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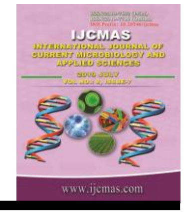

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Effect of Pigeonpea to Irrigation and Mulch Regime

M.A. Solanki[1*], A.L. Chalodia[2], P.V. Dabhi[1] and M.H. Fadadu[1]

[1]*Department of Soil and Water Engineering, College of Agricultural Engineering and Technology, Navsari Agricultural University, Dediapada – 393040, Gujarat, India*
[2]*Department of soil and water management research unit, Navsari Agricultural University, Navsari, Gujarat, India*

**Corresponding author*

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The field experiment was conducted at college farm, CAET, NAU, Dediapada, during *rabi* season 2017-18. The experiment was laid out in randomized block design with four replications, keeping five treatments of T_1- Drip irrigation with 0.6 PEF, T_2 - Drip irrigation with 0.6 PEF, Drip + Black Plastic Mulch 50 µ with (56 % coverage), T_3 - Drip irrigation with 0.6 PEF, Drip + sugarcane trash mulch @ 5 t/ha with (56 % coverage), T_4 - surface irrigation IW/CPE: 1, 60 mm depth + sugarcane trash mulch @ 5 t/ha (56 % coverage) and T_5 - surface irrigation IW/CPE: 1 (control) with 60 mm depth. Growing of *rabi* pigeonpea resulted significantly higher yield attribute and biological yields in the treatment 0.6 PEF through drip irrigation with sugarcane trash mulch @ 5 t/ha. Among mulch treatments, 0.6 PEF through drip with sugarcane trash mulch @ 5 t/ha was found to be significantly superior over other treatments with higher plant height at harvest (182.66 cm), leaf area index (0.88), stem girth (16.46 mm), root length and spread (40.05 and 27.38 cm), number of pod per plant (273.26), number of seed per plant (981.89), number of seed per pod (3.59), pod yield per plant (147.71 g), grain yield per plant (100.63) and 100 seed weight (11.20 g). The grain yield registered under treatment T_3 and T_4 were 80.66 % and 50.87 % higher than surface (control). Black plastic mulch was found more effective in reducing soil moisture loss followed by organic mulch compared to no mulch which was associated with high moisture depletion and higher soil temperature.

Introduction

Pigeonpea plays an important role in the agricultural economy of India by virtue of its ability to fix atmospheric nitrogen in symbiotic association with Rhizobium. Secondly, their deep penetrating root system enable them to utilize the limited available moisture more efficiently than other crops including cereals and also contribute substantially to the loosening of the soil. Pigeonpea is traditionally grown of India in rainy season crop. Winter pigeonpea has a shorter maturity period. It gets the benefit of clear sky, low relative humidity, mild temperature and low incidence of pests and diseases. Besides, the crop has to face less competition from weeds and responds better to applied inputs. The preliminary varietal trials conducted at many places in south Gujarat in recent past provide conclusive evidences that winter pigeonpea yields are higher or equal to kharif crop, indicating its bright future prospects. In the present day of water scarcity, the optimum method of irrigation plays a vital role in economizing irrigation water and enhancing crop yield. Any extraneous material with which soil is covered called as mulch. It prevents the water loss by evaporation, moderate soil temperature, conserve soil moisture and suppress weed growth. Mulches of various kinds have been used to modify hydrothermal regime and crop growth have been found to depend upon the nature of mulch and the climatic environment. Plastic mulches have been extensively used in developed country and their favorable as well as unfavorable effects on the crop growth have been reported depending upon crops and climatic environment. In India, straw mulching has been practiced for moisture conservation and soil temperature moderation (Anonymous 1982).

Materials and Methods

The field experiment was conducted during the *rabi* season in 2017-18 at College Farm, CAET, NAU, Dediapada. The experiment was laid out in randomized block design with four replications, keeping five treatments of T_1- Drip irrigation with 0.6 PEF, T_2 - Drip irrigation with 0.6 PEF, Drip + Black plastic mulch 50 µ with (56 % coverage), T_3 - Drip irrigation with 0.6 PEF, Drip + sugarcane trash mulch @ 5 t/ha with (56 % coverage), T_4 - surface irrigation IW/CPE: 1, 60 mm depth + sugarcane trash mulch @ 5 t/ha (56 % coverage) and T_5 - surface irrigation IW/CPE: 1 (control) with 60 mm depth. The soil of experimental plot was clayey loam in texture and slightly alkaline in reaction (pH 7.82). The soil possessed normal electrical conductivity (0.32 dS/m), low availability organic carbon (0.34), low available nitrogen (204.32 kg/ha), medium available phosphorus (31.48 kg/ha) and low available potassium (66.55 kg/ha). Recommended doses of fertilizer, *i.e.* 20:40:0 kg NPK ha-^{1} was applied through urea and single super phosphate at time of sowing. Pigeonpea crop was sown in 21st of November at a spacing of 60 x 20: 120 cm in paired row experimentation and harvested at the physiological maturity stage at the end of April. During the pigeon pea crop period the mean weekly maximum temperature ranged from 26 to 40.7 ºC with an average of 34.05 ºC and mean weekly minimum temperature ranged from 14.3 to 25.3 ºC with an average of 18.86 ºC, relative humidity varied from 18.4 to 78.0 % with an average of 48.36 %, weekly bright sunshine hours per day varied from 4.8 to 10.3 hours with an average of 8.30 hr. Likewise the mean weekly wind velocity ranged from 1.4 to 6.5 km/hr with an average of 3.2 km/hr, pan evaporation ranged from 2.30 to 16.8 mm d^{-1} with an average of 7.37 mm d^{-1} (show in Fig. 1).

Irrigations were scheduled based on the USWB Class A pan evaporation rates for each treatment under drip irrigation and surface (control) irrigation and calculated following formula.

$$\text{Opretion time (m)} = \frac{\text{F x CPE x S x 60}}{\text{R x N}}$$

Where, F = Fraction of pan evaporation
CPE = Cumulative pan evaporation
S = Size of plot (m^2)
R = Rate of discharge of an emitters (lph)
N = Number of emitters per plot

The surface control plots were irrigated in each furrow of paired rows through a dike from discharging outlet water point and calibrated volume into control plots separately.

$$\text{Time required to irrigate plot (m)} = \frac{\text{Plot size(m)}^2 \text{ x Depth of irrigation water (mm)}}{\text{Discharge rate of irrigation water (mm)}}$$

Initially, two common irrigations of 40 mm depth were given to all treatments for better establishment of the crop Pigeonpea variety GT-102 was used as test variety, before sowing seeds were treated with dithane M-45 fungicide, imida 35FS insecticide and Rhizobium culture. The growth and yield observations were recorded in ten plants randomly selected in each treatment.

Soil temperature

Soil temperature was determined using soil thermometers placed underneath the different mulch material. Soil temperature readings were taken every day at two different times of the day at (8:00 to 9:00 AM) and (5:00 to 6:00 PM). Soil thermometers were installed in each treatment at two depths namely; 5 cm and 15 cm.

Soil moisture distribution

Soil moisture content was estimated gravimetric method, soil sample collected before and after irrigation and after weighing the samples were oven dried at 105 ºC for 24-36 hr attaining a constant weight. The following formula was used to calculate the soil moisture content.

$$\text{moisture content(\%)} = \frac{\text{Fresh wt. (g)} - \text{Dry wt. (g)}}{\text{Dry wt. (g)}} \text{ x } 100$$

Soil samples were taken at a spacing of about 30 - 45 cm distance from lateral line and Surface control in furrow at a depth of 0-10, 10-20 and 20-30 for studying soil moisture distribution pattern in each drip irrigation and surface control regime. This observation was made during periods of branching, flowering, pod development and maturity stage.

Results and Discussion

Soil temperature

Soil temperature is one of the main yield determinant factors that regulate biomass accumulation and growth of plants and it plays an important role in the growth and development of the canopy. Mulch material may differently affect the temperature of soils due to local the environmental conditions. Average for daily maximum, minimum, and mean soil temperatures observed in the present experiment were significantly higher in plastic mulch and lower in the organic mulched soil than the bare land soil respectively for different treatments (show in graphically depicted in figure 2a,b and 3). Soil temperatures of up to 1.73 ºC and 1.53 ºC were recorded higher in black plastic mulch at 5 cm and 15 cm respectively. Soil temperature variation between maximum and minimum was highest when black plastic mulch and organic mulch were lowest variations. In general, variations in soil temperature increased with water deficit being greater with plastic and lower with organic mulch compared to no mulch at all different irrigation regimes. High temperature variations are reported negative impact on the general plant physiology.

Soil moisture content distribution

The lower soil moisture content distribution was observed in all treatments for before irrigation than the after irrigation. Higher gravimetric moisture content was observed in plastic mulch (T_2) with comparative in days and soil depth *viz.*, before irrigation with average moisture content of 22.01, 23.29 and 24.41 % respectively and after irrigation soil moisture of 31.65, 29.84 and 28.50 % respectively. Among the treatment (T_3) of drip

+ organic mulch moisture content was observed before irrigation average of 21.45, 22.93 and 24.02 % respectively and after irrigation moisture content average of 30.79, 29.44 and 27.94 % respectively. In treatment (T_4) surface + organic mulch was soil moisture content observed before irrigation with an average 21.42, 23.09 and 23.98 % respectively and after irrigation moisture content with an average of 30.56, 29.40 and 28.13 % respectively. Only drip treatment (T_1) was observed before irrigation of soil moisture content with an average of 19.82, 21.85 and 23.08 % respectively and after irrigation with an average of 29.18, 28.12 and 27.17 % respectively. In the treatment (T_5) surface (control) moisture content was observed before irrigation average of 20.33, 22.22 and 22.85 % respectively and after irrigation an average of 29.23, 28.19 and 27.24 % respectively (show in graphically depicted in figure 3, 4, 5, 6, 7 and 8).

Fig.1 Meteorological data during the crop period

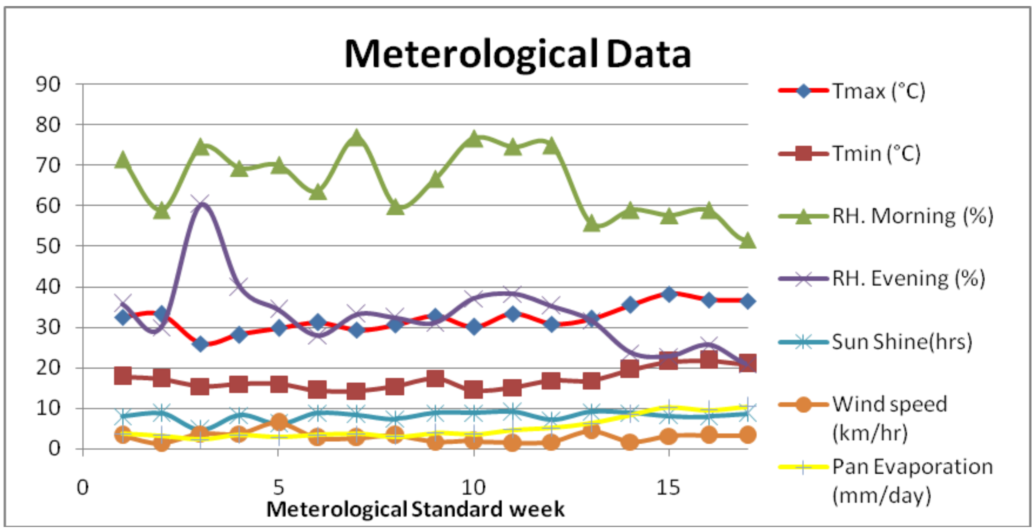

Fig.2a Soil temperature observed in the evening at 5 and 15 cm depth of all treatments

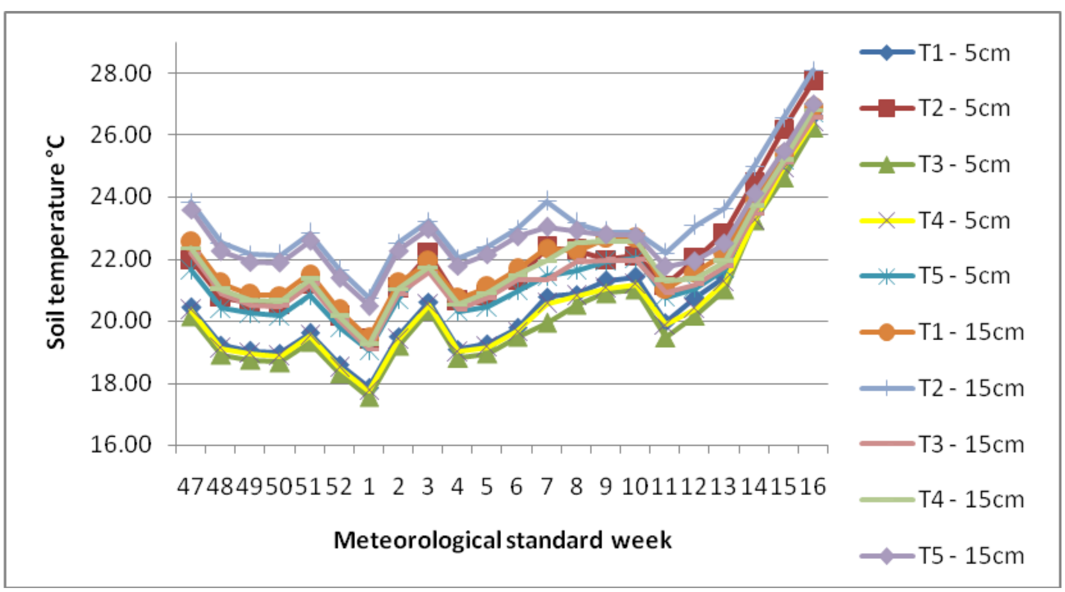

Fig.2b Soil temperature observed in the evening at 5 and 15 cm depth of all treatments

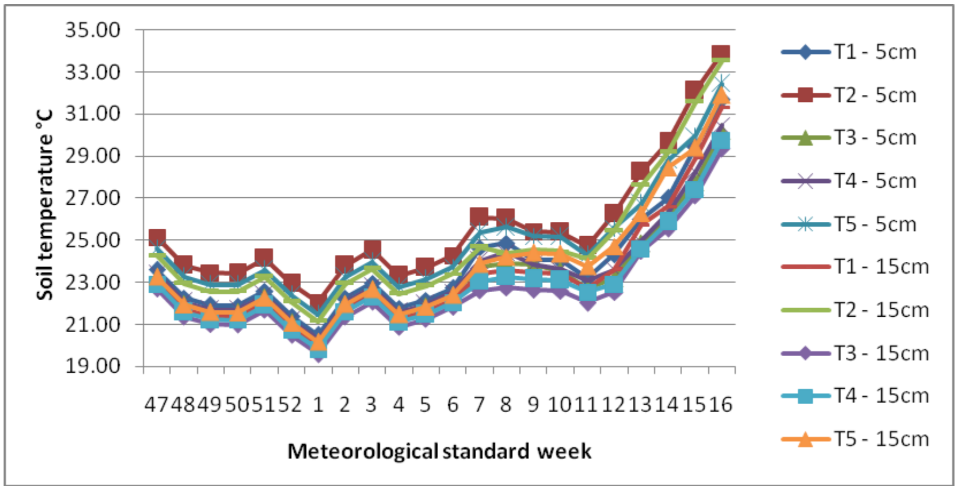

Fig.3 Soil moisture content observed before irrigation at 0-10 cm depth

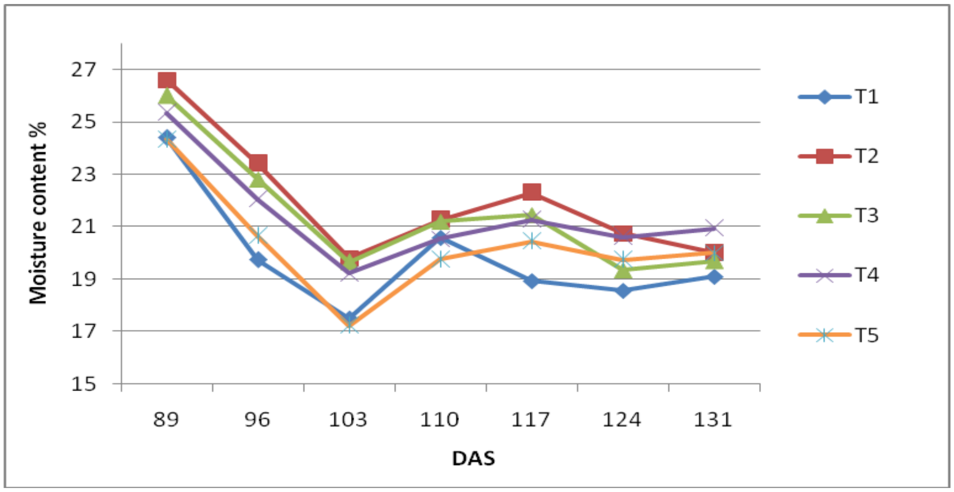

Fig.4 Soil moisture content observed before irrigation at 10-20 cm depth

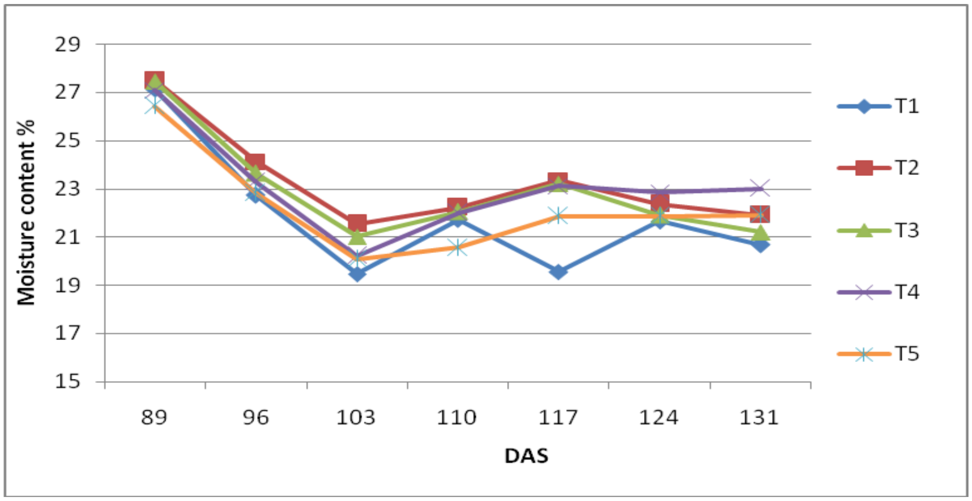

Fig.5 Soil moisture content observed before irrigation at 20-30 cm depth

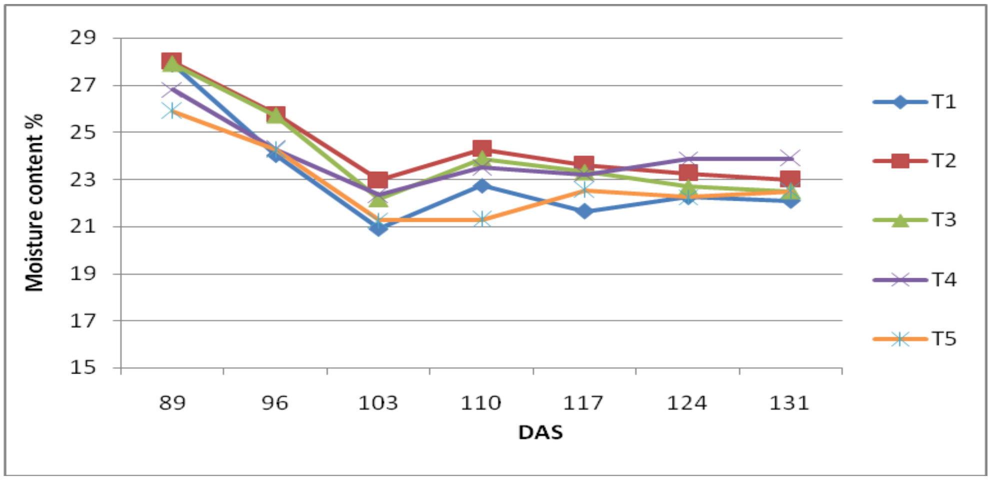

Fig.6 Soil moisture content observed after irrigation at 0-10 cm depth

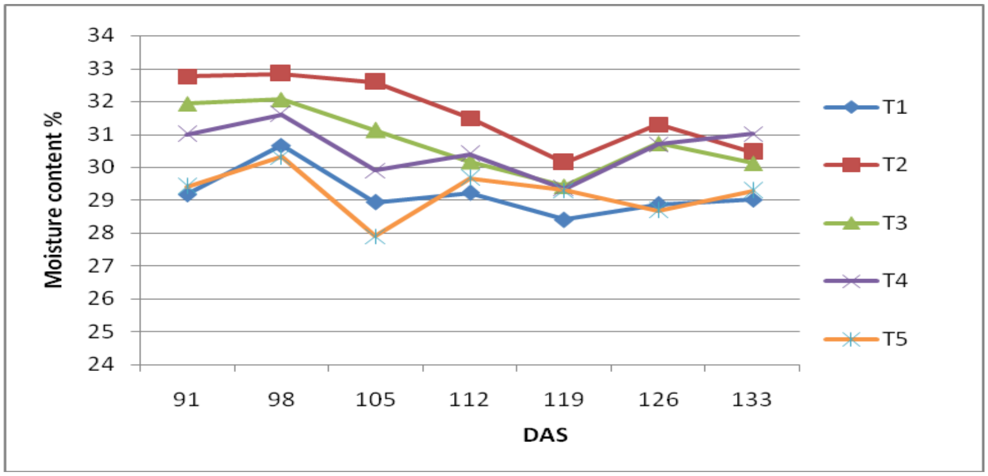

Fig.7 Soil moisture content observed after irrigation at 10-20 cm depth

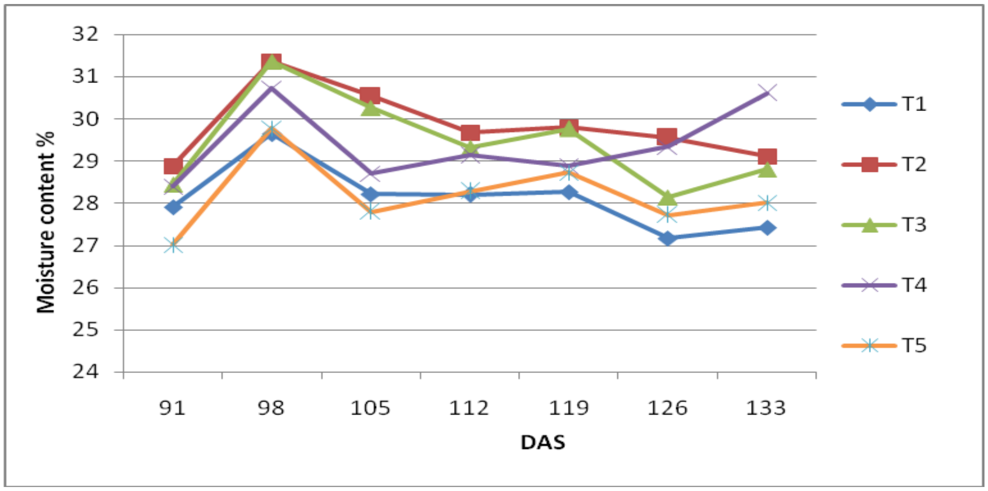

Fig.8 Soil moisture content observed after irrigation at 20-30 cm depth

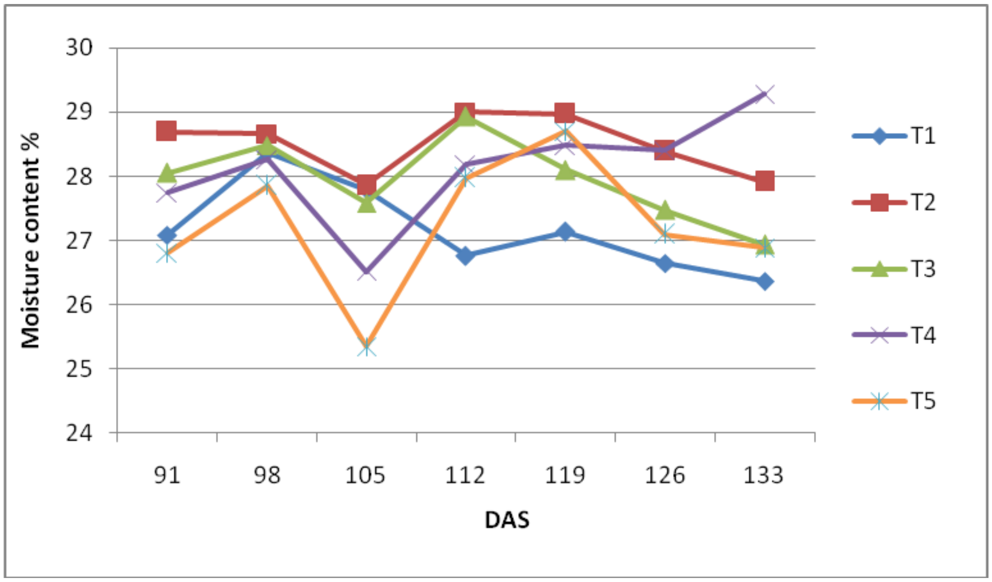

Table.1 Effect of irrigation and mulch on pigeonpea growth parameter

Treatments	Plant population		Plant height (cm) At harvest	Leaf area index At harvest	Stem girth (mm)	Root length (cm)	Root spread (cm)	Days to flowering	Days to pod initiation
	Initial plant stands (%)	Final plant stands at harvest (%)							
T_1	87.50	96.25	175.13	0.68	15.06	33.31	22.81	87.00	101.00
T_2	81.25	93.75	176.15	0.64	15.28	34.15	22.96	84.00	100.00
T_3	83.75	88.75	182.66	0.88	16.46	40.05	27.38	87.00	101.00
T_4	68.75	80.00	178.14	0.78	15.74	36.91	24.58	89.00	104.00
T_5	70.00	92.50	169.15	0.58	13.57	30.47	20.64	89.00	104.00
mean	78.30	90.25	176.24	0.71	15.22	34.98	23.67	87.20	102.00
S.Em. ±	3.87	3.22	2.55	0.03	0.39	1.66	1.22	-	-
CD (P≤ 0.05 %)	11.91*	9.92*	7.85*	0.10*	1.21*	5.11*	3.76*	-	-
C.V. %	9.88	7.13	2.89	9.20	5.17	9.49	10.31	-	-

* Significant at P ≤ 0.05 %

Table.2 Effect of irrigation and mulch on grain yield attributes of pigeonpea

Treatments	Number of pods per plant	Number of seeds per plant	Number of seeds per pod	Pod weight per plant (g)	Grain yield per plant (g)	100 seed weight (g)	Grain yield (kg/ha)
T_1	246.64	827.61	3.36	132.92	91.00	10.72	2718.92
T_2	210.88	684.13	3.25	114.26	73.44	10.52	2353.25
T_3	273.26	981.89	3.59	147.71	100.63	11.20	3318.49
T_4	250.85	877.98	3.50	134.90	93.15	10.97	2771.36
T_5	201.14	669.80	3.33	105.63	61.02	9.88	1836.87
mean	236.55	808.30	3.41	127.08	83.85	10.66	2599.78
S.Em. ±	6.00	27.57	0.09	4.88	3.94	0.23	108.17
CD ($P \leq 0.05$ %)	18.48*	84.95*	NS	15.03*	12.15*	0.69*	333.29*
C.V. %	5.07	6.82	5.31	7.68	9.41	4.22	8.32

* Significant at $P \leq 0.05$ %, NS- non significant

Effect on growth attributes

The results pertaining to morphogenic characters *viz.*, plant population, plant height, leaf area index, stem girth, root length and spread at time of harvest, days to flowering and days to pod initiation are presented in Table 1 as affected by different irrigation and mulching treatments. The initial plant stand after 13 DAS germination and final plant stand at harvest ranged from 68.75% to 87.50% and 80.00% to 96.25 % respectively. During initial establishment stage of crop in organic mulch, more insects and pests were attacked resulting in low plant population in organic mulch as compared to other treatments. The results of days to flowering and pod initiation was early in treatment T_2 (drip + black plastic mulch 50 µ with 56 % coverage) flowering (84 Days) and pod initiation (100 Days) than treatments T_3 and T_1 respectively.

The plastic mulching resulted in early germination due to increase in soil temperature and higher moisture conservation than the organic mulch; subsequent vigorous growth of crop might be the reasons for early flowering and pod initiation in mulching with drip irrigation treatments resulting in early synchronized flowering and pod initiation. Early germination, vigorous crop growth, early flowering and podding of pigeonpea crop might be the reason for early maturity in mulching treatments. Similar results were observed by Mahalakshmi (2011) for rabi pigeonpea. The plant height was initially increased higher (establishment and vegetative stage) in treatment T_2 after that lead to reproductive and maturity stage in significantly higher plant observed in treatment T_3 registered of 182.66 cm and at par with treatments T_4, T_2 and T_1. Significant leaf area index at harvest of 0.88 was recorded in treatment T_3 and it was at par with treatment T_4 (0.78) and T_4 at par with treatment T_1 (0.68) and T_1 at par with treatments T_2 and T_5. The average LAI increased at a lower rate up to 90 DAS and thereafter it increased linearly with the ontogeny of the plant, reaching a peak value at 120 DAS, then due to age effect of leaves, it was found to decrease linearly and at harvest the LAI recorded lower value. These results were in conformity with those reported by Mahalakshmi *et al.,* (2011). Leaf area expansion is dependent on leaf turgor potential (Boyer, 1970). Further, it is well documented that cell enlargement is very sensitive to water deficits and the consequence is a marked reduction in leaf area (Begg and Turner, 1976 and Hasio *et al.*, 1976). Stem girth was recorded significantly higher in T_3 treatment (16.46 mm) which was at par with treatments T_4 and T_2. Here also T_3 treatment recorded significantly higher root length (40.05) and spread (27.38 cm) which was at par with treatment T_4, T_2 and T_1. Whereas favorable soil, water and plant water balance were shown to stimulate increased activity of meristematic cells and cell elongation of internodes resulting in a higher growth rate of stem in turn promoting the plant height of pigeonpea (Gardner *et al.*, 1985 and Jaleel *et al.*, 2009). Similar results were reported by Selva (2009).

Effect on yield attributes and yield

The results pertaining to number of pods per plant, number of seeds per plant, number of seed per pod, pod weight per plant, grain yield per plant, 100 seed weight and grain yield (Table 2) as affected by different irrigation and mulching treatments were obtained. In all the possible combinations of treatment T_3 (0.6 PEF of irrigation with organic mulch (drip + sugarcane trash mulch @ 5 t/ha with (56 % coverage)) showed its superiority than rest of the treatment combinations in respect to number of pods per plant recorded (273.26) and number of seed per plant (981.89) than the treatment T_4 recorded of (250.85 & 877.98) and which was statically at par with treatment T_1 registered of (246.64 & 827.61) respectively. Number of seeds per pod was not significantly influenced by various treatment data showed in table 2, However, among the different treatment results, the mulch treatment T_3 recorded numerically higher number of seeds per pod of 3.59 which was higher than treatments T_4 (3.50) and T_1 (3.36). Pods weight (147.71 g/plant) and grain yield per plant (100.63 g) were statically at par with treatments T_4 and T_1. Also treatment T_3 test (100 seed) weight recorded significantly higher grain weight (11.20 g) which was at par with treatments T_4, T_1, and T_2 whereas significantly higher grain yield in treatment T_3 (3318.49 kg/ha) was recorded which was higher than treatment T_4 (2771.36 kg/ha) and statistically at par with treatment T_1. Lowest grain yield were recorded in treatment T_2 (2353.25 kg/ha) and T_5 (1086.87 kg/ha). The increase in pod and grain yield per plant under drip irrigation might be due to adequate water supply at all the critical growth stages and ultimately reflected in higher uptake of nutrients which might have resulted in better pod development and grain feeling. This finding is in conformity with those reported by Sarkar *et al.*, (2010) and Mahalakshmi (2011).

This implies that drip irrigation favours in terms of yield attributes in comparison to remaining levels of irrigation, due to availability of sufficient moisture supply throughout the entire growth period. These results are in close conformity with the findings of Solanki (2006) and Mahalakshmi *et al.*, (2011) for rabi pigeon pea. Among all the yield parameters, treatment T_3 proved its superiority over rest of the treatments (with mulching and without mulching).

It was concluded that based on results, it is recommended that pigeonpea (cv. GT-102) can be grown during *rabi* season under Dediapada Taluka region irrigated with drip irrigation (discharge 4 lph) 0.6 PEF + sugarcane trash mulch @ 5 t/ha, throughout the crop life which was given maximum yield of 3318.49 kg/ha. It was also observed that the second highest yield was found in surface irrigation (IW/CPE: 1, 60 mm depth + sugarcane trash mulch @ 5 t/ha) with 2771.36 kg/ha over rest of the treatments.

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