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Influence on flower, fruit, yield and quality of custard apple (*annonas squamosa* l.) by drip fertigation

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ABSTRACT

A study was conducted during 2019 to 2020 and 2020 to 2021 to find out the effect of drip fertigation on flower, fruit yield and quality of custard apple (Annonas squamosa L.) Cv. Balanagar. The experiment was laid out in factorial randomized block design with eight treatment combinations which included four levels of fertigation (100, 75, 50% and surface application) and two sources of fertilizers, which included water soluble fertilizers and solid fertilizers with four replication. Nitrogen, phosphorus and potassium (NPK) content of solid and water soluble fertilizers were applied through fertigation as well as soil application to test various attributes of 5-years-old custard apple cv. Balanagar. The investigation indicated that 100% RDF (recommend dose of fertilizers) with water soluble fertilizers (F_1S_2) resulted in maximum number of flowers per branch (53.15), number of flowers per plant (305.69), days from flowering to fruit set (8.21days), number of fruits per plant (84.55), average fruit weight (184.93g) fruit yield per plant (13.03 kg), Non reducing sugar (3.54 %), Reducing sugar (16.65 %), total sugar (20.22%), TSS/acid ratio (84.35%), Shelf life (7.50 days). However, surface application of 100% RDF with solid fertilizers (F_4S_1) resulted in minimum flower, fruit, yield and quality attributes in custard apple

Key words: Custard apple, fertigation, source of fertilizers, yield, quality

INTRODUCTION

Custard apple (*Annona squamosa* L.) belongs to family Annonaceae and is one of the finest fruits gifted to India by tropical America. It is commonly found in India and is cultivated an area of 38,000 ha with production of 3, 20,000 MT (Anonymous 2018). Custard apple, popularly known as Sitaphal is grown mainly in the States of Andhra Pradesh, Assam, Tamil Nadu, Madhya Pradesh and grows wild in Deccan plateau and some parts of central India. Custard apple is generally classified as semi wild fruit by virtue of its spontaneous spread in forests, wastelands and other uncultivated places. It is hardy, tolerant to drought, salinity and saline irrigation water to certain extent. It grows very well even on a shallow soil. It also sheds off leaves during stress period to minimize the moisture loss from plant tissues through transpiration and thus a most appropriate fruit crop for rain fed region. Custard apple is known by varied names as Sitaphal, Sugar apple and Shariffa. It is considered as one of the delicious and nutritionally valuable fruits meant for table purpose. Fruits have an edible, soft, granular, juicy and sugary pulp with mild flavour and with slight acidity. Fruits are considered for their medicinal value besides their general use in ice cream, confectionery, certain milk products and in making preserves such as jam, jelly and other products. It is considered as beneficial for cardiac disease, diabetes, hyperthyroidism and cancer. It contains about 28-55% of edible portion consisting of 73.30% moisture, 1.60% protein, 0.30% fat, 0.70% mineral matter, 23.90% carbohydrates, 0.20% calcium, 0.40% phosphorus, 1.0% iron, 12.4-18.15% sugar and 0.26-0.65% acidity with caloric value of 105 KCal/100g.

Custard apple gives better response to fertilizer application in respect to yield and quality of fruits. But, the low productivity of custard apple may be due to less adoption of improved crop management technology in respect of planting system, nutrition, plant protection and irrigation etc. Among several other factors affecting the productivity of fruit trees, as custard apple trees removes large amount of nutrients from soil, balance fertilization seems to be an important factor governing the productivity of custard apple trees. Nutrition of fruit tree is an important part of orchard management practices. Nutrients have

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certain specific role to play in the plant and their presence is must for a plant to complete its life cycle and to determine the fruitfulness and physico - chemical properties of the fruit.The fertilizers are becoming costly input day by day. Hence, it is felt necessary to study the efficient use of this input. This can be achieved by adopting efficient use of drip system of irrigation. The application of fertilizers through irrigation system is called "fertigation". It has become a common practice in modern irrigated agriculture. Increased yields, improvement in quality of the produce, irrigation and fertilizer use efficiencies and protection of the soil environment are some of the main characteristics of this method, which made it very popular throughout the world.

Fertilizer must supply and maintain an optimum level of nutrients within the root zone. For this new irrigation and fertilization techniques are required. Combined irrigation and fertilization is ideal for this purpose, with irrigation water acting as a vehicle for the nutrients required by crops. One of the major factors to promote modern fertigation is the development of micro irrigation systems, which include drips, jets and micro-sprinklers. Fertigation technology involves application of fertilizers with drip irrigation system at a slow and controlled rate to the root zone. A significant goal of fertilizer studies is to develop cultural practices by which crop nutrient requirements are satisfied through maximum uptake of nutrients from a minimum quantity of applied fertilizers. In general, injection of fertilizers into irrigation water gives a better crop response than either band or broadcast application. Fertigation gives flexibility of fertilization, which enables the specific nutritional requirements of the crop, to be met at different stages of its growth.The area under custard apple is increasing in India on commercial scale and no work has been done with respect to different levels of fertigation. Therefore, the present study was under taken to evaluate the fertigation system involving sources of fertilizers and various levels of fertilizers in comparison to farmers practice (soil application of RDF) on flower, fruit, yield and quality of custard apple.

MATERIALS AND METHODS

The experiments were conducted at the Horticulture Garden, Department of Horticulture, College of Agriculture, Raichur, Karnataka, during 2019-20 and 2020-21 on uniform 5 year old custard apple *cv.* Balanagar which were spaced at 4.5 × 4.5 m (494 plant ha^{-1}). The region belongs to Agro-Climatic Zone-II (North-Eastern dry zone) of Karnataka. Raichur is located at 16.21° N, 77.35° E longitude and an altitude of 407 meters above mean sea level. The experimental site was clay loamy with pH of 7.0-7.3. The soil was fertile, with organic content (0.45 %), low available nitrogen (212.8 kg/ha), medium available phosphorous (27.1 P_2O_5 kg/ha) and potassium (237.7 K_2O kg/ha). There were 4 levels of fertigation, namely fertigation at 100% RDF (F_1), fertigation at 75% RDF (F_2), fertigation at 50% RDF (F_3) and surface application at 100% RDF (F_4) with two source of fertilizers were used in the experiment were, solid fertilizer (S_1) and water soluble fertilizer (S_2) along with eight treatment combinations. The experiment was laid out in factorial randomized block design with four replications and two plants were kept in each treatment. The recommended fertilizer dose of 250: 125:125 g NPK $plant^{-1}$ $year^{-1}$ was adopted for fertigation as well as soil application. The fertigation system was installed in the experimental orchard. The drip unit consisted of 63 and 40 mm PVC pipes, valves, venturi, a sand filter which was connected in series. The main PVC line was 63 mm in diameter to which a sub-main of 40 mm diameter was fixed. Lateral drip inline (16 mm LLDPE) were drawn from the sub mains parallel to the plant rows. One lateral was placed for one row of plants with two drippers at a discharge rate of four litres per hour. The water source for the drip system was from bore well near the experimental site. Well decomposed farmyard manure was applied at the rate of ten kg per plant at the time of basin preparation. The fertigation was given to custard apple plants as per treatments. Solid fertilizers like urea, di ammonium phosphate and muriate of potash were applied in the form of liquid fertilizers by soaking it in water for overnight and water soluble fertilizers like 19:19:19 along with urea were applied in five split doses at twenty days intervals after pruning. The observation on number of flowers per branch, number of flowers per plant, days from flowering to fruit set, number of fruits per plant, average fruit weight, fruit yield per plant, non reducing sugar, reducing sugar, total sugar, TSS/acid ratio, shelf life. The data obtained on various characters were subjected to Factorial RBD analysis and interpretation of the data was carried out in accordance to Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Flower, fruit and yield attributing parameters

Pooled data over two years indicates that flower parameters were non significantly influenced by different fertigation levels and source of fertilizers treatments (Table 1). Application of fertilizers through fertigation of 100% RDF with water soluble fertilizers (F_1S_2) was found maximum number of flowers per branch (53.15), number of flowers per plant (305.69). Application of 100 % RDF as water soluble fertilizers through fertigation produced high number of flowers. The total numbers of flowers were increased with increasing nitrogen levels. The present investigation is in line with findings of Verma and Bhattacharyya (2005) and Pandey *et al.* (2013). Better photo assimilates and hormonal balance would have improved the sink strength of trees treated with 100% RDF as water soluble fertilizers through fertigation acceleration of mega and microsporogenesis and differentiation of axillary buds into reproductive ones. The higher level of N, P and K resulted in flower production than lower levels (Suresh *et al.* 2018) in aonla. The two year pooled data on days from flowering to fruit set were significantly influenced by different fertigation levels and source of fertilizers treatments (Table 1). Minimum days from flowering to fruit set was observed in fertigation of 100% RDF with water soluble fertilizers (8.21 days) which was statistically at par with fertigation of 75% RDF with water soluble fertilizers (F_2S_2), which registered a minimum days to fruit set(8.94 days). Maximum number of days from flowering to fruit set (15.66 Days) was observed under surface application of 100% RDF with solid fertilizers (F_4S_1). The fewer days taken for flowering to fruit set might be due to regular and continuous availability of nutrients for longer period which helped to synthesis and deposition of photo-assimilates. This might led to induce better growth, fruit bud differentiation (FBD) and transfer of photo assimilates from source to sink increased flowering to fruit set (Agrawal *et al.,* 2010, Jayakumar *et al.,* 2010) in papaya.

Table 1: Flower attributing parameters influenced by drip fertigation on custard apple Cv. Balanagar

Treatment	No. flowers per branch			No. flowers per plant			Days from flowering to fruit set (Days)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
F_1S_1- Fertigation of 100 % RDF with solid fertilizers	41.11	61.11	51.11	285.05	302.87	293.96	12.46	12.06	12.26
F_1S_2- Fertigation of 100% RDF with water soluble fertilizers	42.75	63.55	53.15	296.43	314.96	305.69	8.34	8.08	8.21
F_2S_1- Fertigation of 75 % RDF with solid fertilizers	38.34	57.00	47.67	265.86	282.48	274.17	13.39	12.97	13.18
F_2S_2-Fertigation of 75 % RDF with water soluble fertilizers	41.47	61.65	51.56	287.53	305.51	296.52	9.08	8.79	8.94
F_3S_1-Fertigation of 50 % RDF with solid fertilizers	37.10	55.15	46.12	257.24	273.32	265.28	13.75	13.51	13.63
F_3S_2-Fertigation of 50 % RDF with water soluble fertilizers	40.30	59.91	50.11	279.46	296.93	288.19	13.97	13.53	13.75
F_4S_1-Surface application 100 % RDF with solid fertilizers	36.80	54.71	45.76	255.20	271.15	263.18	14.05	13.98	14.01
F_4S_2-Surface application 100 % RDF with water soluble fertilizers	39.10	58.13	48.62	271.16	288.11	279.64	15.91	15.41	15.66
SEm±	1.89	2.81	2.35	13.08	13.90	13.48	0.22	0.21	0.21
CD @ 5 %	NS	NS	NS	NS	NS	NS	0.64	0.62	0.63

The observations on a number of fruits per plant, fruit weight and yield per plant were recorded for two years and presented in Table 2. Fertigation of 100% RDF with water soluble fertilizers (F_1S_2) had significantly resulted higher in the number of fruits (84.55), average fruit weight (184.93 g) fruit yield per plant (13.03 kg) which was statistically at par with fertigation of 75% RDF with water soluble fertilizers (F_2S_2), which recorded number of fruits per plant (80.46), average fruit weight (177.53 g) fruit yield per plant (12.40 kg). However, lesser values were recorded for number of fruits (70.52), average fruit weight (155.59 g) and fruit yield per plant (10.87 kg) under surface application of 100% RDF with solid fertilizers (F_4S_1). The yield attributing characters were significantly influenced by either application of 100 % and 75 % recommended dose of water soluble fertilizers through fertigation over the conventional method of soil application of 100% RDF. This might be due to the continuous supply of optimum dose of water-soluble fertilizers in available form through fertigation at critical stages of plant growth. This might have resulted in higher uptake and better translocation of assimilates from source to sink, which in turn increased the yield attributes. More nutrient and moisture per plant, which is beneficial in improving all the morphological characters of fruits. Thus, photo assimilate production is higher, which allows the plants to express their potential by forming more racemes and in turns the yield attributing parameter. Raghupathi *et al.* (2002), who observed that significant increase in crop yield of banana with increased fertigation levels of N P K. Higher yields obtained under fertigation was also reported by Vijayakumar (2001) in mango and Haneef *et al.* (2014) in pomegranate who observed significant increase in crop yield with increasing fertigation levels. Similar results of increased average fruit weight, and plant yield increased with higher dose application of water soluble nutrient through fertigation. Similar finding are accordance with Shirgure and Shrivastav (2016) in mandarin Sandeep kumar *et al.* (2020) in citrus.

Table 2: Yield attributing parameters influenced by drip fertigation on custard apple Cv. Balanagar

Treatment	No. fruits per plant			Average fruit weight (g)			Fruit yield (kg plant^{-1})		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
F_1S_1- Fertigation of 100 % RDF with solid fertilizers	72.74	81.29	77.01	154.52	181.45	167.97	9.98	13.76	11.87
F_1S_2- Fertigation of 100% RDF with water soluble fertilizers	79.86	89.24	84.55	170.12	199.79	184.93	10.95	15.11	13.03
F_2S_1- Fertigation of 75 % RDF with solid fertilizers	72.43	82.51	76.69	156.30	183.56	169.90	9.93	13.70	11.82
F_2S_2-Fertigation of 75 % RDF with water soluble fertilizers	76.00	86.41	80.46	163.31	191.80	177.53	10.42	14.38	12.40
F_3S_1-Fertigation of 50 % RDF with solid fertilizers	69.71	80.24	73.81	149.81	175.94	162.85	9.56	13.19	11.38
F_3S_2-Fertigation of 50 % RDF with water soluble fertilizers	69.34	78.19	73.41	149.0	174.99	161.97	9.51	13.12	11.31
F_4S_1-Surface application 100 % RDF with solid fertilizers	66.61	74.43	70.52	143.13	168.10	155.59	9.14	12.60	10.87
F_4S_2-Surface application 100 % RDF with water soluble fertilizers	67.17	75.06	71.12	143.76	168.83	156.27	9.21	12.71	10.96
SEm±	1.35	1.58	1.43	2.87	4.95	3.12	0.19	0.26	0.22
CD @ 5 %	3.97	4.64	4.20	8.43	9.91	9.17	0.54	0.75	0.68

Quality parameters

Pooled data over two years indicates that quality parameters were significantly influenced by different fertigation level and source of fertilizers treatments (Table 3). Significantly maximum non reducing sugar (3.54%), reducing sugar (16.65%), total sugar (20.22%) were observed in fertigation at 100% RDF with water soluble fertilizers (F_1S_2) which was on par with

fertigation of 75% RDF with water soluble fertilizers (F_2S_2) which recorded non reducing sugar (3.40%), reducing sugar (15.94%), total sugar (19.41%) while, minimum non reducing sugar (2.98%), reducing sugar (13.99%), total sugar (17.01%) was recorded in the surface application at 100% RDF with solid fertilizers. Drip irrigation at 100% level improved all quality components because drip irrigation provides a consistent moisture regime in the soil this might accelerate root growth and resulting in optimum availability of nutrient and proper translocation of food materials which accelerated the fruit growth and development, consequently improved the quality characters in the fruits. The increase in juice content might be because of more absorption of water and minerals from the soil resulting into increased juice content and total sugar (Nath *et al.,* 2002). Prasad and Mali (2000) found total sugar, reducing sugar and non-reducing sugar to be highest at optimum level of N in pomegranate cv. Jalore Seedless. Singh, (2013) also recorded sugar content to increase with N level. Dheware *et al.,* 2020 in mango also recorded the same phenomenon that optimum level of N increases the total sugar, reducing sugar and non-reducing sugar of the fruits.

Table 3 Quality attributing parameters influenced by drip fertigation on custard apple Cv. Balanagar

Treatment	Non reducing sugar (%)			Reducing sugar (%)			Total sugar (%)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
F_1S_1- Fertigation of 100 % RDF with solid fertilizers	3.07	3.36	3.25	15.02	15.22	15.12	18.30	18.45	18.58
F_1S_2- Fertigation of 100% RDF with water soluble fertilizers	3.38	3.70	3.54	16.59	16.71	16.65	20.14	20.31	20.22
F_2S_1- Fertigation of 75 % RDF with solid fertilizers	3.10	3.40	3.21	15.36	15.16	15.26	18.51	18.66	18.37
F_2S_2-Fertigation of 75 % RDF with water soluble fertilizers	3.24	3.55	3.40	15.98	15.90	15.94	19.34	19.50	19.41
F_3S_1-Fertigation of 50 % RDF with solid fertilizers	2.97	3.26	3.12	14.57	14.59	14.58	17.74	17.89	17.81
F_3S_2-Fertigation of 50 % RDF with water soluble fertilizers	2.96	3.24	3.10	14.66	14.51	14.59	17.64	17.79	17.71
F_4S_1-Surface application 100 % RDF with solid fertilizers	2.84	3.12	2.98	14.04	13.94	13.99	16.95	17.09	17.01
F_4S_2-Surface application 100 % RDF with water soluble fertilizers	2.85	3.13	2.99	14.15	14.05	14.10	17.02	17.16	17.09
SEm±	0.06	0.06	0.06	0.26	0.28	0.28	0.34	0.34	0.34
CD @ 5 %	0.17	0.18	0.18	0.77	0.83	0.83	1.00	1.01	1.00

The data on TSS/acid ratio, shelf life of custard apple fruits as influenced by different fertigation levels and source of fertilizers are presented in table (Table 4). Significantly maximum TSS/acid ratio (90.01), shelf life (7.50 days) were observed in fertigation at 100% RDF with water soluble fertilizers (F_1S_2) which was on par with fertigation of 75% RDF with water soluble fertilizers (F_2S_2) which recorded TSS/acid ratio (86.41), shelf life (7.20 days) while, minimum TSS/acid ratio (70.96), shelf life (6.31 days) was recorded in the surface application at 100% RDF with solid fertilizers. The TSS/ acid ratio exhibited maximum value with fertigation of 100% RDF with water soluble fertilizers. As the fruit maturity approaches in custard apple acidity decreases in proportion to TSS, which gives a fruit excellent sugar acid blend and is one of the most desirable characters of excellent fruit quality. These findings are in accordance with Neilsen *et al.* (2000) reported acidity to decrease and soluble solids to increase in response to higher N in 'Gala' apples. Same findings were also reported by Prasad and Mali (2000) who also found acidity to decrease with increasing N level in

Table 4 Quality attributing parameters influenced by drip fertigation on custard apple Cv. Balanagar

Treatment	TSS/acid ratio (%)			Shelf life (Days)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
F_1S_1- Fertigation of 100 % RDF with solid fertilizers	71.48	81.75	76.61	6.54	7.08	6.81
F_1S_2- Fertigation of 100% RDF with water soluble fertilizers	78.70	90.01	84.35	7.20	7.80	7.50
F_2S_1- Fertigation of 75 % RDF with solid fertilizers	72.31	82.70	77.49	6.61	7.16	6.89
F_2S_2-Fertigation of 75 % RDF with water soluble fertilizers	75.55	86.41	80.97	6.91	7.49	7.20
F_3S_1-Fertigation of 50 % RDF with solid fertilizers	69.30	79.27	74.27	6.31	6.87	6.60
F_3S_2-Fertigation of 50 % RDF with water soluble fertilizers	68.93	78.84	73.87	6.30	6.83	6.57
F_4S_1-Surface application 100 % RDF with solid fertilizers	66.22	75.73	70.96	6.05	6.56	6.31
F_4S_2-Surface application 100 % RDF with water soluble fertilizers	66.51	76.06	71.28	6.08	6.59	6.33
SEm±	1.33	1.52	1.42	0.12	0.13	0.13
CD @ 5 %	3.90	4.46	4.10	0.36	0.39	0.37

pomegranate cv. Jalore Seedless. Another worker, Singh *et al.* (2006) also recorded higher TSS: acid ratio with higher doses of N level in pomegranate cv. Ganesh. Purendra Kumar *et al.,* 2020 in guava recorded higher TSS: acid ratio with higher doses of N through fertigation. Fertigation of 100 % RDF has resulted in better nutrition which has produced more reserved food material (carbohydrates) in fruits. High carbohydrate accumulation is responsible for increasing the shelf-life of fruit. It might be the attributing factor for the positive effects of nutrition in enhancing the shelf life of fruits. Extra photosynthates in plants reserved as carbohydrates which might have increased the C: N ratio of plant, high carbohydrates reserve favours the longer shelf life of fruits because the pre-harvest factor of a plant definitely affects their postharvest life. Singh and Bijimol (2012) also observed that the nitrogen is an essential constituent of various proteins and play an active part in various metabolic processes which might have some role in augmenting the shelf life of fruits.

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