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Full Length Research Paper

Drip and micro sprinkler irrigation on pollen characteristics in cocoa (*Theobroma cacao* L.)

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An experiment was conducted during 2010 and 2011 to investigate the impact of N, P and K fertilizers through fertigation on pollen features of cocoa was conducted at Tamil Nadu Agricultural University, India. The study was laid out in randomized block design with thirteen treatment combinations. The study shown that, fertigation with 125 % Recommended Fertilizer Dose as water soluble fertilizer through fertigation by micro sprinkler irrigation (T_{10}) recorded the highest number of pollen characters *viz*., area of pollen grain (504.1 µm^2), equivalent diameter of the pollen grain (27.4 microns), radius of the pollen grain (13.3 microns), pollen output (34.9), pollen viability (89.2 %), pollen germination (88.1 %) and pollen tube length.

Key words: Fertigation, fertilizer, drip, micro sprinkler, pollen grains.

INTRODUCTION

India offers considerable scope for cocoa cultivation, production and further development. Though cocoa has been known as the beverage crop even before tea and coffee, it is relatively a new crop to India. Cocoa readily 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 beans in cocoa (single bean weight of more than 2g) will enable the farmers to earn more income. Being a shallow rooted crop, cocoa requires frequent doses of fertilizers coupled with soil moisture to utilize the nutrients more effectively.

Fertigation ensures higher fertilizer use efficiency, besides providing scope for making soil amendments and even biological methods of plant protection. In the fertigation method, fertilizers can be applied throughout the crop growing season in phased manner, in various split doses, in any desired concentration. This is in contrast to the conventional practice where larger amounts of fertilizers are placed on the soil at the beginning of the season in one or very few split doses (Dangler and Locascio, 1990).

Considering the high yield potential in cocoa, nutrient application with due consideration on various crop growth stages *viz*., vegetative, flowering, pod set, pod development and maturity will help in realizing the potential yield (Krishnamoorthy and Rajamani, 2013). Flowering is cauliflorous and flowering cycle follows certain seasonal patterns. In India, it occurs from January to February with a peak in July to August. Flowering and fruit set are the most critical events occurring after establishment of a crop (Davenport and Nunez-Elisea, 1990). Fertilization at proper time and proper dose will increase the pod yield. Pollen growth in cocoa is determined by multi various factors like genetic factor, environmental factors, age of the tree, plant growth hormones, availability of soil moisture and nutrients as reported by Thondaiman (2011). Hence, the study was undertaken to evaluate the pollen characters of cocoa using different fertigation schedules by drip and micro sprinkler irrigation.

MATERIALS AND METHODS

Six year old cocoa trees were selected for the study. In coconut plantation of thirty year old, the cocoa plants are intercropped with a spacing of 3 x 3 m. In case of drip irrigation, two emitters were installed with a discharging rate of 8 lph (litres per hour). Two micro sprinklers trans-

Table 1. Treatment details of the experiment.

Treatments	Dosage	Method of application / irrigation
T_1	100 % RDF	Surface application + flood irrigation (control)
T_2	75 % RDF as WSF	Drip
T_3	100 % RDF as WSF	Drip
T_4	125 % RDF as WSF	Drip
T_5	75 % RDF as straight fertilizers	Drip
T_6	100 % RDF as straight fertilizers	Drip
T_7	125 % RDF as straight fertilizers	Drip
T_8	75 % RDF as WSF	Micro sprinkler
T_9	100 % RDF as WSF	Micro sprinkler
T_{10}	125 % RDF as WSF	Micro sprinkler
T_{11}	75 % RDF as straight fertilizers	Micro sprinkler
T_{12}	100 % RDF as straight fertilizers	Micro sprinkler
T_{13}	125 % RDF as straight fertilizers	Micro sprinkler

RDF - Recommended dose of fertilizer
WSF - water soluble fertilizer

Table 2. Effect of drip and micro sprinkler fertigation on area and equivalent diameter of the pollen grain at various seasons.

Treatments	Area of the pollen grain (µm^2)			Equivalent diameter of the pollen grain (Microns)		
	1st season	2nd season	Mean	1st season	2nd season	Mean
T_1	309.5	311.6	310.6	20.3	21.6	20.9
T_2	337.6	348.9	343.2	21.7	21.9	21.8
T_3	395.1	438.9	417.0	23.7	23.8	23.7
T_4	451.6	386.3	418.9	24.7	25.4	25.0
T_5	317.1	322.6	319.8	21.0	21.6	21.3
T_6	351.3	364.7	358.0	22.0	22.5	22.3
T_7	393.1	400.7	396.9	23.3	23.9	23.7
T_8	457.3	422.8	440.1	25.0	24.9	24.9
T_9	497.5	486.1	491.8	26.3	26.6	26.5
T_{10}	509.8	498.3	504.1	27.7	27.1	27.4
T_{11}	452.5	473.7	463.1	24.7	24.3	24.5
T_{12}	464.4	459.6	462.0	25.0	25.0	25.0
T_{13}	496.9	478.6	487.7	26.0	25.9	25.9
SEd	9.18	8.74		0.43	0.42	
CD (0.05)	18.95	18.04		0.89	0.88	
CD (0.01)	25.82	24.59		1.22	1.19	

mitting @ 60 lph micro sprinkler^{-1} were installed to cover the entire basin. The micro sprinkler type is half sub circle with a height of 30 cm and it has sprinkling capacity of 60 cm area. The venturi was used for mixing of fertilizer with water.

Design of the Experiment - Randomized Block Design (RBD)

Number of Replications - Three

Total number of treatments - Thirteen (Table 1) (Krishnamoorthy and Rajamani, 2013)

An annual application of 100 g N, 40 g P_2O_5 and 140 g K_2O through the mode of surface irrigation (T_1) is recommended for annual basis per tree in two splits (1st dose in 1st week of April and 2nd dose in 1st week of September). Surface irrigation was carried out once in seven day's interval. The fertilizers were applied through drip and micro sprinkler irrigation system (fertigation) at weekly intervals for drip and micro sprinkler treatments (T_2 to T_{13}) and the irrigation was carried out once in a day (20 litres tree^{-1} day^{-1}).

The geometry of the pollen grains was studied during 2010 and 2011. Pollens grains were collected from freshly dehisced anthers by gently tapping the anthers on glass slides which containing a drop of glycerol. Then cover slips were placed over the pollens and slides were observed under a microscope with the aid of ocular and stage micrometers (Mishra et al., 2006) connected with a computer in ordinary light. The observations were recorded

Table 3. Effect of drip and micro sprinkler fertigation on radius and perimeter of the pollen grain at various seasons.

Treatments	Radius of the pollen grain (Microns)			Perimeter of the pollen grain (Microns)		
	1st season	2nd season	Mean	1st season	2nd season	Mean
T_1	10.0	10.1	10.1	75.0	77.3	76.1
T_2	10.2	10.2	10.2	79.3	78.7	78.9
T_3	11.9	11.8	11.9	82.8	81.4	82.1
T_4	12.1	11.9	12.1	85.8	82.9	84.4
T_5	10.2	10.2	10.2	77.3	77.7	77.5
T_6	11.2	11.1	11.1	79.5	78.2	78.9
T_7	11.7	11.5	11.6	82.8	83.9	83.4
T_8	12.4	12.2	12.3	93.7	89.7	91.7
T_9	13.2	13.1	13.1	97.8	99.3	98.6
T_{10}	13.3	13.3	13.3	98.9	96.2	97.5
T_{11}	12.4	12.6	12.5	87.4	86.5	86.9
T_{12}	12.5	12.9	12.7	96.0	97.7	96.9
T_{13}	12.9	13.1	12.9	97.8	95.6	96.7
SEd	0.22	0.22		1.60	1.58	
CD (0.05)	0.45	0.45		3.30	3.27	
CD (0.01)	0.61	0.61		4.50	4.45	

from 50 pollen grains in each treatment and the data were analyzed in Q 500 MC WIN software programme.

RESULTS

In the present study, high variation was noticed in the pollen characters with various fertigation treatments. The trees which received 125 % RDF as WSF through fertigation by micro sprinkler irrigation (T_{10}) registered the highest pollen grain area (509.8 and 498.3 μm^2) and equivalent diameter of the pollen grain (27.7 and 27.1 microns) (Table 2).

The same treatment (T_{10}) registered more radius of the pollen grain (13.3 and 13.3 microns) during first and second season in 2011. The highest perimeter of the pollen grain was recorded in T_{10} *i.e*. 125 % RDF as water soluble fertilizer through fertigation by micro sprinkler irrigation (98.9 microns) during first season in 2011 (Table 3). During second season, the T_9 *i.e*. 100 % RDF as water soluble fertilizer through fertigation by micro sprinkler irrigation registered highest value (99.3 microns). Among the several treatments, the treatment which received 125 % RDF as water soluble fertilizer through fertigation by micro sprinkler irrigation recorded more pollen output (34.9), pollen viability (89.2 %) and pollen germination (88.1 %) during 2011 (Table 4).

The control *i.e.* 100 % of RDF as surface application with flood irrigation (T_1) registered minimum pollen tube length (12.8, 60.9, 142.6, 183.0, 262.5, 306.6 microns and 12.4, 54.9, 130.4, 190.7, 274.1, 290.1 microns) at 1, 5, 10, 15, 20 and 25 hours after dehiscence of anther) during first and second season in 2011 (Table 5).

DISCUSSION

Among the different combinations, water soluble fertilizer with micro sprinkler irrigation showed better results. The micro climate under the canopy of cocoa tree under micro sprinkler irrigation is generally cool which leads to reduction in leaf temperature and reduced transpiration rate. Hence water content in plant is maintained at higher side which results in increased photosynthesis rate. Better photo-assimilates and hormonal balance would have improved the sink strength of trees treated with cent % RDF through micro sprinkler fertigation (subjected to higher levels of available nutrients through fertigation) through acceleration of mega and microsporogenesis and differentiation of axillary buds into reproductive ones. Takahashi et al. (1993) also found that higher level of N, P and K resulted in increased area of the pollen grain.

Application of water soluble fertilizers through micro sprinkler fertigation registered better results in pollen parameters like equivalent diameter, radius, perimeter, pollen output, pollen viability, pollen germination and pollen tube length. These might be due to enhanced level of auxin-like substances which would have been triggered by split application of WSF through micro sprinkler fertigation. High pollen output, increased pollen germination are the main factors contributing to increase the pod set. High level of auxin-like substances may promote flowering parameters either by nullifying the effect of GA_3 (or) by decreasing the permeability of cell membrane, particularly the plasmalemma (Serenella Nardia et al., 2002). Kristina Batelja Lodeta et al. (2010) also supported this by stating that amino-succinamic acid (B 995) increases the membrane permeability. Many plant growth substances develop a strong physical association

Table 4. Effect of drip and micro sprinkler fertigation on pollen output (numbers), pollen viability (%) and pollen germination (%) at various seasons.

Treatments	Pollen output / 10 anthers			Pollen viability (%)			Pollen germination (%)		
	1st season	2nd season	Mean	1st season	2nd season	Mean	1st season	2nd season	Mean
T_1	25.4	24.5	24.9	72.1	75.3	73.7	52.5	59.4	55.9
T_2	27.0	26.3	26.7	74.7	76.0	75.4	63.1	74.4	68.8
T_3	29.3	28.5	28.9	76.5	77.7	77.1	71.3	66.8	69.0
T_4	30.5	30.7	30.6	80.2	79.5	79.8	76.9	79.0	78.0
T_5	30.9	30.6	30.8	74.9	76.9	75.9	54.6	70.6	62.6
T_6	30.9	31.0	30.9	78.4	75.4	76.9	78.5	72.3	75.4
T_7	31.0	31.9	31.5	76.9	78.0	77.5	75.6	74.6	75.1
T_8	32.3	31.0	31.7	79.9	81.9	80.9	82.0	80.9	81.5
T_9	33.8	33.6	33.7	88.7	89.7	89.2	90.9	84.6	87.8
T_{10}	34.5	35.4	34.9	90.5	87.8	89.2	88.7	87.4	88.1
T_{11}	30.6	31.1	30.9	82.3	84.4	83.4	79.3	81.4	80.4
T_{12}	32.0	33.2	32.6	86.3	82.5	84.4	86.0	78.9	82.5
T_{13}	33.4	33.5	33.4	86.0	83.2	84.6	81.7	93.2	87.5
SEd	0.54	0.55		1.39	1.35		1.61	1.47	
CD (0.05)	1.11	1.14		2.86	2.79		3.33	3.03	
CD (0.01)	1.51	1.56		3.89	3.80		4.54	4.13	

Table 5. Effect of drip and micro sprinkler fertigation on pollen tube length (Microns).

Treatments	Hours after dehiscence of anther											
	1st season						2nd season					
	1	5	10	15	20	25	1	5	10	15	20	25
T_1	12.8	60.9	142.6	183.0	262.5	306.6	12.4	54.9	130.4	190.7	274.1	290.1
T_2	14.7	76.9	153.3	197.3	273.9	332.8	14.1	72.3	133.4	196.9	283.0	301.8
T_3	14.9	78.6	151.0	216.3	280.4	323.4	14.2	69.3	149.7	208.1	282.4	310.4
T_4	15.0	81.5	143.5	210.6	281.6	318.8	16.8	59.7	150.3	206.9	285.3	320.5
T_5	14.7	61.9	164.7	199.8	276.7	309.4	14.3	56.6	135.0	204.6	290.5	306.2
T_6	14.2	61.3	148.7	200.5	284.8	312.8	15.4	62.8	140.0	226.4	280.6	304.6
T_7	15.2	70.3	162.8	216.9	289.1	310.7	15.6	71.5	138.9	214.3	291.9	312.5
T_8	19.2	96.8	168.2	240.4	314.9	336.1	18.0	76.6	178.2	229.6	301.8	330.9
T_9	24.3	91.7	174.1	238.2	300.4	347.2	24.8	108.3	182.8	240.8	318.3	352.4
T_{10}	19.2	100.8	170.0	233.6	306.2	341.1	17.4	94.6	172.8	238.9	316.7	368.7
T_{11}	18.9	120.4	169.3	220.6	292.6	325.8	18.2	83.0	170.4	231.6	311.0	331.7
T_{12}	20.6	98.1	178.8	219.7	314.0	348.7	20.7	99.7	174.3	244.8	308.9	354.1
T_{13}	22.6	100.4	183.9	234.5	299.8	354.9	26.9	99.1	186.9	236.8	313.5	360.7
SEd	0.42	2.13	2.81	3.81	4.86	5.47	0.47	1.99	3.13	3.89	4.91	5.69
CD (0.05)	0.87	4.39	5.81	7.86	10.03	11.28	0.96	4.11	6.45	8.02	10.14	11.75
CD (0.01)	1.19	5.98	7.91	10.71	13.67	15.38	1.31	5.60	8.80	10.93	13.81	16.01

with lecithin and have direct influence on cell membrane functions as opined by Keith Cowan (2006).

CONCLUSION

Fertigation studies on cocoa through micro sprinkler irrigation with a dose of 100 or 125 % RDF as water soluble fertilizer (WSF) has shown increase in pollen characters like area of pollen grain**,** equivalent diameter of the pollen grain, radius of the pollen grain, pollen output, pollen viability, pollen germination, pollen tube length. Water applied through micro sprinkler irrigation nearer to the root zone always maintains soil moisture in field capacity range, no moisture stress and favourable micro climate occur during the pollen formation stage and

thereby the premature flower and pod drop was minimized. This might have resulted in higher per cent of pod set as evident from Thondaiman (2011).

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