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Influence of Drip Irrigation and Plastic Mulch on Young Cashew (*Anacardium occidentale* L.)

Santosh D.T.[1], K.N. Tiwari[2] and Sagar Maitra[1*]

[1]Center for Smart Agriculture, Centurion University Technology and Management, Odisha, India
[2]Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur, West Bengal, India

*Corresponding author: sagar.maitra@cutm.ac.in

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ABSTRACT

A field trial was conducted on the lateritic sandy loam soils of Kharagpur, West Bengal, India, during 2017-2020 to access the efficacy of different drip irrigation levels with and without plastic mulch on growth and yield of cashew (*Anacardium occidentale* L.). Three levels of irrigation water applied through the drip, ring basin irrigation method combined with plastic mulch experimented with three replications on cashew plants. Reference evapotranspiration was estimated using the FAO-56 Penman-Monteith approach. The cashew crop water requirement was calculated using reference evapotranspiration data and crop co-efficient for different crop growth stages. The irrigation water was applied at 60%, 80%, and 100% of the crop water requirement. Irrigation intervals were at 2 and 5 days respectively in drip and ring basin irrigation treatments. The water requirement of the Cashew crop varies between 15.4 L (1.2 mm) per day per plant in the winter season and 39.1 L (3.1 mm) per day per plant in the summer season for 100% water requirement treatment at the peak growth stage. Among the different irrigation levels tested, application of 100 % volume of water through drip irrigation with plastic mulch at (VDM) recorded maximum height (4.22 m), girth (56.55 cm), canopy (4.95 m), number of Primary branches (3.67), secondary branches (13.67) and yield (1.23 t ha^{-1}) comparing to all other treatments.

HIGHLIGHTS

- Estimatition of crop water requirement of Cashew under drip and plastic mulch.
- Performance of three year old cashew under different irrigation levels.

Keywords: Cashew, drip irrigation, plastic mulch, crop water requirement

Cashew (*Anacardium occidentale* L.), a native of Brazil, was introduced in India during the second half of the sixteenth century for afforestation and soil conservation. From its humble beginning as a crop intended to check soil erosion, cashew has emerged as a major foreign exchange earner next only to tea and coffee. Cashew nut is one of the essential nuts grown in the world and ranks first. In India, cashew was cultivated in 10,62,000 ha in 2017-18 with a production of 8,17,000 tonnes, and productivity was 1.29 t/ha (GoI, 2018).

Water is one of the essential inputs in crop production, and it is also a limiting natural resource (FAO, 2017; Zaman *et al*. 2017; Singh *et al*. 2021). Considering the shrinkage of water resources worldwide, smart and efficient irrigation methods are to be adopted to increase water productivity (Maitra and Pine, 2019). Out of the several irrigation methods, drip irrigation is the most water-saving and energy-efficient system. The available literature

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reports that there is 50 to 70 percent saving in irrigation water and 10 to 70 percent increase in yield of fruits and vegetable crops by using drip irrigation (Tiwari *et al*. 2014; Patil and Tiwari, 2018; Santosh and Tiwari, 2017, 2019 and Santosh and Maitra,2021). Mulching has a beneficial effect on soil moisture conservation, early production, and reducing the incidence of weeds, pests, and diseases (Pedda Ghouse Peera *et al*. 2020). Use of different types of soil covers or mulches like straw, leaves, husk, crop residues, and black plastics have been found to conserve moisture, control weeds, moderate soil temperature, and increase in yield of different vegetables (Santosh and Maitra, 2021). The response of cashew plants to the combined effect of drip irrigation and plastic mulch and influence on plant growth and development in West Bengal conditions have not been established. Moreover, the root system of cashew plants at young age is very shallow and not capable of withstanding during heavy wind, so soil water management is one of the crucial during this time as it has a greater influence on optimum root growth and nutrient availability. Hence, an experiment was conducted to evaluate crop water requirement and to study the effect of different irrigation levels with drip on the growth and development of young cashew under mulch and non-mulch conditions.

MATERIALS AND METHODS

Location and soil of the experimental field

The experiment was conducted at the experimental farm of the Agricultural and Food Engineering Department, IIT, Kharagpur, India (22°19` N, 87°19` E, 48 m) during 2017-20. The site consisted of red lateritic soil with a sandy loam texture (18.4% clay, 22.6% silt, and 59.0%sand), a maximum water holding capacity of 14.9%, bulk density 1.44 g cm^{-3}, and a steady state infiltration rate of 10 mm h^{-1}.

Treatments and field preparation

Cashew plants of V4 variety were transplanted at a spacing of 5m × 5m during the rainy season (July) in 2017 on 1000 m^2 area. An experiment was laid out in randomized block design (RBD) with 8 treatments and 3 replications. Details of the experimental layout are shown in Fig. 1. Standard cultural practices for cashew cultivation were followed as per the recommendations. The irrigation treatments were given based on the estimated amount of daily crop water requirement and methods of irrigation system. The various treatments for the experiment were as follows:

- T_1 (VD): 100% irrigation requirement with drip without mulch.
- T_2 (VD+PM): 100% irrigation requirement with drip with mulch.
- T_3 (0.8VD): 80% irrigation requirement with drip without mulch.
- T_4 (0.8VD+PM): 80% irrigation requirement with drip with mulch.
- T_5 (0.6VD): 60% irrigation requirement with drip without mulch.
- T_6 (0.6VD+PM): 60% irrigation requirement with drip with mulch.
- T_7 (RB+PM): 100% irrigation requirement under ring basin method with mulch.
- T_8 (RB): 100% irrigation requirement under ring basin method without mulch.

Estimation of water requirement and irrigation application

Reference crop evapotranspiration (ET_0) was estimated using FAO-56 Penman-Monteith approach (Allen *et al*. 1998). The values of crop coefficient (Kc) suggested by Allen *et al*. (1998) were considered. The actual evapotranspiration was estimated by multiplying reference evapotranspiration and crop coefficients for different months. The crop water requirement of cashew was estimated by using the following equations:

$$ET_0 = \frac{0.408\Delta\left(R_n - G\right) + \frac{\gamma(900)}{T+273}u_2\left(e_s - e_a\right)}{\Delta + \gamma\left(1 + 0.34u_2\right)} \quad \ldots(1)$$

Where,

ET_0 = reference evapotranspiration [mm day^{-1}]

R_n = net radiation at the crop surface [mj m^{-2} day^{-1}],

G = soil heat flux density [mj m^{-2} day^{-1}],

$e_s - e_a$ = saturation vapor pressure deficit [kPa],

e_s = saturation vapor pressure at T_c [kPa],

e_a = actual vapor pressure [kPa],

Δ = slope of the saturation vapor pressure temperature relationship [kPa $^0C^{-1}$]

γ = psychrometric constant [kPa $^0C^{-1}$] and

u_2 = wind speed at 2 m height [m s^{-1}]

$$IR = ET_o \times Kc - Re \quad \ldots(2)$$

Where

IR - Net depth of irrigation (mm day^{-1})

ET_0 - Reference evapotranspiration (mm day^{-1})

Kc - Crop coefficient

Re - Effective rainfall (mm day^{-1})

The net volume of water required by the plant can be calculated by the relationship

$$V = IR \times A \quad \ldots(3)$$

Where

V- Net volume of water required by a plant (L day^{-1} $plant^{-1}$)

A- Area under each plant (i.e., spacing between rows, *m* × spacing between plants, *m*)

Effective rainfall is the part of the rainfall that forms the part of the consumptive use. After subtracting the effective rainfall from the total irrigation requirement (Eq. 2). The water requirement was estimated for the cashew plant for three years using Eq. 3.

RESULTS AND DISCUSSION

Estimated water requirement in cashew

Reference crop evapotranspiration (ET_0) was estimated using the FAO-56 modified Penman method using weather data for three consecutive years. The actual evapotranspiration was estimated by multiplying reference evapotranspiration with crop canopy coefficient for different years based on the establishment of crop canopy. Crop canopy coefficient was found as 0.45, 0.5, and 0.55 for three years for canopy covers of 1.25, 1.48, and 1.79 m, respectively. Wetting area for drip was considered as 30%, 40%, and 50% for the first, second, and third year, respectively. As the crop canopy and root area increase with plant age, the wetting area also increased. The daily irrigation water requirement for the cashew plant was estimated by subtracting the effective rainfall from the calculated evapotranspiration. The estimated quantity of water applied to cashew was 605, 663, and 745 mm per year for the first, second, and third year, respectively. This trend showed a steady increase in water requirement with increased plant age. Average daily crop evapotranspiration values for different months in different years were presented in Table 1. The irrigation water requirement of cashew varied from 7.8 to 17.6 L day^{-1} $plant^{-1}$ for the first year, 12.4 to 26.1 L day^{-1} $plant^{-1}$ for the second year, and 15.4 to 36.1 L day^{-1} $plant^{-1}$for the third year.

Table 1: Estimated water requirement of Cashew crop for consecutive three years (2017-20)

Months	ET_o (mm day^{-1})			ET_C (mm day^{-1})			Water Requirement (L $plant^{-1}$ day^{-1})		
	First Year	Second Year	Third Year	First Year	Second Year	Third Year	First Year	Second Year	Third Year
January	2.42	2.56	2.39	1.1	1.3	1.3	8.2	12.8	16.4
February	3.15	3.29	3.16	1.4	1.6	1.7	17.7	16.5	21.7
March	4.25	3.87	4.57	1.9	1.9	2.5	23.9	19.4	31.4
April	5.00	4.49	5.68	2.2	2.2	3.1	28.1	22.5	39.1
May	5.22	5.21	4.97	2.3	2.6	2.7	29.4	26.1	34.2
June	4.72	4.67	4.66	2.1	2.3	2.6	26.6	23.4	32.0
July	3.79	3.59	3.71	1.7	1.8	2.0	21.3	18.0	25.5
August	3.65	3.57	3.76	1.6	1.8	2.1	20.6	17.9	25.9
September	3.42	3.49	3.44	1.5	1.7	1.9	19.2	17.5	23.7
October	3.32	3.51	3.13	1.5	1.8	1.7	18.7	17.6	21.5
November	2.94	2.90	2.88	1.3	1.5	1.6	16.5	14.5	19.8
December	2.32	2.47	2.24	1.0	1.2	1.2	13.0	12.4	15.4

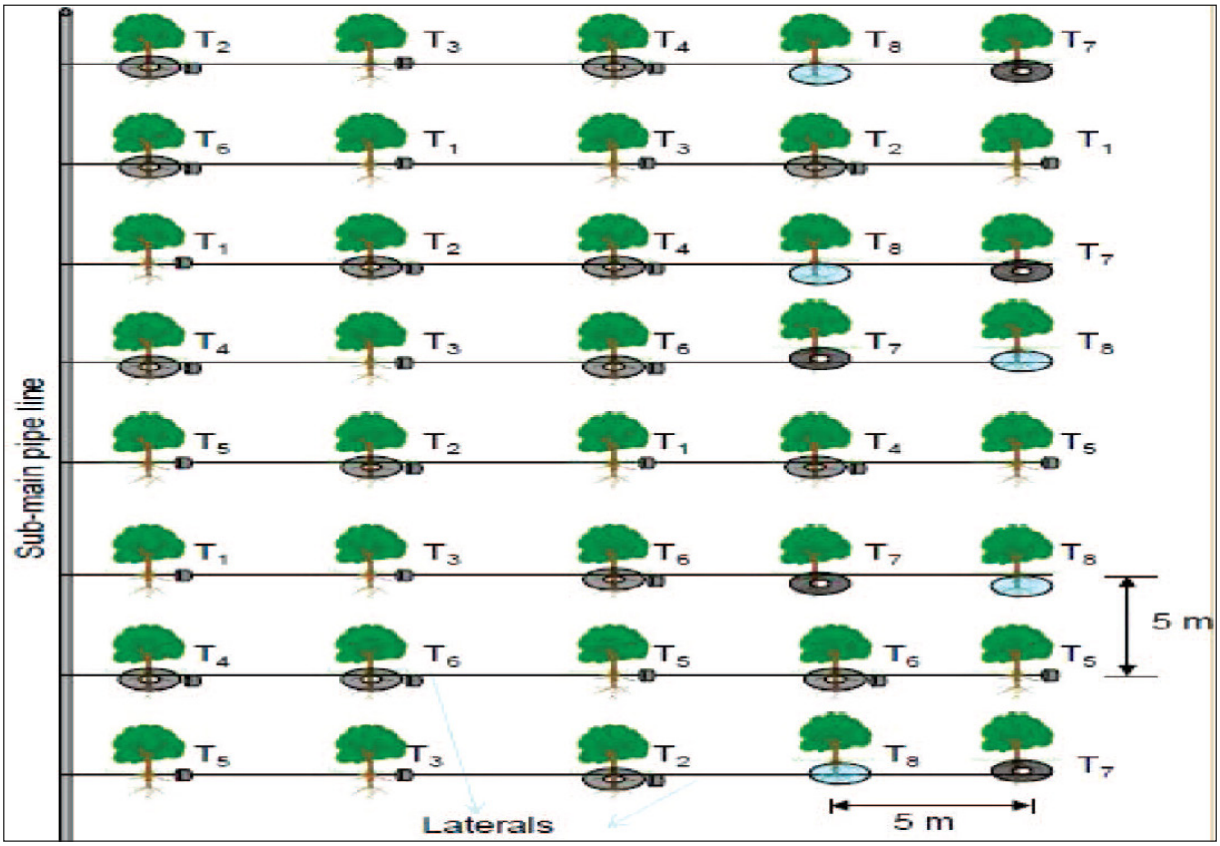

Fig. 1: Schematic layout of experimental plot

Effect of irrigation levels on biometric attributes of cashew

Treatment-wise biometric observations of the crop were recorded from 2017 to 2020. Table 2 showed the pooled values of biometric attributes, namely, plant height, stem girth, canopy coverage, primary and secondary branches, and yield under different treatments. From Table 2, it was revealed that drip irrigation with plastic mulch has a significant influence on plant growth and yield compared to ring basin irrigation with and without mulch (T_7 and T_8).

Significant influence of drip irrigation and plastic mulch was observed on the vegetative growth. Profuse flowering and fruit set were also observed though plants were in their young age. Based on analysis of biometric observations, maximum height (4.22 m) was obtained in the treatment (VD+ PM) followed by treatment (0.8 VD) 3.95 m and treatment (VD) 3.75 M and least plant height was recorded in-ring basin treatment due to water loss and non-uniform moisture availability to plant. In the case of the girth of a plant, the maximum value was recorded in treatment (VD + PM) (56.55 cm) followed by VD (54.99) and 0.6VD + PM (54.90), but the least value was recorded in 0.8 VD (52.23); however, it did not show any significant difference among the treatments. Large canopy size (4.95 m) was observed in VD + PM treatment (T_2), and least was in-ring basin (T_8). Moreover, the treatment 0.8 VD + PM (T_4) was at par with treatment T_2, which is recorded the highest canopy area in the expression of canopy length, and they were significantly superior to other treatments. A number of primary branches failed to show the significant difference among the treatments. Still, the highest number of primary branches (3.67 plant^{-1}) was noted in treatment VD + PM (T_2), and the least is in-ring without mulch (T_8). But the number of secondary branches did not show a significant difference among the treatments. However, the highest number of branches was recorded in the treatment VD + PM (13.67 plant^{-1}).

The yield data presented in Table 2 showed that cashew yield was also significantly different among different treatments. Maximum yield of 1.23 t ha^{-1} was recorded with T_2 (VD+PM), and the second-

Table 2: Biometric observation of three-year-old cashew

Treatment	Average height (m)	Average girth (cm)	Canopy (E-W) (m)	Number of primary branches	Number of secondary branches	Yield (t ha^{-1})
T_1 (VD)	3.75	54.99	4.47	3.00	12.67	0.97
T_2 (VD+PM)	4.22	56.55	4.95	3.67	13.67	1.23
T_3 (0.8 VD)	3.95	52.23	4.10	3.00	12.33	0.91
T_4 (0.8 VD+PM)	3.47	54.78	4.82	3.33	13.33	1.08
T_5 (0.6 VD)	2.99	53.22	3.95	2.33	11.33	0.87
T_6 (0.6 VD+PM)	2.81	54.90	4.10	2.67	11.67	0.90
T_7 (RB+PM)	2.74	53.57	3.77	2.33	12.00	0.79
T_8 (RB)	2.56	53.83	3.40	2.33	10.67	0.66
CD (0.05)	0.12	NS	0.48	NS	1.28	0.22

highest yield was obtained from T_4 (0.8VD+PM) treatment (1.08 t ha^{-1}). With the same level of irrigation water applied in two treatments, the yield was consistently more significant in the case of plastic mulch-treated plants. This could be due to moisture conserved and greater water availability to plants than non-mulched conditions, as was found for Sapota by Tiwari *et al*. (2014). The lowest yield was recorded under the ring basin irrigation method without plastic mulch (0.66 t ha^{-1}). This might be due to water stress during the critical growth period, coupled with aeration problems immediately after irrigation in the first few days. Another reason to get low yield by surface irrigation might be due to insufficient nutrients for crop growth because of high weed infestation. This result is corroborated with the findings of Senapti *et. al.* (2021) and Tiwari *et al*. (2014).

CONCLUSION

The study revealed that about 745 mm of water is needed to meet the irrigation requirement of three-year-old cashew plants grown under sub-tropical and sub-humid climatic conditions of Kharagpur, West Bengal. Daily water requirement of young cashew plants varied from 15.4 to 36.1 L day^{-1} $plant^{-1}$, which could be supplied by using two online drip emitters of 4 L h^{-1} capacity for each plant. Estimated water requirement value for young cashew plants can be used for similar agro-climatic condition. Cent percent irrigation requirement met with drip and black plastic mulch showed superiority over all other treatments in respect of plant growth and development of cashew crops at juvenile period. The present study concludes that young cashew plants may be irrigated with 100% irrigation water through drip irrigation with black plastic mulching.

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