attributed to application of higher RDP as basal dose during bahar initiation might have resulted in higher availability in soil and there upon accumulation of P in succulent leaf (Greeshma, 2016) [2]. During harvest stage, significantly maximum phosphorous content in leaves was recorded in I_4 treatment (CDI_{100}) followed by I_3 treatment (PRD_{50}). Whereas, minimum phosphorous content in leaves was observed in I_2 treatment (PRD_{75}). The decreased phosphorous content in PRD_{75} and PRD_{100} irrigation treatments could be attributed to Birch effect due to alternate wetting and drying of rootzone by improving microbial and enzymatic activity of soil and greater increase in volume of root system with higher activity of feeder roots. In fertigation, N_2 recorded higher phosphorous content in leaves. With the advancement of crop growth, the P content decreased recording lowest per cent after the harvest of crop. This may be attributed to decreased P content in soil due to precipitation of P with Ca to insoluble form (Wasterman and Leytem, 2003) [10].

Table 1: Nitrogen content (%) of leaves at flowering and harvest stages as influenced by different irrigation and fertigation in pomegranate *cv.* Bhagwa

Irrigation (I)	Before bahar treatment stage			At flowering stage			At harvest stage		
	Pooled			Pooled			Pooled		
	N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
I_1	1.90	1.87	1.88	1.88	1.86	1.87	1.42	1.46	1.44
I_2	1.92	1.90	1.91	1.95	1.91	1.93	1.31	1.39	1.35
I_3	1.88	1.86	1.86	1.82	1.77	1.79	1.51	1.53	1.52
I_4	1.88	1.85	1.86	1.85	1.83	1.84	1.46	1.51	1.48
Mean	1.89	1.86		1.87	1.84		1.42	1.47	
For comparing means of	S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%	
Irrigation (I)	0.010	NS		0.005	0.010		0.005	0.010	
Nutrients (N)	0.006	NS		0.007	0.020		0.007	0.020	
Irrigation (I) x Nutriments (N)	0.010	0.04		0.010	0.030		0.010	0.030	

PRD: Partial root drying, Factor-II: Two different levels of fertigation
CI- Conventional (Normal two side irrigation), N_1- RDF $_{100}$
Factor-1: Four different levels of irrigation (PRD and conventional) N_2- RDF $_{75}$ I_1 -PRD $_{100}$, I_2 – PRD_{75} I_3 – PRD_{50} I_4- Conventional $_{100}$
NS- Non-Significant

Table 2: Phosphorous content of leaves (%) at flowering and harvest stages as influenced different irrigation and fertigation in pomegranate *cv.* Bhagwa

Irrigation (I)	Before bahar treatment stage			At flowering stage			At harvest stage		
	Pooled			Pooled			Pooled		
	N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
I_1	0.36	0.33	0.34	0.37	0.32	0.34	0.18	0.18	0.18
I_2	0.36	0.35	0.35	0.38	0.35	0.36	0.15	0.16	0.15
I_3	0.31	0.31	0.31	0.28	0.27	0.27	0.20	0.21	0.21
I_4	0.34	0.33	0.33	0.34	0.30	0.32	0.25	0.27	0.26
Mean	0.34	0.33		0.34	0.31		0.19	0.20	
For comparing means of	S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%	
Irrigation (I)	0.004	0.014		0.004	0.010		0.003	0.008	
Nutrients (N)	0.003	0.010		0.005	0.010		0.004	0.012	
Irrigation (I) x Nutriments (N)	0.006	0.020		0.008	NS		0.006	0.017	

PRD: Partial root drying, Factor-II: Two different levels of fertigation
CI- Conventional (Normal two side irrigation) N_1- RDF $_{100}$
Factor-1: Four different levels of irrigation (PRD and conventional) N_2- RDF $_{75}$
I_1 -PRD $_{100}$ I_2 – PRD_{75} I_3 – PRD_{50} I_4- Conventional $_{100}$
NS- Non-Significant

Before pruning and at flowering period of experiment, among four different irrigation treatments, potassium content in leaves was recorded maximum in I_2 treatment (PRD_{75}) followed by I_1 treatment (PRD_{100}). Whereas, minimum potassium content in leaves was recorded in I_3 treatment (PRD_{50}) (Table. 3). The increased quantity of potassium content in mild and even zero water stress treatment in PRD irrigation regime might be due to enlarged root system due to negative effect of PRD irrigation on excess shoot growth and diversion of carbohydrates into root growth as well due to birch effect. Among the fertigation treatments, maximum potassium content in leaves was noticed in N_1 (RDF_{100} treatment). Highest potassium content in leaf was observed in 100 fertigation treatment at flowering stage, owing to higher availability of K in soil due to high amount of basal soil application. In harvesting stage, potassium content in leaves slightly decreased than that of flowering stage. Among four different irrigation treatments, potassium content in leaves was found maximum in I_3 treatment (PRD_{50}) followed by I_4 treatment CDI_{100}. Whereas, minimum leaves potassium content was observed in I_2 treatment (PRD_{75}). The decreased potassium content in PRD_{75} and PRD_{100} irrigation treatments could be attributed to Birch effect due to alternate wetting and drying of rootzone by improving microbial and enzymatic activity of soil and greater increase in volume of root system with higher activity of feeder roots enhances higher uptake of K from soil to plants system, and its utilization from growing fruits resulted in decreased quantity of potassium in leaves. These results are opined by earlier worker revealed by Guimera *et al.*, (1995) [3] in strawberry. Between two different fertigation treatments, leaves potassium content was recorded maximum in N_2 (RDF_{75}) treatment and it might be due to antagonistic effect of other mineral nutrients like calcium resulted in reduced uptake and translocation in plants indicate their deficiency in the crop however, the visual symptoms were not seen on the leaves as revealed by earlier workers of Raghupathi and Bhargawa (1998_b) [7] in pomegranate.

Table 3: Potassium content of leaves (%) at flowering and harvest stages as influenced by different irrigation and fertigation in pomegranate *cv.* Bhagwa

Irrigation (I)	Before bahar treatment stage			At flowering stage			At harvest stage		
	Pooled			Pooled			Pooled		
	N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
I_1	1.91	1.88	1.90	1.91	1.88	1.89	1.32	1.35	1.34
I_2	1.91	1.90	1.90	1.95	1.92	1.93	1.26	1.31	1.28
I_3	1.84	1.83	1.84	1.82	1.78	1.80	1.36	1.40	1.40
I_4	1.86	1.86	1.86	1.86	1.84	1.85	1.33	1.40	1.38
Mean	1.88	1.87		1.88	1.85				
For comparing means of	S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%	
Irrigation (I)	0.004	0.010		0.004	0.010		0.0042	0.0122	
Nutrients (N)	0.003	NS		0.006	0.020		0.0060	0.0172	
Irrigation (I) x Nutriments (N)	0.006	0.010		0.009	0.020		0.0084	0.0243	

PRD: Partial root drying
CI- Conventional (Normal two side irrigation)
Factor-1: Four different levels of irrigation (PRD and conventional)
I_1 -PRD $_{100}$ I_2 – PRD_{75} I_3 – PRD_{50} I_4- Conventional $_{100}$
NS- Non Significant
Factor-II: Two different levels of fertigation
N_1- RDF $_{100}$
N_2- RDF $_{75}$

Before pruning and at flowering stage, among four different irrigation treatments, calcium content in the leaves was recorded maximum in I_2 treatment (PRD_{75}) followed by I_1 treatment (PRD_{100}). Whereas, minimum calcium content in leaves was observed in I_3 treatment (PRD_{50}) (Table. 4). The increased quantity of calcium content in mild and even zero water stress treatment in PRD irrigation regime might be due to Birch effect due to alternate wetting and drying of rootzone by improving microbial and enzymatic activity of soil and greater root volume of roots with enhanced activity of feeder roots enables faster conversion of complex into simpler form to be ready for uptake. Among the fertigation treatments, maximum calcium content in leaves was noticed in N_1 (RDF_{100} treatment) than that of N_2 but did not varied significantly.

In harvesting stage, among four different irrigation treatments, the maximum calcium content in leaves was recorded in I_3 treatment (PRD_{50}) followed by I_4 treatment (CDI_{100}). Whereas, minimum calcium content in leaves was observed in I_2 treatment (PRD_{75}). The decreased calcium content in PRD_{75} and PRD_{100} irrigation treatments could be attributed to Birch effect due to alternate wetting and drying of rootzone by improving microbial and enzymatic activity of soil and greater increase in volume of root system with higher activity of feeder roots enhances higher uptake and absorption of Ca from soil to plants system resulted in decreased quantity of potassium in soil. These results are in agreement with those revealed by earlier workers of Dry *et al.* (2000) [1] in grape with respect fertigation treatments, slightly maximum calcium content in leaves was observed in N_1 treatment (RDF_{100}).

Table 4: Calcium content (%) of leaves at flowering and harvest stages as influenced by different irrigation and fertigation in pomegranate *cv.* Bhagwa

Irrigation (I)	Before bahar treatment stage			At flowering stage			At harvest stage		
	Pooled			Pooled			Pooled		
	N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
I_1	2.02	2.01	2.02	1.29	1.26	1.27	2.02	2.00	2.01
I_2	2.08	2.02	2.05	1.22	1.19	1.20	2.10	2.03	2.06
I_3	1.98	1.95	1.96	1.41	1.39	1.40	1.92	1.90	1.91
I_4	2.00	2.00	2.00	1.37	1.34	1.35	1.98	1.98	1.98
Mean	2.00	2.00		1.32	1.29		2.01	1.97	
For comparing means of	S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%	
Irrigation (I)	0.006	0.018		0.002	0.007		0.005	0.015	
Nutrients (N)	0.004	NS		0.003	0.010		0.007	0.021	
Irrigation (I) x Nutriments (N)	0.008	0.026		0.004	0.014		0.010	0.030	

PRD: Partial root drying
CI- Conventional (Normal two side irrigation)
Factor-1: Four different levels of irrigation (PRD and conventional)
I_1 -PRD $_{100}$ I_2 – PRD_{75} I_3 – PRD_{50} I_4- Conventional $_{100}$
NS- Non-Significant
Factor-II: Two different levels of fertigation
N_1- RDF $_{100}$
N_2- RDF $_{75}$

Table 5: Magnesium content of leaves (%) at flowering and harvest stages as influenced by different irrigation and fertigation in pomegranate *cv*. Bhagwa

Irrigation (I)	Before bahar treatment stage			At flowering stage			At harvest stage		
	Pooled			Pooled			Pooled		
	N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
I_1	0.51	0.50	0.50	0.55	0.53	0.54	0.48	0.47	0.48
I_2	0.53	0.53	0.53	0.57	0.55	0.56	0.48	0.49	0.48
I_3	0.49	0.49	0.49	0.48	0.46	0.47	0.44	0.43	0.43
I_4	0.50	0.48	0.49	0.52	0.50	0.51	0.47	0.45	0.46

Mean	0.50	0.50	0.53	0.51	0.47	0.46
For comparing means of	S.Em. ±	C.D. at 5%	S.Em. ±	C.D. at 5%	S.Em. ±	C.D. at 5%
Irrigation (I)	0.005	0.016	0.021	0.003	0.003	0.009
Nutrients (N)	0.004	NS	0.015	0.004	0.004	0.013
Irrigation (I) x Nutrients (N)	0.007	0.023	NS	0.006	0.006	0.018

PRD: Partial root drying Factor-II: Two different levels of fertigation
CI- Conventional (Normal two side irrigation) N_1- RDF $_{100}$
Factor-1: Four different levels of irrigation (PRD and conventional) N_2- RDF $_{75}$
I_1 -PRD $_{100}$ I_2 – PRD_{75} I_3 – PRD_{50} I_4- Conventional $_{100}$
NS- Non Significant

Before pruning and at flowering stage, among four different irrigation treatments, the highest magnesium content in leaves was recorded in I_2 treatment (PRD_{75}) followed by I_1 treatment (PRD_{100}). Whereas, lower magnesium content in leaves was observed in I_3 treatment (PRD_{50}) at flowering stage (Table. 5). The increased quantity of magnesium content in mild and even zero water stress treatment in PRD irrigation regime might be due to Birch effect due to alternate wetting and drying of rootzone by improving microbial and enzymatic activity of soil and greater root volume of roots with enhanced activity of feeder roots enables faster conversion of complex into simpler form to be ready for uptake. Among the fertigation treatments, N_1 (RDF_{100}) recorded significantly maximum magnesium content in leaves during both years of experimentation. The better growth of the plant with higher chlorophyll might have triggered higher uptake of nutrients especially Mg from the soil and there by their accumulation in plant. However, the leaf concentration was found to be in optimum range as revealed by earlier workers of Raghupathi and Bhargava. (1998_b) [7].

During harvest stage, similar trend has observed with significantly maximum magnesium content in leaves was recorded in both I_1 treatment (PRD_{100}) and I_2 treatment (PRD_{75}) whereas, minimum magnesium content in leaves was observed in I_3 treatment (PRD_{50}). The decreased magnesium content in PRD_{75} and PRD_{100} irrigation treatments could be attributed to Birch effect due to alternate wetting and drying of rootzone by improving microbial and enzymatic activity of soil and greater increase in volume of root system with higher activity of feeder roots enhances higher uptake of Mg from soil to plants system resulted in decreased quantity of potassium in soil. These results are in agreement with those revealed by earlier workers of Dry *et al.* (2000) [1] in grape. In fertigation, again N_1 recorded higher magnesium content in leaves.

Conclusion

The maximum nitrogen content in leaves (1.93%), phosphorous (0.36%), potassium (1.93%), calcium (2.06%) and magnesium content in leaves (0.56%) was recorded in I_2 treatment (PRD_{75}). During harvest stage, significantly maximum nitrogen content in leaves (1.52%), potassium (1.40%) and calcium (1.40%) was recorded in I_3 treatment (PRD_{50}). While with respect to calcium content during harvest stage, significantly maximum values (0.26%) was recorded in I_4 treatment (CDI_{100}) and maximum magnesium content in leaves (0.48%) was recorded in both I_1 treatment (PRD_{100}) and I_2 treatment (PRD_{75}).

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