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Growth, Yield and Nutrient Uptake of Pineapple cv Simhachalam as Influenced by Levels of Fertigation and Mulching

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ABSTRACT

The effect of fertigation levels with or without plastic mulching ; on the vegetative growth, yield and nutrient uptake of pineapple variety 'Simhachalam' was studied in both plant and ratoon crops at experimental research farm of Odisha University of Agriculture and Technology, Bhubaneswar during 2016-19. Different levels of the recommended fertilizers and mulching were tried along with a control. In both the plant and ratoon crops, fertigation with recommended fertilizer dose with mulch resulted in maximum values in plant height (100.1 cm, 94.5 cm), number of leaves (58.4, 51.8), D-leaf length (87.8 cm, 81.1 cm), width (4.7cm, 4.5cm), fruit weight with crown (1.243 kg, 1.065 kg), yield per hectare (55.98 t/ha, 46.78 t/ha), vegetative dry matter (42.80 t/ha), nitrogen, phosphorus and potash uptake by the vegetative biomass (73.51 kg/ha, 7.12 kg/ha, 111.99 kg/ha) respectively, fruit dry matter (15.57 t/ha) , N, P_2O_5, K_2O uptake in fruit (223.13 kg/ha, 18.55 kg/ha and 369.34 kg/ha) respectively.

Keywords Pineapple, Simhachalam, Fertigation, Plastic mulch, Nutrient uptake.

INTRODUCTION

Pineapple is one of the tropical fruits that is highly demanded in the international market. India is the fifth largest producer of pineapple with an annual production of 1706 thousand MT from 103 thousand hectare area in 2017- 18 (NHB data, 2017-18). The nutritional status of the pineapple plants plays a major role on influencing the plant growth, production and fruit quality. Pineapple is a shallow feeder with high N and K requirement. Since these nutrients are prone to heavy losses in soils, practices relating to time of application and form of fertilizer determine their efficient use. Many studies on nutritional requirement have suggested that a dose of N, P_2O_5 and K_2O at 12, 4 and 12 g/plant/year respectively is optimum under Indian conditions. The fruit weight of the pineapple is directly dependent on plant vigour at the time of floral differentiation. The use

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of balanced fertilization at appropriate time and of proper quantity plays a vital role in enhancing the productivity of crop. There is a dearth of studies in pineapple crop in terms of nutrient management especially through micro-irrigation. Application of required nutrients through 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). In pineapple through fertigation, application of fertilizer in small doses can be given in the entire growing season which can match the crop nutrient requirements and eventually maximize the returns per unit amount of fertilizer. Pineapple crop is closely spaced and due to it spiny leaves, performing inter-cultural operations including fertilization becomes difficult which can be eased by spreading drip lines between the plots of pineapple crop. Therefore, the present investigation was carried out to observe the effects of varying nutrient doses under fertigation and mulching on the growth, yield and nutrient uptake of pineapple plants.

MATERIALS AND METHODS

The effects of different levels of fertigation with or without mulch on growth, yield and nutrient uptake of pineapple var Simhachalam were studied at PFDC experimental research farm, Odisha University of Agriculture and Technology, Bhubaneswar during 2016-19 in both plant and ratoon crops. The experimental site is located on a flat land at 20°16´ N latitude and 85°47´E longitude and at an altitude of 52 m above mean sea level. The site belongs to the East and South-Eastern Coastal Plain Zone. The annual rainfall ranges from 125 to 150 cm per year. Most of the rainfall is received through South-West monsoon from June to September. Scanty and occasional rain is also received during winter season. The soil of the experimental area was lateritic and slight acidic with sandy loam texture and an EC of 0.014 dSm^{-1}. The soil organic carbon content was 2.26% with available nitrogen, phosphorus and potassium of 93, 4.9 and 67 kg/ ha, respectively, at the time of planting. Uniform, disease free suckers weighing 400–500 g were used for planting in trenches with 30 × 60 × 90 cm spacing accommodating around 44000 plants/ ha. The experiment was laid out in Randomized Block Design with seven treatments and three replications. The land was divided into seven individual raised beds of 5.4 m^2 (3.0m × 1.8 m) size replicated thrice and separated by drainage channels. The beds were covered with 50-micron black plastic mulch. The source of water for irrigation was the well existing in the field. The fertigation system had a 2 Hp motor, 50 L sand filter, venturi system, 60 mm PVC main line, 50 mm PVC sub main line and 16 mm LDPE lateral lines. The water requirement of pine-apple plant at different growth stages of pineapple for the experimental region was calculated from the consolidated evapotranspiration and rainfall data of from 2016-2019 obtained from the meteorological observatory of Department of Agro-meteorology, Odisha University of Agriculture and Technology. 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). Irrigation was done through drippers at 2 lph discharge rate, one hour daily during March to May and one hour on alternate days during November to February. From June to October plots were irrigated at an interval of 3 days depending upon the available soil moisture due to rains. Water soluble fertilizers viz., urea, sulfate of potash and monoammonium phosphate were used in the experiment which were applied through a venturi. The 100%, 80% and 60% RDF of water-soluble fertilizer were regulated by operating the tap connected at the starting end of each lateral. Drip laterals were laid along the length of each raised bed with the spacing of 60 cm between two adjacent laterals. Fertigation to individual plot in each replication was controlled by a manual regulating valve fixed to each lateral line. Fertigation was scheduled at fortnightly intervals starting from second month of planting till flower induction in the plant crop. The details of the treatments are furnished below :

T_1 : Fertigation with 100% recommended dose of fertilizer without mulch,

T_2 : Fertigation with 80% recommended dose of fertilizer without mulch,

T_3 : Fertigation with 60% recommended dose of fertilizer without mulch,

Table 1. Effect of different levels of fertigation with or without mulch on growth atrributes.

Treatment	Plant height (cm) Plant crop	Plant height (cm) Ratoon crop	Number of leaves Plant crop	Number of leaves Ratoon crop	D-leaf length (cm) Plant crop	D-leaf length (cm) Ratoon crop	D-leaf width (cm) Plant crop	D-leaf width (cm) Ratoon crop
T_1	92.1	79.5	49.5	43.1	80.6	72.5	4.2	4.1
T_2	87.8	68.9	42.5	38.4	75.6	66.4	4.0	3.9
T_3	59.9	53.9	35.7	33.9	64.1	59.1	3.1	2.7
T_4	100.1	94.5	58.4	51.8	87.8	81.1	4.7	4.5
T_5	104.4	78.9	48.6	44.9	81.8	73.0	4.5	4.6
T_6	69.2	59.6	39.1	36.3	68.8	64.2	3.5	3.3
T_7	78.1	66.7	46.1	41.8	74.8	68.9	3.9	3.8
SEm(±)	2.49	2.21	1.76	1.43	1.85	1.36	0.11	0.18
CD (5%)	7.68	6.82	5.43	4.42	5.71	4.18	0.34	0.56

T_4 : Fertigation with 100% recommended dose of fertilizer with mulch,

T_5 : Fertigation with 80% recommended dose of fertilizer with mulch,

T_6 : Fertigation with 60% recommended dose of fertilizer with mulch,

T_7 : Drip irrigation with 100% recommended dose of fertilizer as soil application without mulch.

After fruit harvesting of the plant crop, one healthy sucker was kept on the mother plant by de-suckering the other emerging suckers. In the ratoon crop, fertigation was followed in a similar manner after fruit harvest of the plant crop till the flower induction. In treatment T_7, the conventional method of fertilizer application (100% RDF @12:4:12 g NPK per plant) was followed by applying 1/4th quantity of N and K as basal and remaining quantity were given in three equal splits at three-month interval till flower induction. Full dose of phosphorus was applied as basal at the time of planting. The observations on growth parameters were recorded at flower induction in both the plant and ratoon crops. The plant height was measured from the base to the tip of the tallest leaf and expressed in cm. All the functional and fully developed leaves were counted and recorded as the number of leaves. The D leaf, the tallest among all the leaves, was measured for length and width. The length was taken from the base to the tip of the leaf while the width from the middle, widest region of the leaf lamina. Plants were cleaned to remove soil debris and separated into roots, stems, leaves, fruit and crown. Plant parts were then weighed to determine fresh matter and oven dried under forced ventilation (65°C) for approximately 72 h until reaching a constant mass. The fresh and dry biomass of plant components and the fruit with crown was calculated and converted to t ha^{-1}. The vegetative biomass corresponds to the average fresh and dry matter of leaves, roots, and stems. The accumulation of macronutrients in the vegetative biomass and fruit compartments were evaluated at the end of the crop cycle. The data were statistically analyzed with 0.05 probabilities using R software.

RESULTS AND DISCUSSION

A perusal of data presented in Table 1 with regard to the effect of different levels of fertigation with or without mulch on growth attributes shows a significant variation among the treatments. Treatment T_4 (100 % RDF through fertigation with mulch) recorded maximum plant height (94.5 cm) in ratoon crop, number of leaves (58.4, 51.8) and D-leaf length (87.8 cm, 81.1 cm) in plant and ratoon crop respectively at flower induction stage. However, T_5 (80% RDF through fertigation with mulch) was found statistically at par with T_4 for plant height in plant crop i.e., 104.4 cm and D-leaf width (4.5 cm, 4.6 cm) in plant and ratoon crop respectively. The NPK fertigation with mulch had a positive influence on pineapple fruit weight with crown and fruit yield per hectare (Table 2). Highest fruit weight with crown was recorded in T_4 (1.243 kg, 1.065 kg) which was at par with T_5 (1.141 kg, 0.934 kg) in plant and ratoon crop respective-

Table 2. Effect of different levels of fertigation with or without mulch on yield atrributes.

Treatment	Fruit weight with crown (kg) Plant crop	Fruit weight with crown (kg) Ratoon crop	Yield hectare^{-1} (tonnes) Plant crop	Yield hectare^{-1} (tonnes) Ratoon crop
T_1	1.052	0.896	47.12	39.90
T_2	0.934	0.803	42.45	35.95
T_3	0.760	0.635	30.62	26.85
T_4	1.243	1.065	55.98	46.78
T_5	1.141	0.934	49.91	40.92
T_6	0.799	0.744	37.95	31.85
T_7	1.008	0.809	46.92	33.72
SEm(±)	0.035	0.042	2.51	2.71
CD (5%)	0.108	0.129	6.19	8.34

ly. Consequently, yield per hectare was observed highest in T_4 (55.98 t/ha, 46.78 t/ha) which was at par with T_5 (1.141 kg, 0.934 kg) in plant and ratoon crop respectively. Observations made on dry matter accumulation and nutrient uptake by plant (Table 3) exhibited that the treatment which received 100% RDF through fertigation along-with mulch recorded highest dry matter (42.80 t/ha) which was found at par with 80% RDF through fertigation along-with mulch (37.57 t/ha). Nitrogen, phosphorus and potash uptake by the vegetative biomass was found highest in T_4 (73.51 kg/ha, 7.12 kg/ha, 111.99 kg/ha) respectively. T_5 was statistically at par with T_4 in terms of nitrogen and potash uptake i.e., 61.91 kg/ha and 84.51 kg/ha respectively (Table 3). The maximum gain in fruit dry matter (Table 4) was estimated in T_4(15.57 t/ha) which was statistically at par with T_5 (15.08 t/ha). N, P_2O_5, K_2O uptake in fruit was recorded highest in T_4 (223.13 kg/ha, 18.55 kg/ha and 369.34 kg/ha) respectively. T_5 was statistically at par with T_4 in terms of nitrogen and phosphorus uptake i.e., 199.48 kg/ha and 12.83 kg/ha respectively.

In pineapple, the initial vigour of the plant at the moment of flower induction is positively associated with yield attributes of the fruit at harvest. Plant height, plant girth, initiation of D-leaf and overall vegetative growth of pineapple is considered to be important factors to judge the vigour of pineapple crop (Bareily and Deb 2018). The height of the pineapple plant is an important growth character directly linked with its productive potential in terms of fruit yield.

Table 3. Effect of different levels of fertigation with or without mulch on vegetative biomass and nutrient uptake.

Treatment	Plant fresh biomass weight (t/ha)	Plant dry matter weight (t/ha)	Plant N uptake (kg/ha)	Plant P uptake (kg/ha)	Plant K uptake (kg/ha)
T_1	182.95	36.99	58.40	4.03	83.07
T_2	171.43	34.29	47.51	3.11	61.46
T_3	145.47	29.09	19.96	1.14	31.45
T_4	214.01	42.80	73.51	7.12	111.99
T_5	187.83	37.57	61.91	4.46	84.51
T_6	146.7	29.34	22.89	1.16	32.36
T_7	168.67	33.13	48.61	3.32	44.73
SEm (±)	9.55	2.31	5.45	0.71	11.80
CD (5%)	29.414	7.12	16.80	2.20	36.36

Number of functional leaves retained at flower induction is crucial for determining the yield potential. The D-leaf of the pineapple plant is the youngest and physiologically mature leaf which reflects the current nutrient status of the plant with acceptable accuracy. The number of functional leaves indicates the development status of the plant at flower induction stage. A pineapple crop should produce sufficient number of leaves to harness the light energy and synthesize adequate photosynthates for biomass production. Melo *et al.* (2006) also observed that there is a significant and positive correlation between leaf area and shoot dry matter, stem dry matter and fruit mass of 'Perola' pineapple plants. In the present study, T_4 showed better results than T_1 and T_7, which were 100% RDF applied through fertigation and conventional methods respectively without mulch, which might be due to the combination of fertigation and mulching. The differences observed in the plant growth might be due to low N uptake by the plants. The improvement in biometric parameters due to fertigation with 100% RDF and mulching could be ascribed to proper supply and translocation of nutrients with sufficient moisture availability in the root zone of the plants and minimized leaching of nutrients due to mulching. Followed by T_4, the performance of T_5 (80% RDF fertigation with mulch) was better than all other treatments which showed that effective use of fertilizers in combination with mulch can result in better growth and development of the plant. These results are in

Table 4. Effect of different levels of fertigation with or without mulch on fruit biomass and nutrient uptake.

Treat-ment	Fruit fresh weight (t/ha)	Fruit dry weight (t/ha)	Fruit N uptake (kg/ha)	Fruit P uptake (kg/ha)	Fruit K uptake (kg/ha)
T_1	46.53	13.95	180.26	12.14	251.94
T_2	43.17	12.95	140.10	10.33	185.79
T_3	34.91	10.47	55.06	4.30	85.69
T_4	51.92	15.57	223.13	18.55	369.34
T_5	50.28	15.08	199.48	12.83	314.07
T_6	35.81	10.74	69.01	5.40	94.89
T_7	43.09	13.12	137.98	13.09	199.52
SEm (±)	1.910	0.881	14.502	2.501	15.022
CD (5%)	5.882	2.713	44.666	7.703	46.267

accordance with the findings of Bonomo *et al.* (2020), Maneesha *et al.* (2019) and Paoli *et al*. (2017) on the effects of fertigation on pineapple and Tiwari (2017) on the effects of fertigation and black plastic mulch on banana. In the control treatment (soil application of fertilizers without mulch) the same 100% RDF were applied to the soil and the performance could not match with the fertigated treatments with mulching which might be due to leaching loss of the nutrients and presence of weeds in the former. The total dry matter accumulation is one of the factors that determine yield. Post-flowering dry matter accumulation greatly influences fruit yield, since most of the photosynthates produced at this stage are transferred for fruit development. The nutrient uptake which is the product of nutrient concentration and dry matter, varied significantly by various fertigation levels with or without mulching. The higher dry matter content and uptake of plant macronutrients (N, P and K) by plants treated with 100% and 80% RDF with mulch might have resulted due to higher accumulation of all these nutrients in soil by frequent application through fertigation. These results are in consistent with those of Bareily and Deb (2018). In the present study, the NPK fertigation with mulch appreciably increased 16.2 % in terms of yield in plant crop when compared to T_7 where same dose of fertilizer was applied conventionally without mulch. The fertilizer saving through fertigation are presumably because fertilizer and water are applied to soil, in a frequent intervals where active roots are concentrated. Besides mulching might have played a vital role in preventing weed growth which might have helped the crop to absorb the applied nutrient properly without any competition. Moreover, conservation of moisture due to mulching might have improved microclimate both beneath and above the soil surface as compared to non-mulched treatments. The positive influence of fertigation on growth and yield might be the result of higher nutrient uptake by the fertigated crop. The mechanism causing higher uptake through fertigation may perhaps be the combined influence of optimal soil moisture availability in the root zone and reduction in loss of applied nutrients due to application of small quantities in regular intervals to match crop uptake. The present studies corroborate the findings of Pegoraro *et al.* (2014), Hanafi *et al.* (2004).

CONCLUSION

Growth response of pineapple to NPK fertigation with and without mulching indicated that all the treatments were significantly affected by different levels of fertigation. Complete RDF through fertigation and mulch followed by 80% RDF through fertigation and mulch responded better in terms of growth, yield and nutrient uptake in main and ratoon crops. It is concluded that fertigation applied at 80% RDF with mulching can produce equivalent results to the 100% RDF application through fertigation or soil without mulch with regard to growth, fruit yield and nutrient uptake in pineapple crop.

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