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Effect of partial root drying technique and fertigation on soil 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 soil nutrients 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. Among the interaction effect between irrigation and fertigation levels during flowering stage, maximum soil nitrogen content was noticed in I_2N_1 treatment (284.17 kg ha^{-1}) followed by I_1N_1 treatment (282.39 kg ha^{-1}). Whereas, minimum soil nitrogen content was noticed in I_3N_2 treatment (276.20 kg ha^{-1}). In harvest stage, the maximum soil nitrogen content was observed in I_3N_1 treatment (219.75 kg ha^{-1}) followed by I_3N_2 treatment (218.88 kg ha^{-1}). Whereas, minimum soil nitrogen content was noticed in I_2N_2 treatment (206.75 kg ha^{-1}).

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

Introduction

Pomegranate (*Punica granatum* L.) is an important fruit crop growing in dry subtropical and arid regions owing to its hardiness and ability to withstand adverse soil and climatic conditions. It belongs to the family Lythraceae and is considered to be originated in South-west Asia, probably from Iran with chromosome number of 2n = 16 and 18 (Smith, 1976) [11]. It is one of the popular commercial fruits preferred by the consumers throughout the world for its sweet- acidic taste, outstanding dessert quality and excellent blend. The fruit is also popular due to the organoleptic characteristics of the arils i.e. the seeds, nutritional and therapeutic benefits for treating cancer, indigestion and leprosy cure (Sonawane, 2017) [6]. Currently in India, pomegranate is cultivating in an area of 2.62 lakh ha with a production of 30.34 lakh MT. Maharashtra is the leading producer of pomegranate followed by Karnataka, Andhra Pradesh, Gujarat and Tamil Nadu (Anon., 2021) [12]. Commercially, pomegranate is irrigated through drip irrigation, which is a most efficient irrigation method supplies water to the plants equivalent to its consumptive use but pomegranate being a highly drought tolerant crop which is a boon for pomegranate growers to save further more water by adopting novel irrigation technology like partial root drying technique, a sustainable crop specific water saving irrigation techniques without detrimental effect on yield and quality of the fruits. It is novel technique of irrigation which involves giving irrigation at only half side of the plant root, keep the soil wet and other part of the root dry, and in this way one part of root absorb water and other remain dry for the next irrigation time. Under sub-tropical climatic conditions, pomegranate bears heavily which can exhaust the plant and essential nutrient elements in soil, needed for proper growth and development. Fertigation is a method of fertilizer application in which water soluble solid/ liquid fertilizers is given to the plants through drip irrigation. It is the most adopted fertilizer application method for their easiness, effective and convenience to maintain optimum fertility level and water supply according to the specific requirement to nourish the crop sufficiently to enhance the growth and productivity without adverse effect on environment.

Fertigation enhances nutrient use efficiency besides saving Labour cost for external application, ensuring nutrient as well as water use efficiency by increasing root mass ability to trap and hold water and nutrients. Further, it allows precise and accurate placement of nutrient at critical crop growth stages.

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).
3. 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 soil samples were collected from 0-30 cm depth and 30 cm distance away from the emitter using post hole auger at three stages *viz*., before pruning, flowering and at harvest of the fruit. Available nitrogen content in soil was estimated by alkaline permanganate method developed by Subbaih and Asija (1956) [8]. Olsen's extractant (0.5 M $NaHCO_3$) was used to extract available phosphorus in soil at a ratio of 1:10 soil to extractant using a spectrophotometer. The available potassium content in soil was assessed by extracting with neutral normal ammonium acetate (pH 7.0) at a ratio of 1:5 soil to extractant, then measuring the potassium in the extract with a flame photometer (Jackson, 1973) [5]. Exchangeable Ca and Mg were extracted with neutral normal ammonium acetate (pH 7.0) at 1:5 soil to extractant ratio and determined by versanate titration method (Jackson, 1973) [5]. Experimental data collected was subjected to statistical analysis by adopting Fisher's method of Analysis of Variance (ANOVA) as outlined in Gomez and Gomez (1984) [13]. Critical Difference (CD) values were calculated whenever the "F" test was significant at 5 per cent level.

Results and Discussion

There was a considerable difference, according to the results analysis with respect to soil all soil nutrient content among the irrigation treatments and interaction effects as recorded during both the years of experimentation but fertigation treatments showed non-significant difference during the period of flowering whereas during the harvesting period it showed significant difference in both the year of experimentation (Table 1). Before pruning and at flowering period of both the year of experimentation, among the 4 different irrigation treatment the maximum soil nitrogen content was noticed in I_2 treatment (PRD_{75}) which was on par with I_1 (PRD_{100}) treatment. While the minimum soil nitrogen content was observed in I_3 (PRD_{50}) treatment. 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 root zone 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. During harvest stage, significantly maximum soil nitrogen content was recorded in I_3 treatment (PRD_{50}) followed by I_4 treatment (CDI_{100}). Whereas, minimum soil nitrogen content was observed in I_2 treatment ($PRD7_5$). 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 root zone 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 of nutrients from soil resulted in decreased quantity of nutrients. Similar results were revealed by earlier works of Dry *et al.* (2000) [2] in grape, Songsri *et al*, (2008) [7] in peanut, and Wang *et al.* (2010) [9] in tomato. In fertigation, again N_1 recorded maximum nitrogen content.

With respect to soil phosphorous Before pruning and at flowering stage, among four different irrigation treatments, the highest soil phosphorous content was recorded in I_2 treatment (PRD_{75}) followed by I_1 treatment PRD_{100}. Whereas, minimum soil phosphorous content was observed in I_3 treatment (PRD_{50}) (Table. 2). This results of increased P in higher irrigation levels are in agreement with earlier workers of those revealed by Guimera *et al.* (1995) [3] in strawberry, and Dodd *et al*. (2015) [1] 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. 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. Further, lesser fixation of P under higher soil moisture condition results in higher solubilization and uptake of P from soil to plants system as a result of which there is a decreased quantity of phosphorous in soil. These results are opined by earlier workers of those revealed by Hussen *et al.* (2019) [4] in Mung Bean, Xu *et al.* (2004) [10] in Lettuce and

Songsri *et al.* (2008) [7] in Maize. In fertigation, again N_1 recorded higher soil phosphorous content.

Before pruning and flowering stage, among four different irrigation treatments, the highest soil potassium content (246.04 kg ha^{-1}) was recorded in I_2 treatment (PRD_{75}) followed by I_1 treatment PRD_{100}. Whereas, minimum soil potassium content was observed in I_3 treatment (PRD_{50}) at flowering stage (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, N_1 (RDF_{100}) recorded significantly maximum soil potassium content during both the years. During harvest stage, significantly maximum soil potassium content was recorded in I_3 treatment (PRD_{50}) followed by I_4 (CDI_{100}) treatment. Whereas, minimum soil 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 resulted in decreased quantity of potassium in soil. These results are opined by earlier workers of those revealed by Guimera *et al.*, (1995) [3] in strawberry. In fertigation, again N_1 recorded higher soil potassium content.

Coming to soil calcium content, before pruning and at flowering stage, among four different irrigation treatments, significantly maximum soil calcium content was recorded in I_2 treatment (PRD_{75}) which is on par with I_3 treatment. Whereas, minimum soil calcium content was observed in I_1 treatment (PRD_{100}) and I_4 treatment (CDI_{100}) (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, soil calcium content was statistically found maximum in N_1 treatment (RDF_{100}). During harvesting stage, maximum soil calcium content was recorded in I_3 treatment (PRD_{50}) which was on par with I_4 treatment CDI_{100}. Whereas, minimum soil calcium content 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 root zone 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 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) [2] in grape. Among the fertigation treatments, soil calcium content was statistically found maximum in N_2 treatment (RDF_{75}).

Before pruning and at flowering stage, among the four different irrigation treatments considerably maximum soil magnesium content was recorded in I_1 treatment (PRD_{100}) followed by I_2 treatment (PRD_{75}). However, minimum soil magnesium content was noticed in I_3 treatment (PRD_{50}) (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, soil magnesium content was statistically found maximum in N_1 treatment (RDF_{100}). In the harvesting stage, maximum soil magnesium content was observed in I_3 treatment (PRD_{50}) followed by I_4 treatment. While, minimum soil magnesium content was recorded in I_1 treatment (PRD_{100}), 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) [2] in grape. Whereas, fertigation treatment didn't show any significant difference with respect to soil magnesium content.

Table 1: Soil available nitrogen content (kg ha^{-1}) 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	282.39	280.71	281.55	264.33	261.83	263.08	210.15	208.50	209.33
I_2	284.17	283.00	283.58	263.57	264.16	263.87	208.04	206.75	207.40
I_3	278.65	276.20	277.42	262.16	260.50	261.33	219.75	218.88	219.32
I_4	280.29	278.88	279.58	262.66	260.50	261.58	214.75	210.97	212.86
Mean	281.37	279.70		263.18	261.75		213.17	211.28	
For comparing means of	S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%	
Irrigation (I)	0.68	1.97		0.89	2.69		0.64	1.87	
Nutrients (N)	0.96	NS		0.63	1.90		0.91	1.89	
Irrigation (I) x Nutriments (N)	1.36	3.95		1.27	3.81		1.29	3.75	

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 2: Soil available phosphorous content (kg ha^{-1}) 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	60.57	58.52	59.54	55.16	54.83	55.00	48.01	44.47	46.24
I_2	65.00	62.91	63.95	56.50	55.16	55.83	43.90	41.25	42.58
I_3	55.99	55.02	55.50	52.83	52.61	52.72	55.25	52.23	53.74
I_4	58.42	57.92	58.17	52.50	52.97	52.73	53.49	50.18	51.83
Mean	59.99	58.59		54.25	53.89		50.16	47.03	
For comparing means of	S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%	
Irrigation (I)	0.37	1.09		0.36	1.03		0.40	1.16	
Nutrients (N)	0.53	NS		0.24	0.73		0.56	1.64	
Irrigation (I) x Nutriments (N)	0.75	2.18		0.48	1.46		0.80	2.32	

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 3: Soil available potassium content (kg ha^{-1}) 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	240.72	238.36	239.54	229.66	230.58	229.66	211.62	208.46	210.04
I_2	247.42	244.66	246.04	233.41	233.62	233.41	202.39	199.15	200.77
I_3	230.66	229.51	230.08	225.66	226.08	225.66	225.25	221.90	223.57
I_4	234.42	231.66	233.04	225.50	227.00	225.50	217.20	213.63	215.42
Mean	238.30	236.05		228.56		228.56	214.11	210.78	
For comparing means of	S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%	
Irrigation (I)	0.22	0.64		0.17	0.53		0.17	0.50	
Nutrients (N)	0.31	0.91		0.12	0.38		0.24	0.71	
Irrigation (I) x Nutriments (N)	0.44	1.29		0.25	0.75		0.34	1.00	

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 4: Soil exchangeable calcium content (C mol (p+) kg^{-1}) 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	9.36	9.33	9.34	9.41	9.35	9.38	8.39	8.41	8.40
I_2	9.52	9.47	9.50	9.43	9.51	9.47	8.27	8.31	8.29
I_3	9.51	9.45	9.48	9.50	9.37	9.43	8.53	8.59	8.56
I_4	9.37	9.32	9.34	9.29	9.29	9.29	8.48	8.52	8.50
Mean	9.44	9.39		9.41	9.38		8.42	8.46	
For comparing means of	S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%		S.Em. ±	C.D. at 5%	
Irrigation (I)	0.01	0.02		0.02	0.07		0.05	0.14	
Nutrients (N)	0.01	0.04		0.01	0.05		0.07	0.21	
Irrigation (I) x Nutriments (N)	0.02	0.05		0.03	0.11		0.10	0.29	

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		0.003	0.009		0.003	0.009	
Nutrients (N)	0.004	NS		0.004	0.013		0.004	0.013	
Irrigation (I) x Nutriments (N)	0.007	0.023		0.006	0.019		0.006	0.018	

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 $_{75}$

Conclusion

The present study reveals that among the 4 different irrigation treatments at pruning and flowering period, maximum soil nutrients was noticed in I_2 treatment (PRD$_{75}$) which was on par with I_1 (PRD$_{100}$) treatment. While the minimum soil nitrogen content was observed in I_3 (PRD$_{50}$) treatment. In the harvesting stage, maximum soil nutrients content was observed in I_3 treatment (PRD$_{50}$) followed by I_4 treatment. While, minimum soil nutrient content was recorded in I_1 treatment (PRD$_{100}$). Among fertigation treatments, N_1 (RDF$_{100}$) recorded higher soil potassium content than N_2 treatment RDF$_{75}$).

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