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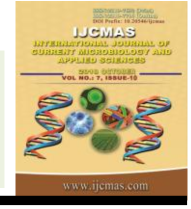

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Effect of Drip Fertigation Levels on Fruit Quality Characters of Aonla (*Emblica officinalis* Gaertn.) cv. NA-7

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A B S T R A C T

Investigations were undertaken to study the influence of drip fertigation levels on fruit quality characters in aonla was carried out during 2011 to 2013. The experiment was laid out in randomized block design with eight treatments of fertigation levels, namely 75, 100 and 125% recommended dose of water soluble fertilizers including, soil application (control) and replicated three times, to test various fruit quality attributes of 8 years aonla cv. NA.7 grown under drip fertigation. The investigation indicated that 125 % recommended dose of water soluble fertilizers (T_8) applied through fertigation resulted in maximum fruit quality characters viz., TSS (13.1^0 Brix and 13.6 ^{0} Brix), Acidity (2.10 % and 2.15%), Ascorbic acid (575.8mg gand 580.6mg g), Reducing sugar (2.70 % and 3.10 %), Non-Reducing sugar (1.60% and 1.85 %) and Total sugar (4.30% and 4.95%) during 2011-2012 and 2012-2013 respectively. Therefore (T_8) 125 % recommended doses of NPK in the form of water soluble fertilizers can be suggested for increasing the yield of eight years old aonla cv. NA.7 significantly.

Introduction

Aonla (*Emblica officinalis* L. Gaertn) is an important indigenous emerging fruit crop owing to its hardiness and ability to withstand adverse soil and climatic conditions and belongs to the family Euphorbiceae subfamily Phyllanthoideae (Arun *et al.*, 2009). It is originated in tropical South East Asia particularly South India (Virendra Singh *et al.*, 2009). It is being cultivated since ancient times in India. The fruit is highly nutritive for human consumption. It is the richest source of vitamin C (600-1300 mg/100g) among the fruits next to Barbados cherry and also useful for general improvement of health and medicinal purpose (Ram Kumar *et al.*, 2011). Aonla is mainly cultivated in Mayanmar, Bangladesh, Sri Lanka Iran and Iraq. India ranks first in the world in aonla area and production. The area under aonla cultivation in India is about 77,000 hectares with an annual production 8, 26,000 tonnes (Anon, 2011). Since the natural ground water potential is diminishing, many farmers in India have opted drip irrigation. Through drip irrigation, fertigation is easier with high nutrient use efficiency, saving in labour, less weed infestation besides enhancing the productivity (Thiyagarajan, 2006).

Aonla responds to applied fertilizers to meet its nutrient requirements. Through fertigation methods, nutrients are added to the soil in adequate doses and interval through which qualitative improvement of produce can also be attained to a larger extent. Production of quality fruits in aonla will enable the farmers to earn more income. In Tamil Nadu, a dose of 200:500:200 g NPK tree^{-1}year^{-1} is generally recommended (TNAU) for aonla.

This study was aimed to evaluate the fertigation system involving drip irrigation methods; various levels of fertilizers with a comparison on the farmers practice (surface irrigation + soil application of RDF) on leaf NPK and yield per tree of aonla

Materials and Methods

A field experiment was conducted at the Department of Horticulture, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai during the year 2011-12 and 2012-13. The research experiment conducted at College Model Orchard was aimed to standardize the fertigation schedule for aonla, to study the effect of fertigation with N, P and K fertilizers on growth, yield and quality of aonla. The details of materials used T_1-Surface Irrigation with soil application of 100% RDF (Control), T_2-Drip Irrigation with soil application of 100 % RDF T_3-Drip Fertigation of 75% RDF as Commercial Fertilizers, T_4-Drip Fertigation of 100 % RDF as Commercial Fertilizers, T_5-Drip Fertigation of 125% RDF as Commercial Fertilizers T_6-Drip Fertigation of 75% RDF as Water Soluble Fertilizers (WSF), T_7-Drip Fertigation of 100% RDF as Water Soluble Fertilizers (WSF) T_8- Drip Fertigation of 125% RDF as Water Soluble Fertilizers (WSF). All other recommended package of practices were followed to raise the crop as per the Crop Production Techniques of Horticultural Crops (2012).

For the treatment T_1-Soil application with surface irrigation was done in two split doses during April and September. For the treatment T_2-Soil application with drip irrigation was done in two split doses during April and September. For drip fertigation treatments (T_3-T_5) P was applied as basal through SSP, N and K were injected at weekly in equal splits. For drip fertigation treatments (T_6- T_8) the WSF namely MAP, SOP and Urea were injected at weekly intervals in equal splits (52 weeks). RDF: 200:500:200 g NPK/tree/year.

Results and Discussion

Effect of drip fertigation on quality parameters

In any production system, the primary goal is to achieve the highest fruit yield per unit area with optimum fruit quality. In aonla, the quality is mainly judged by total soluble solids (TSS), total sugars, acidity and ascorbic acid content in fruits. Application of nutrients, either through soil (or) fertigation, has made a remarkable effect on fruit quality as observed by Syamal and Mishra (1988), Suriyapananant (1992) and Shah *et al.*, (2002).

Total Soluble Solids

The total soluble solid content was significantly differed among the treatments. This increased by application of 125 per cent RDF through fertigation (13.1 and 13.6 ^{o}Brix) followed by 100 per cent RDF through fertigation (12.6 and 13.2 ^{o}Brix) during 2011-2012 to 2012 -2013 respectively. The lowest total soluble solid content was recorded in control *i.e.* 6.5 and 7.0 ^{o}Brix in 2011-2012 to 2012 -2013 respectively.

Pooled Mean total soluble solid content was the highest due to 125 per cent RDF through fertigation (T_8) (13.34 ^{o}Brix) and it was followed by 100 per cent RDF through fertigation (T_7) (12.90^{o} Brix). The lowest total soluble solid (6.75 ^{o} Brix) was recorded in control (T_1).The role of potassium in carbohydrate synthesis, breakdown and translocation, synthesis of protein and neutralization of physiologically important organic acids (Tistale and Nelson, 1966). Besides, potassium is involved in phloem loading and unloading of sucrose and amino acids and storage of sucrose in the form of starch in developing fruits by activating the enzyme 'starch synthase' (Mengel and Kirkby, 1987) (Table 1).

Titrable acidity

Titrable acidity was significantly influenced among the treatments and increased by application of 100 per cent RDF through soil application, *i.e.* control (3.20 and 3.50 %). The lowest titrable acidity was recorded in treatments T_8 (2.10 and 2.15 %) during 2011-2012 to 2012 -2013, respectively. It was followed by T_7 *i.e.* (2.17 and 2.20 %) in 2011-2012 to 2012 -2013 respectively.

Similar trend was noticed in the pooled mean values also. The application of 100 per cent RDF through soil *i.e.* control recorded the highest titrable acidity (3.35 %). The lowest titrable acidity was recorded in treatments T_8 followed by T_7 (2.12 and 2.18 %) respectively. Increased level of potassium application results in reduced acid content of fruits. This could be due to the fact that under low potassium level, phosphoenol pyruvate (PEP) was apparently shunted into alternate pathways resulting in shortage of acetyl Co-A (Pattee and Teel, 1967). Hence, oxaloacetate appeared to be preferentially formed from PEP in plants with low levels of K and these organic acid derivatives accumulated Neutralization of organic acid due to high K level in tissues could have also resulted in reduction in acidity (Tistale and Nelson, 1966) (Table 2).

Ascorbic acid content

Ascorbic acid content of fruit was significantly different among the treatments and increased by application of 125 per cent RDF through fertigation (T_8) (575.8 and 580.6 mg g^{-1}). It was followed by $T_{7,}$ application of 100 per cent RDF through fertigation (540.3 and 560.3 mg g^{-1}) during 2011-2012 to 2012 -2013 respectively. The lowest ascorbic acid (335.6 and 350.4 mg g^{-1}) content was recorded in treatment T_1 in 2011-2012 to 2012 -2013 respectively.

Similar trend was noticed in the pooled mean values also. The application of 125 per cent RDF through fertigation (T_8) registered the highest ascorbic acid content (578.20 mg g^{-1}). It was followed by $T_{7,}$ (550.29 mg g^{-1}). The lowest ascorbic acid content (343.0 mg g^{-1}) was recorded in treatment 100 per cent RDF through soil (T_1) *i.e.* control (T_1). Potassium is responsible for energy production in the form of ATP and NADPH in chloroplasts by maintaining balanced electric charges. This high-energy status promotes synthesis of secondary metabolites like ascorbic acid (Mengel, 1997) (Table 3).

Table.1 Effect of drip fertigation levels on TSS (^{0} Brix) of aonla cv. NA-7

2012					2013					Pooled mean 2012-2013
Treatments	R_1	R_2	R_3	Mean	Treatments	R_1	R_2	R_3	Mean	
T_1	6.57	6.72	6.21	**6.50**	T_1	7.26	6.65	7.09	**7.00**	6.75
T_2	8.47	8.62	8.11	**8.40**	T_2	9.88	9.53	9.39	**9.60**	9.00
T_3	9.39	9.16	9.96	**9.50**	T_3	10.22	10.21	10.17	**10.2**	9.85
T_4	9.44	10.28	9.68	**9.80**	T_4	11.70	11.45	11.35	**11.5**	10.65
T_5	11.50	11.49	11.51	**11.5**	T_5	12.37	12.39	12.44	**12.4**	11.95
T_6	9.92	9.17	9.71	**9.60**	T_6	11.28	10.90	11.43	**11.2**	10.40
T_7	12.57	12.64	12.59	**12.6**	T_7	13.03	13.24	13.33	**13.2**	12.90
T_8	13.74	12.62	12.94	**13.1**	T_8	13.76	13.65	13.38	**13.6**	13.34
SEd				**0.287**	**SEd**				**0.182**	**0.169**
CD(0.05)				**0.615**	**CD(0.05)**				**0.390**	**0.348**

Table.2 Effect of drip fertigation levels on titrable acidity (%) of aonla cv. NA-7

2012					2013					Pooled mean 2012-2013
Treatments	R_1	R_2	R_3	Mean	Treatments	R_1	R_2	R_3	Mean	
T_1	3.19	3.22	3.20	**3.20**	T_1	3.50	3.50	3.50	**3.50**	3.35
T_2	2.53	2.69	2.64	**2.62**	T_2	2.80	2.75	2.62	**2.72**	2.67
T_3	2.49	2.48	2.53	**2.50**	T_3	2.61	2.57	2.62	**2.60**	2.55
T_4	2.48	2.34	2.38	**2.40**	T_4	2.43	2.40	2.52	**2.45**	2.42
T_5	2.24	2.23	2.22	**2.23**	T_5	2.31	2.28	2.30	**2.30**	2.26
T_6	2.52	2.46	2.43	**2.47**	T_6	2.52	2.54	2.59	**2.55**	2.51
T_7	2.18	2.21	2.12	**2.17**	T_7	2.20	2.20	2.20	**2.20**	2.18
T_8	2.12	2.15	2.03	**2.10**	T_8	2.20	2.14	2.11	**2.15**	2.12
SEd				**0.042**	**SEd**				**0.038**	**0.028**
CD(0.05)				**0.091**	**CD(0.05)**				**0.083**	**0.059**

Table.3 Effect of drip fertigation levels on ascorbic acid (mg g^{-1}) of aonla cv. NA-7

2012					2013					Pooled mean 2012-2013
Treatments	R_1	R_2	R_3	Mean	Treatments	R_1	R_2	R_3	Mean	
T_1	333.53	329.38	343.89	**335.6**	T_1	332.95	354.76	363.49	**350.4**	343.00
T_2	434.24	425.69	422.27	**427.4**	T_2	452.84	430.54	421.62	**435.0**	431.20
T_3	442.55	414.67	434.58	**430.6**	T_3	432.53	440.18	437.99	**436.9**	433.75
T_4	440.50	440.50	440.50	**440.5**	T_4	441.53	449.37	452.50	**447.8**	444.15
T_5	513.87	507.62	509.41	**510.3**	T_5	541.10	508.20	517.60	**522.3**	516.30
T_6	444.26	439.31	437.33	**440.3**	T_6	437.75	454.99	450.06	**447.6**	443.95
T_7	530.98	537.19	552.73	**540.3**	T_7	555.40	545.59	579.91	**560.3**	550.29
T_8	577.24	580.12	570.04	**575.8**	T_8	576.97	569.71	595.12	**580.6**	578.20
SEd				**6.244**	**SEd**				**10.963**	**6.309**
CD(0.05)				**13.393**	**CD(0.05)**				**23.516**	**12.933**

Table.4 Effect of drip fertigation levels on total sugar (%) of aonla cv. NA-7

2012					2013					Pooled mean 2012-2013
Treatments	R_1	R_2	R_3	Mean	Treatments	R_1	R_2	R_3	Mean	
T_1	2.31	2.28	2.21	**2.27**	T_1	2.35	2.47	2.52	**2.45**	2.36
T_2	2.92	2.85	2.87	**2.88**	T_2	3.00	3.05	3.01	**3.02**	2.95
T_3	3.12	2.98	3.08	**3.06**	T_3	3.17	3.40	3.33	**3.30**	3.18
T_4	3.35	3.38	3.47	**3.40**	T_4	3.76	3.85	3.55	**3.72**	3.56
T_5	3.85	3.82	3.73	**3.80**	T_5	4.07	4.24	4.12	**4.14**	3.96
T_6	3.12	3.08	3.11	**3.10**	T_6	3.49	3.20	3.41	**3.37**	3.23
T_7	3.96	3.98	3.91	**3.95**	T_7	4.56	4.45	4.40	**4.47**	4.20
T_8	4.36	4.32	4.21	**4.30**	T_8	5.08	4.77	4.99	**4.95**	4.62
SEd				**0.042**	SEd				**0.101**	**0.054**
CD(0.05)				**0.092**	CD(0.05)				**0.218**	**0.112**

Table.5 Effect of drip fertigation levels on reducing sugar (%) of aonla cv. NA-7

2012					2013					Pooled mean 2012-2013
Treatments	R_1	R_2	R_3	Mean	Treatments	R_1	R_2	R_3	Mean	
T_1	1.44	1.34	1.41	**1.40**	T_1	1.54	1.51	1.44	**1.50**	1.45
T_2	1.82	1.86	1.72	**1.80**	T_2	1.90	1.90	1.90	**1.90**	1.85
T_3	1.88	1.93	1.89	**1.90**	T_3	2.11	2.13	2.06	**2.10**	2.00
T_4	2.20	2.21	2.20	**2.20**	T_4	2.23	2.39	2.28	**2.30**	2.25
T_5	2.47	2.30	2.42	**2.40**	T_5	2.61	2.47	2.42	**2.50**	2.45
T_6	2.05	1.96	1.99	**2.00**	T_6	2.28	2.09	2.23	**2.20**	2.10
T_7	2.50	2.52	2.49	**2.50**	T_7	2.78	2.74	2.88	**2.80**	2.64
T_8	2.61	2.82	2.67	**2.70**	T_8	3.07	3.09	3.14	**3.10**	2.90
SEd				**0.052**	SEd				**0.057**	**0.039**
CD(0.05)				**0.112**	CD(0.05)				**0.122**	**0.080**

Table.6 Effect of drip fertigation levels on non-reducing sugar (%) of aonla cv. NA-7

2012					2013					Pooled mean 2012-2013
Treatments	R_1	R_2	R_3	Mean	Treatments	R_1	R_2	R_3	Mean	
T_1	0.86	0.88	0.87	**0.87**	T_1	0.96	0.91	0.98	**0.95**	0.91
T_2	1.06	1.09	1.10	**1.08**	T_2	1.13	1.15	1.08	**1.12**	1.10
T_3	1.16	1.16	1.16	**1.16**	T_3	1.23	1.19	1.18	**1.20**	1.18
T_4	1.23	1.21	1.16	**1.20**	T_4	1.49	1.37	1.40	**1.42**	1.31
T_5	1.41	1.37	1.42	**1.40**	T_5	1.64	1.64	1.64	**1.64**	1.52
T_6	1.09	1.12	1.10	**1.10**	T_6	1.14	1.16	1.21	**1.17**	1.13
T_7	1.46	1.44	1.45	**1.45**	T_7	1.68	1.61	1.71	**1.67**	1.56
T_8	1.63	1.56	1.61	**1.60**	T_8	1.83	1.86	1.87	**1.85**	1.72
SEd				**0.019**	SEd				**0.030**	**0.018**
CD(0.05)				**0.042**	CD(0.05)				**0.065**	**0.037**

Apart from higher sugar content observed with higher level of K applied, increased ascorbic acid content was noticed in fruits. This might be due to the fact that K could have helped to slow down the enzyme system that encouraged the oxidation of ascorbic acid, thus helping the plants to accumulate more ascorbic acid content in fruits (Ananthi, 2002). The present results are in agreement with that of Brantley and Warren (1960), Deswal and Patil (1984), Balakrishnan *et al.*, (1996) and Mahalakshmi *et al.*, (2000) in banana.

Total sugars

The total sugar content in the fruit was significantly different among the treatments and increased by application of 125 per cent RDF through fertigation (T_8) (4.30 and 4.95 %) followed by 100 per cent RDF through fertigation (T_7) (3.95 and 4.47 %) during 2011-2012 to 2012 -2013 respectively. The lowest total sugar was recorded in control *i.e.* 2.27 and 2.45 % (T_1) in 2011-2012 to 2012 -2013 respectively (Table 4).

Pooled mean values of total sugars were the highest in 125 per cent RDF through fertigation (T_8) (4.62 %). It was followed by 100 per cent RDF through fertigation T_7 (4.20%). The lowest total sugar content was recorded by control (T_1) (2.36 %). Post flowering application of K also favours the conversion of starch into simple sugars during ripening by activating 'sucrose synthase' enzyme, resulting in higher sugar content in fruits.

In plants, well supplied with K, the osmotic potential of the phloem sap and the volume flow rate are higher than that observed in plants supplied with low available potassium level and as a result, sucrose concentration in the phloem sap is increased in well-nourished trees (Marschner, 1995).

Reducing sugars

The reducing sugar content in the fruit was significantly different among the treatments and increased by application of 125 per cent RDF through fertigation (T_8) (2.70 and 3.10 %). It was followed by 100 per cent RDF through fertigation (T_7) (2.50 and 2.80 %) during 2011-2012 to 2012 -2013, respectively. The lowest reducing sugar (1.40 and 1.50 %) was recorded in control (T_1) in 2011-2012 to 2012-2013 respectively. The mean of reducing sugar content was the highest (2.90 %) in 125 per cent RDF fertigation treatment (T_8). It was followed by T_7 (100 per cent RDF) through fertigation (2.64%). The lowest reducing sugar was recorded by control (1.45 %) (T_1) (Table 5).

Non-reducing sugars

Among the two years taken for study, a significant effect was noticed during 2011-2012 to 2012 -2013 for the treatments applied with respect to non-reducing sugar content. The non-reducing sugar content in the fruit (1.60 and 1.85 %) was significantly increased by application of 125 per cent RDF through fertigation (T_8) (Table 6). It was followed by 100 per cent RDF through fertigation (1.45 and 1.67 %) (T_7) during 2011-2012 to 2012 -2013, respectively. The lowest non-reducing sugar (0.87 and 0.95 %) was recorded in control (T_1) in 2011-2012 to 2012 -2013 respectively. The pooled mean of non-reducing sugar content was the highest (1.72 %) in 125 per cent RDF fertigation treatment (T_8). It was followed by T_7 through fertigation (1.56 %). The lowest non-reducing sugar was recorded by control (0.91 %). Quality characters such as TSS, Ascorbic acid, Titrable Acidity, Reducing Sugar, Non Reducing Sugar and Total Sugar of the fruits were significantly enhanced due to application of 125 per cent RDF as WSF through drip in both the years of experimentation.

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