Journal of Agricultural Engineering and Food Technology
p-ISSN: 2350-0085; e-ISSN: 2350-0263; Volume 3, Issue 3; July-September, 2016 pp. 221-224

http://www.krishisanskriti.org/Publication.html

Effect of Drip Irrigation and Plastic Mulch on Young Cashew Plants

K.N. Tiwari[1], A.R. Reddy[2], Santosh D.T.[3] and V.K. Singh[4]

Department of Agricultural and Food Engineering
IIT Kharagpur, West Bengal-721302
E-mail: [2]rajbckv@gmail.com

Abstract—*A field trial was conducted on the lateritic sandy loam soils of Kharagpur, West Bengal, India during 2012-2015 with an objective 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 drip, ring basin irrigation method in combination with plastic mulch were experimented with three replications on cashew plants. Reference evapotranspiration was estimated using 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 Cashew crop varies between 15.4 L (1.2 mm) per day per plant in winter season and 39.1 L (3.1 mm) per day per plant in summer season for 100% water requirement treatment at peak growth stage. Among the different irrigation levels tested, application of 100 % volume of water through drip irrigation with plastic mulch at (VDM) (T2)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.*

1. INTRODUCTION

Cashew (*Anacardium occidentale*) crop, a native of Brazil, was introduced in India during the later half of the sixteenth century for the purpose of 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 important nuts grown in the world and ranked first. Among various nuts such as hazelnuts, almonds, etc., Out of the several irrigation methods, drip irrigation is the most water saving and energy efficient system. The available literature reports that there is 50 to 70 per cent saving in irrigation water and 10 to 70 per cent increase in yield of fruits and vegetable crops by using drip irrigation [1-4].

Mulching has beneficial effect on early production and reduction in the incidence of insect, pest and diseases. 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 [5]. The response of cashew plants to the combine effect of drip irrigation and plastic mulch and influence on plant growth and development in West Bengal situation have not been established. Moreover, the root system of cashew plants in young age is very shallow and not capable to withstand during heavy wind, so soil water management is one of the crucial events during this time as it has 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 levels of irrigation with drip on growth and development of young cashew plants under mulch and non mulch conditions.

2. MATERIALS AND METHODS

2.1 Location and Soil of Experimental Field

The experiment was conducted at the experimental farm of Agricultural and Food Engineering Department, IIT, Kharagpur, India (22°19` N, 87°19` E, 48 m) during 2012-15. The site consisted of a 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}.

2.2 Treatment Details

Cashew plants of V4 variety were transplanted at a spacing of 5m × 5m during rainy season (July) in the year 2012 on 1000 m^2 area. Experiment was laid out in randomized block design (RBD) with 8 treatments and 3 replications. Details of the experimental layout are shown in Figure 1. Standard cultural practices for cashew crop 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:

T1 (VD): 100% water requirement with drip without mulch

T2 (VDM): 100% water requirement with drip and mulch

T3 (0.8VD): 80% water requirement with drip without mulch

T4 (0.8VDM): 80% water requirement with drip and mulch

T5 (0.6VD): 60% water requirement with drip without mulch

T6 (0.6VDM): 60% water requirement with drip and mulch

T7 (RBM): 100% water requirement under ring basin method with mulch

T8 (RB): 100% water requirement under ring basin method without mulch

2.3 Estimation of Water Requirement

Reference crop evapotranspiration (ET_0) was estimated using FAO-56 Penman Monteith approach [6]. The values of crop coefficient (Kc) suggested by [6] 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.

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

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 ^{0}C^{-1}]

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

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

IR = ETo x Kc - Re ------ (2)

Where

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

ETo- 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 x A ------ (3)

Where

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

Area under each plant (i.e. spacing between rows, m x spacing between plants, m)

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

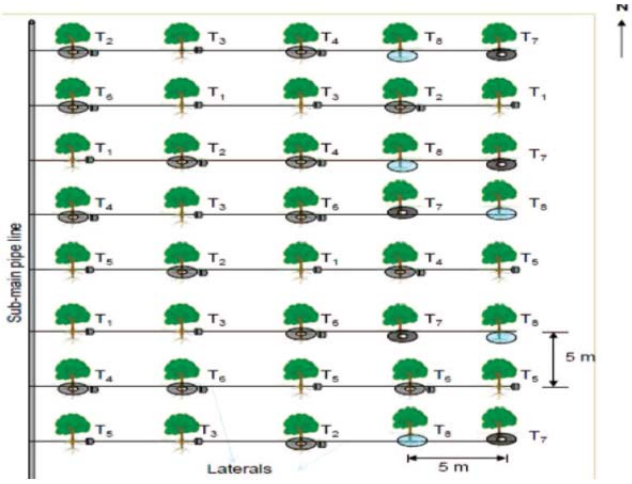

Fig. 1: Schematic layout of experimental plot

3. RESULTS AND DISCUSSION

3.1. Estimated water requirement for Cashew

Reference crop evapotranspiration (ET_o) was estimated using the FAO-56 modified Penman method using weather data for consecutive three year. The actual evapotranspiration was estimated by multiplying reference evapotranspiration with crop canopy coefficient for different year based on establishment of crop canopy. Crop canopy coefficient found as 0.45, 0.5 and 0.55 for three years for canopy covers of 1.25, 1.48 & 1.79 m respectively. Wetting area for drip was considered as 30%, 40% and 50% for first, second and third year respectively. As crop canopy and root area increases with plant age similarly wetting area also increases. 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 plants was 605, 663 and 745 mm per year for first, second and third year respectively. This trend shows steady increase in water requirement with increase in plant age. Average daily crop evapotranspiration values for different months in different years are tabulated in Table 1. The irrigation water requirement of cashew varies, from 7.8 to 17.6 L day^{-1} plant^{-1} for first year, 12.4 to 26.1 L day^{-1} plant^{-1} for 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 (2012-2015)

Months	ET_C (mm day $^{-1}$)			Water Requirement (L plant^{-1} day^{-1})		
	1st Year	2nd Year	3rd Year	1st Year	2nd Year	3rd Year
January	1.1	1.3	1.3	8.2	12.8	16.4
February	1.4	1.6	1.7	17.7	16.5	21.7
March	1.9	1.9	2.5	23.9	19.4	31.4
April	2.2	2.2	3.1	28.1	22.5	39.1
May	2.3	2.6	2.7	29.4	26.1	34.2
June	2.1	2.3	2.6	26.6	23.4	32.0
July	1.7	1.8	2.0	21.3	18.0	25.5
August	1.6	1.8	2.1	20.6	17.9	25.9
September	1.5	1.7	1.9	19.2	17.5	23.7
October	1.5	1.8	1.7	18.7	17.6	21.5
November	1.3	1.5	1.6	16.5	14.5	19.8
December	1.0	1.2	1.2	13.0	12.4	15.4

3.2 Effect of irrigation levels on biometric properties of cashew plant

Treatment wise biometric observations of the crop were recorded from 2012 to 2015. Table 2 shows the pooled values of biometric attributes (plant height, girth, canopy coverage, primary & secondary branches and yield) under different treatments. From the Table 2, it is revealed that the drip irrigation with plastic mulch has the significant influence on plant growth and yield in comparison to ring basin irrigation with and without mulch (T_7 & T_8).

Table 2: Biometric observation of three year cashew plant

Treatment	Height (m)	Girth (cm)	Canopy (E-W) (m)	No. of Secondary branches	Yield (t ha^{-1})
VD	3.75	54.99	4.47	12.67	0.97
VD+PM	4.22	56.55	4.95	13.67	1.23
0.8 VD	3.95	52.23	4.10	12.33	0.91
0.8 VD+PM	3.47	54.78	4.82	13.33	1.08
0.6 VD	2.99	53.22	3.95	11.33	0.87
0.6 VD+PM	2.81	54.90	4.10	11.67	0.90
RB+PM	2.74	53.57	3.77	12.00	0.79
RB	2.56	53.83	3.40	10.67	0.66
CD (0.05)	0.12	NS	0.48	1.28	0.22

Significant influence of drip irrigation and plastic mulch was observed on vegetative growth of crop. Profuse flowering and fruit setting was also observed in the current year, though plants are in their young age. Based on analysis of biometric observations, maximum height (4.22 m) in 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 case of girth of a plant maximum girth is recorded in treatment (VD + PM) (56.55 cm) followed by treatments VD (54.99) and 0.6VD + PM (54.90) but in this case the least is recorded in 0.8 VD (52.23), however it does not shown any significant difference between the treatments. Large canopy size (4.95 m) was observed in VD + PM treatment and least is in ring basin more over treatment 0.8 VD + PM at par with treatment which is recorded highest canopy area and they are significantly different from each treatment. Number of primary branches failed to show the significant difference among the treatments but highest numbers of primary branches (3.67 plant^{-1}) were recorded in treatment VD + PM and least is in ring without mulch treatment. But no of secondary branches proved to show the significant difference with in the treatments and the highest no of branches were recorded in the treatment VD + PM (13.67 plant^{-1}) were also recorded under this treatment.

The yield data presented in Table 2 shows that the yield of cashew was also significantly different for different treatment combinations. Maximum yield of 1.23 t ha^{-1} was found in treatment T2 (VD+PM) and the second highest yield obtained from T4 (0.8VD+PM) treatment (1.08 t ha^{-1}). With the same level of irrigation water applied in two treatments, the yield was always greater in case of plastic mulch treated plants. This could be due to moisture conserved and greater water availability to plants as compared to non mulched condition as was found for Sapota crop by [7]. The lowest yield was recorded under 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 problem in first few days immediately after irrigation. Another reason to get low yield by surface irrigation might be due to less availability of nutrients for crop growth due to leaching with high weed infestation between the crops [8]. This result is corroborated with the findings of [5, 9] and [10].

4. CONCLUSION

About 745 mm of water is needed to meet irrigation requirement of three year old cashew plants grown under sub-tropical, sub-humid climate 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 tree. Estimated water requirement value for young cashew plants can be used for similar agro climatic condition. Cent per cent irrigation requirement met with drip along with black plastic mulch showed superiority over all other treatments in respect of plant growth and development of cashew crops at juvenile period.

5. ACKNOWLEDGMENT

Author gratefully acknowledges NCPAH, Min. of Agriculture, Govt. of India for providing financial support to Precision Faming Development Centre to carry out this research work.

REFERENCES

[1] Sivanappan, R.K., Drip irrigation in fruit crops. *Punjab Hort. J.*, **29, 1987:** 83-85..

[2] Jadhav, S.S.,Gutal, G.B. and Chougule, A.A., Cost economics of the drip irrigation system for tomato crop. *Proc. of the XI International Congress on the use of Plastics in Agriculture*, New Delhi, India, 26th Feb.- 2nd March, 1990, pp. 171-176.

[3] Shrivastava, P.K., Parikh, M.M., Sawani, N.G. and Raman, S, Effect of drip irrigation and mulching on tomato yield. *Agricultural Water Management*, **25,** 1994**:**179-184.

[4] Cetin, B., Yazgan, S. and Tipi, T., Economics of drip irrigation of olives in Turkey. *Agricultural Water Management*, **66, 2004:** 145-151.

[5] Tiwari K N, Singh, R M, Mal P K and Chattopadhya A.,. Feasibility of drip irrigation under different soil covers in tomato. Journal of Agricultural Engineering, ISAE, 35(2) 1998: 41-49.

[6] Allen, R.G., Pereira, L.S. and Smith, M., Crop evapotranspiration, guidelines for computing crop water requirements. *Irrigation and drainage*, Paper No.56, FAO, Rome, Italy, 1998 p. 300.

[7] Tiwari, K.N., Mukesh Kumar, Santosh, D.T., Vikash Kumar Singh, Maji, M.K and Karan, A.K., Influence of Drip Irrigation and Plastic Mulch on Yield of Sapota (*Achraszapota*) and Soil Nutrients. Irrigation & Drainage Systems Engineering, 3 (1), 2014:1-8.

[8] Pattanaik S K, Sahu N N, Pradhan P C and Mohanty M K. 2003. Response of Banana to drip irrigation under different irrigation designs. Journal of Agricultural Engineering, ISAE, 40(3):29-34.

[9] Tiwari K N, Mal P K, Singh R M and Chattopadhya A., Response of Okra to drip irrigation under mulch and non-mulch conditions. Agricultural Water Management, 38, 1998: 91-102.

[10] Singh A., Economic feasibility of drip irrigated tomato crop under rainfed condition. Agricultural Engineering Today, ISAE, 31(3&4), 2007: 1-5.