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Maneesha SR
ICAR- Central Coastal Agricultural Research Institute, Ela, Old Goa, Goa, India

S Priya Devi
ICAR- Central Coastal Agricultural Research Institute, Ela, Old Goa, Goa, India

RM Vijayakumar
Department of Fruit crops, HC&RI, TNAU, Coimbatore, India

K Soorianathasundaram
Department of Fruit crops, HC&RI, TNAU, Coimbatore, India

Correspondence
RM Vijayakumar
Department of Fruit crops, HC&RI, TNAU, Coimbatore, India

Effect of fertigation on vegetative growth of pineapple (*Ananas comosus* (L.) Merr.) Variety 'Giant Kew'

Maneesha SR, S Priya Devi, RM Vijayakumar and K Soorianathasundaram

Abstract
The effect of fertigation levels on the vegetative growth of pineapple variety 'Giant Kew' was studied during the crop establishment stage and the flower induction stage of the plant crop. The treatments were T0: Surface irrigation+ Conventional application of 100 % RDN (12:4:12 g NPK/ plant/ cycle), T1: Drip irrigation + Conventional application of 100% RDN (12:4:12 g NPK/ plant/ cycle), T2: Drip fertigation with 125% RDN (15: 5:15 g NPK/ plant/ cycle),T3: Drip fertigation with 100 % RDN (12:4:12 g NPK/ plant/ cycle), T4: Drip fertigation with 75 % RDN (9:3:9 g NPK/ plant/ cycle) and T5: Drip fertigation with 50 % RDN (6:2:6 g NPK/ plant/ cycle).At crop establishment stage, the highest plant height (58.24 cm) and stem girth (36.33 cm) were recorded in T2 treatment. The number of leaves were high in T2 (17.46) and T3 (17.82) treatments.The plants under T2 and T3 also had the highest D leaf length (63.47 cm, 85.09 cm respectively), D leaf width (3.59 cm and 3.57 cm respectively) and D leaf thickness. D leaf weight was highest in T2 treatment (42.39 g). At flower induction stage, T2 had the highest plant height (85.03 cm), Number of leaves (48.91) and stem girth (41.88 cm) which was on par with T3 and T4. D leaf length, D leaf weight and D leaf thickness were also high in T2 treatment. Chlorophyll a, chlorophyll b and total chlorophyll content and chlorophyll a/ b ratio was the highest in T2, but there was no significant difference between the treatments.

Keywords: fertigation, vegetative parameters, D leaf, pineapple, Giant Kew

Introduction

Pineapple (*Ananas comosus* (L.) Merr.) is the third most important tropical fruit after banana and citrus (Rohrbach*et al*., 2003) [12] with an annual world production of 25.8 million tons of fruits (FAOSTAT, 2018)[7]. India is the fifth largest producer of pineapple with an annual production of 1.97 million tons from 114 million hectare area in 2016-17 (INDIASTAT, 2018)[6]. The productivity of pineapple in India is 18 tons/ ha. It is consumed mainly as a fresh fruit and a wide range of processed products are also prepared out of it. It contains a proteolytic enzyme 'Bromelain' which imparts medicinal properties to this plant (Lotz-Winter, 1990). The fiber extracted from the pineapple leaves are used for the preparation of 'Pina cloth' (Hayes, 1960). Pineapple has many xerophytic adaptations like wax coated fleshy erect leaves with sunken stomata, spines on the leaf margin, and spiral arrangement of the leaves at short internodes to a club shaped dwarf stem giving a rosette appearance to the plant. Its roots can spread up to 1-2 m laterally and 85 cm in depth. Pineapple is an obligate Crassulacean acid metabolism (CAM) plant which stores carbon dioxide and fixes it as malic acid at night when stomata open (Zhang *et al.* 2014)[14]. This mechanism increases the efficiency of photosynthesis while preventing excessive water loss due to transpiration from open stomata during day time. Though it is a hardy crop and mainly grown in rainfed conditions, it requires water and nutrient supply during establishment stage and flowering period.

The West coast region of India has a specific feature of heavy monsoon from June- September followed by a severe water shortage up to April. So, adequate irrigation is needed for survival of the crops. Heavy rainfall during the monsoon in this region causes leaching of the nutrients thereby reducing the nutrient use efficiency. Application of required nutrients through the micro irrigation system (fertigation) can reduce the nutrient loss and increase the nutrient use efficiency since it reduces surface evaporation, surface runoff and deep percolation of applied water (Jiusheng*et al.* 2003)[8].In regions where water and labour are precious resources, fertigation can be a boon for the crop production.

Water soluble fertilizers or conventional fertilizers which are soluble in water can be used for fertigation. It reduces the fertilizer charges and improves the efficiency of nutrient uptake by reducing the leaching losses through the conventional application of fertilizers and surface irrigation. Fertigation can save water, nutrients and labour involved in managing these resources and make farming a profitable venture in long run. Drip fertigation will aid in easy application and concentration of nutrients suitable to the plant according to its developmental stage (Elhindi*et al.* 2015)[5]. Use of water soluble straight fertilizers like Urea, Super phosphates and Muriate of potash will reduce the cost of cultivation and enhance production.

Pineapple irrigation and nutrient management are often neglected since it is a hardy fruit crop cultivated as a rainfed crop in hilly slopes with fewer amounts of nutrients. It has a long vegetative state extending up to 10-12 months. The plant vigour and yield potential can be assessed by the growth during the vegetative stage. Suckers, the commonly used planting material will take 3-4 months to establish a good root system. Application of phosphates fertilizers at the time of planting of pineapple suckers as basal dose helps to develop root system and faster establishment. Nitrogen and Potassium are required in early growth stages and flowering time. Application of high dose of nutrients at the time of fruit development will reduce the fruit quality. Multiple harvests due to the irregular flowering are a problem to the pineapple farmers. Flower induction using the recommended growth regulators is a common practice in pineapple to assure uniformity in flowering and to avoid staggered harvest. Flower regulation also helps to produce off season crop and fetch good price in the market. Plant growth characteristics, especially, the D leaf parameters like D leaf length, D leaf width, D leaf weight and thickness at the time of flower induction can influence the production potential of the crop.

Materials and Methods

The effect of fertigation on vegetative growth of pineapple variety 'Giant Kew' was studied in different levels of drip fertigation at ICAR-Central Coastal Agricultural Research Institute, Ela, Old Goa, Goa (15^0 48'58" N Longitude, $73^0$92'29" E Latitude, 18.60 MSL altitude) during 2016-2017. The experimental plot had red lateritic soil with neutral pH (6.34) and EC (0.34 dSm^{-1}). The soil organic carbon content was high (1.22 %) with high organic matter content (2.10%).The soil had 143.17 kg/ ha available Nitrogen, 33.43 kg/ ha available Phosphorus and 244.79 kg/ ha available Potassium at the time of planting. Uniform suckers weighing 800-1000 g were used for planting in trenches with 60 x 90 x 45 cm spacing (41152plants/ ha). The source of water for irrigation was the well existing in the field. The fertigation system had a 7Hp motor, 50 L sand filter, venturi system, 63 mm PVC main line, 40 mm PVC sub main line and 16 mm LDPE lateral lines. In line emitters spacing was 60 cm with 4 lph discharge rate.

The water requirement of pineapple plant at different growth stages of pineapple for the experimental region was calculated from the consolidated evapotranspiration and rainfall data of 14 years from 2003-2016 obtained from the meteorological observatory of ICAR- CCARI, Ela, Old Goa. Crop evapotranspiration (Kc) of pineapple was taken as 0.5 up to six months after planting and 0.3 beyond that (Allen *et al*.1994)[1].

The treatments were, T0: Surface irrigation+ Conventional application of 100 % RDN(12:4:12 g NPK/ plant/ cycle), T1: Drip irrigation+ Conventional application of 100% RDN(12:4:12 g NPK/ plant/ cycle), T2: Fertigation with 125% RDN (15: 5:15 g NPK/ plant/ cycle), T3: Fertigation with 100 % RDN (12:4:12 g NPK/ plant/ cycle), T4: Fertigation with 75 % RDN (9:3:9 g NPK/ plant/ cycle), T5: Fertigation with 50 % RDN (6:2:6 g NPK/ plant/ cycle). In T0 and T1 treatments, $1/4^{th}$ quantity of N and K were given as basal and remaining were given in three equal splits at three months interval. Full dose of phosphorus (Rock phosphate 18% P_2O_5) was applied as basal at the time of planting. Percentage nutrient requirement of pineapple at various stages of growth were derived from Malezieux and Bartholomew (2003) and weekly fertigation was followed using Urea (46% N) and Muriate of Potash (60 % K_2O) (Table 1). The total amount of nutrients used in each treatment at various stages is furnished in Table 2. The treatments were applied in randomized blocks with three replications.

Table 1: Requirement of N and K during different crop growth stages of pineapple

Crop stage	Duration (Months)	No. of weeks	Nutrient Requirement (%)	
			N	K
Early vegetative stage	6	24	40	30
Late vegetative stage	4	16	30	30
Flowering stage	3	12	20	20
Fruitdevelopmentstage	3	12	10	20
Fruit maturation stage	2	8	0	0
Total	18	72	100	100

Table 2: Nutrient requirement of the treatments (g/ plant/ cycle)

Treatments	Fertilizer requirement(g)		
	Urea (46% N)	Rock phosphate (18% P_2O_5)	Muriate of Potash (60% K_2O)
T0: Surface irrigation + Conventional application of 100 % RDN(12:4:12 g NPK/ plant/ cycle)	26.08	22.22	20.00
T1: Drip irrigation + Conventional applicationof 100% RDN(12:4:12 g NPK/ plant/ cycle)	26.08	22.22	20.00
T2: Drip fertigation with 125% RDN (15: 5:15 g NPK/ plant/ cycle)	32.60	27.78	25.00
T3: Drip fertigation with 100 % RDN (12:4:12 g NPK/ plant/ cycle)	26.08	22.22	20.00
T4: Drip fertigation with 75 % RDN (9:3:9 g NPK/ plant/ cycle)	19.57	16.67	15.00
T5: Drip fertigation with 50 % RDN (6:2:6 g NPK/ plant/ cycle)	13.04	11.11	10.00

The plant height was measured from the base to the tip of the tallest leaf expressed in cm. Plant spread was taken in East-West and North- South direction and recorded in cm. Stem girth was taken in the base of the plant using measuring tape and noted in cm. All the functional and fully developed leaves were counted and recorded as the number of leaves. The index leaf of pineapple is the D leaf which is the tallest among all leaves. It is identified by holding the plant leaves together and the tallest one which is usually easy to pull out will be the D leaf. D leaf length was taken from the base to the tip of the leaf and width was taken in the middle, broadest region of the leaf lamina. The fresh weight of the leaf was taken and expressed in grams. The thickness of the D leaf was measured in milli meter using the screw gauge. D leaf chlorophyll content was estimated at flower induction stage following the standard procedure using 80 % Acetone as the extraction agent.

$$\text{Chlorophyll a}\left(\frac{\text{mg}}{100\text{ g}}\right)=\frac{12.7\text{ (O.D. at 663 nm)}-2.69\text{ (O.D. at 645 nm)x volume made up}}{\text{weight of the sample x 1000}}\text{x100}$$

$$\text{Chlorophyll b}\left(\frac{\text{mg}}{100\text{ g}}\right)=\frac{22.9\text{ (O.D. at 645 nm)}-4.68\text{ (O.D. at 663 nm)x volume made up}}{\text{weight of the sample x 1000}}\text{x100}$$

$$\text{Total chlorophyll}\left(\frac{\text{mg}}{100\text{ g}}\right)=\frac{20.2\text{ (O.D.at 645 nm)}+8.02\text{ (O.D.at 663 nm)x volume made up}}{\text{weight of the sample x 1000}}\text{x 100}$$

The data were statistically analysed in ANOVA with 0.05 probabilities using the WASP 2.0 software of ICAR-CCARI, Goa.

Results

Thevegetative characters showed highest value in T2: Fertigation with 125% RDN (15: 5:15 g NPK/ plant/ cycle) compared to the other treatments (Table 3).Plant height was highest in T2 (58.24 cm) during crop establishment stage followed by T3 (53.96 cm) and T1 (53.33cm). During flower induction stage, T2 (85.03 cm) had highest plant height followed by T4 (82.96 cm) and T3 (82.93 cm). There was no significant difference between the treatments in the plant spread both in East –West direction and North –South Direction both in crop establishment stage and the flower induction stage. The highest stem girth of 36.33 cm was recorded in T2 treatment followed by T1, T3 and T4 in the crop establishment stage. During flower induction stage, T2 (41.81 cm) had the highest stem girth which was on par with T4 (40.01 cm) and T3 (40.01 cm). The number of leaves was highest in T3 (17.82) and T2 (17.46) treatments during the crop establishment stage. But at the time of flowering, T2 had highest number of leaves followed by T1 (47.91) and T3 (46.20).

D leaf length was highest in T2 treatment (63.47 cm) in crop establishment stage, which was on par with T3 treatment (61.72 cm) (Table 4). In flower induction stage also, T2 had highest D leaf length (85.09 cm) followed by T3 and T4 treatments (82.24 cm and 82.11 cm respectively). D leaf width at crop establishment stage was highest in T3 and T2 (3.59 cm and 3.57 cm respectively). In the flower induction stage also the same was observed but, there was no significant difference between the treatments. D leaf weight was also highest in T2 treatment in both stages (42.39 g and 78.47 g respectively). D leaf thickness was also highest in T2 and T3 treatments (1.19 cm) during the crop establishment stage. In flower induction stage also T2 and T3 had the highest D leaf thickness (2.08 cm and 2.06 cm respectively).

Chlorophyll a, chlorophyll b and total chlorophyll content at flower induction stage had no significant difference between the treatments; however, the values were higher in T2 treatment (23.95 mg/100 g Chlorophyll a, 9.77 mg/100 g Chlorophyll b and 33.71 mg/100 g Total chlorophyll). Chlorophyll a/ b ratio was also highest in T2 treatment (2.85) followed by T4 (2.53) and T3 (2.30).

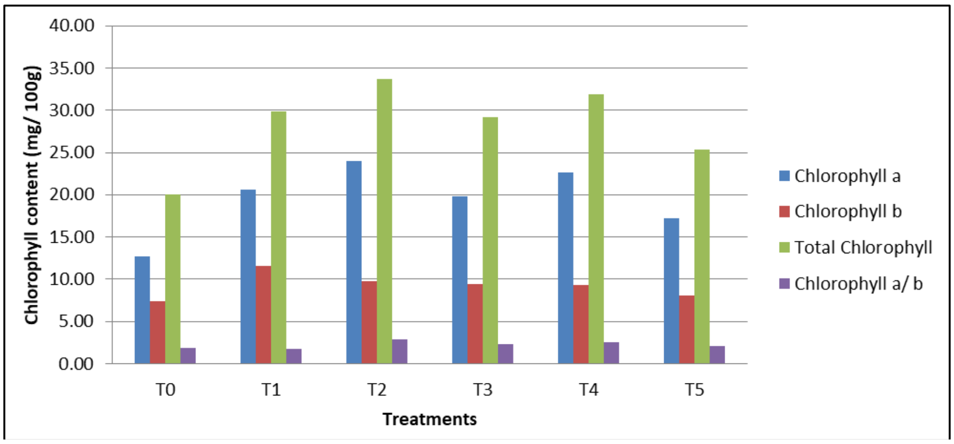

Fig 1: Chlorophyll content of fertigated 'Giant Kew' pineapple at flower induction stage

Table 3: Vegetative parameters of fertigated 'Giant Kew' pineapple

Treatments	Plant height(cm)		Plant spread-NS(cm)		Plant spread-EW(cm)		Stem girth(cm)		Number of leaves	
	I	II	I	II	I	II	I	II	I	II
T0	48.36^{c}	64.95^{d}	75.41	105.33	78.01	103.64	26.52^{c}	28.40^{d}	11.16^{c}	40.44^{c}
T1	53.33^{b}	77.09^{c}	80.53	113.84	83.51	115.67	34.22^{ab}	35.71^{b}	15.56^{b}	47.91^{ab}
T2	58.24^{a}	85.03^{a}	81.27	115.37	82.19	117.58	36.33^{a}	41.88^{a}	17.46^{a}	48.91^{a}
T3	53.96^{b}	82.93^{ab}	81.81	109.18	81.78	113.44	33.51^{ab}	40.01^{a}	17.82^{a}	46.20^{ab}
T4	51.20^{bc}	82.96^{ab}	81.88	108.89	82.53	113.04	33.33^{ab}	40.17^{a}	16.37^{ab}	45.40^{b}
T5	50.64^{bc}	79.64^{bc}	68.60	108.58	74.51	112.15	32.87^{b}	33.02^{c}	15.31^{b}	44.91^{b}
CD (0.05)	4.14	4.39	NS	NS	NS	NS	2.48	2.22	1.62	3.50
SE±	1.39	1.11	0.93	1.34	1.10	1.66	0.63	0.70	0.38	0.61

I-At crop establishment stageII- At flower induction stage

Table4:D leaf characteristics of fertigated 'Giant Kew' pineapple

Treatments	D leaf length(cm)		D leaf width(cm)		D leaf weight(g)		D leaf thickness(mm)	
	I	II	I	II	I	II	I	II
T0	54.50[b]	72.87[c]	3.22[b]	4.61	36.72[cd]	61.58[b]	0.88[c]	1.75[b]
T1	59.64[ab]	79.49[b]	3.42[ab]	4.66	38.41[bc]	69.04[b]	1.11[ab]	2.02[a]
T2	63.47[a]	85.09[a]	3.57[a]	4.80	42.39[a]	78.47[a]	1.19[a]	2.08[a]
T3	61.72[a]	82.24[ab]	3.59[a]	4.72	40.70[ab]	67.00[b]	1.19[a]	2.06[a]
T4	57.96[ab]	82.11[ab]	3.39[ab]	4.71	37.89[bc]	64.67[b]	1.02[abc]	1.79[b]
T5	54.60[b]	79.82[b]	2.93[c]	4.43	33.93[d]	63.19[b]	0.89[bc]	1.75[b]
CD (0.05)	6.13	5.00	0.27	NS	3.75	8.9	0.22	0.23
SE±	0.93	0.97	0.05	0.06	0.62	1.40	0.04	0.04

I-At crop establishment stageII- At flower induction stage

Discussion

Residual soil nutrient content and soil conditions are the best indicators of soil productivity. The uptake of the nutrients depends on soil factors like pH and EC other environmental and plant factors. Conventionally, fertilizers are applied in plant root zone at the time of planting and in split doses at critical growth periods.Most of the conventionally applied nutrients will leach and become unavailable to the plant roots. Therefore the efficiency of conventional fertilizer application is very less. Drip fertigation reduces surface evaporation and deep percolation, obtaining high water use efficiency and Nitrogen Use efficiency (Darwish*et al.* 2006)[4]. The initial soil conditions and fertility status of the experimental plot implies that the soil was deficient in nutrients.Among the treatments, all the vegetative parameters were highest in T2 treatments where 125 % of recommended dose of nutrients was applied through drip. It was clear from the results that the high dose of nutrients applied through drip can increase the vegetative growth of pineapple like any other crops. In T0 treatment, where 100% recommended dose of nutrients were applied in conventional application with surface irrigation, the growth of the plant was limited, which was reflected in the poor vegetative growth of the plant. Malik *et al.* (1994)[9] and Bharambe*et al*. (1997)[3] have reported that there was increase in the availability of soil nutrients under drip fertigation systems compared to the direct application to the soil. N application efficiency and plant productivity can be enhanced and potential N reduction can be avoided by drip fertigation (Asadi*et al.* 2002) [2]. Thompson *et al*.(2000)[13] also suggested that, drip fertigation withN fertilizer dissolved in the irrigation wateris an efficient strategy for water and nutrient application during crop production Among T0, T1 and T3 treatments, where 100% of recommended dose of nutrients were applied through different irrigation systems, it showed that mixing the fertilizers in irrigation water and supplying it through drip lines is the best method than soil application of fertilizers with drip irrigation or surface irrigation. In most of the vegetative characters, the effect of T2 treatment was on par with the T3 or T4 treatment, which showed that, application of reduced amount of nutrients through drip lines, can also perform on par with the heavy dose of nutrients applied directly in soil. Ramniwas*et al.* (2012)[11], Pawar and Dingre (2013)[10] also reported enhanced vegetative growth of fruit crops under higher fertigation doses.

Conclusion

Application of 125% recommended dose of fertilizers as basal application of rock phosphate and weekly drip fertigation with water soluble Urea and Muriate of Potash can improve the vegetative growth of pineapple variety 'Giant Kew' during crop establishment stage and flower induction stage. Plants provided with 75 % and 50 % RDN as drip fertigation were superior in performance than the plants supplied with 100 % RDN along with drip or surface irrigation.

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