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Influence of mulch and drip irrigation on growth and yield of pigeonpea

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Abstract
The field trials were conducted during the two consecutive *kharif* seasons 2016-17 and 2017-18 with three mulching and three irrigation levels viz. 60%, 80%, 100% CPE (cumulative pan evaporation) to determine the growth and yield attributes of pigeonpea (*Cajanus cajan* L.) in Vindhyan plateau of Madhya Pradesh. Mulching and irrigation levels significantly affected (P<0.05) the growth and yield attributes of pigeonpea. The maximum plant height was obtained in black plastic mulch (181.29 cm) and lowest in without mulch (161.99 cm) which has significantly difference of 11.91%. The maximum plant height was recorded in I_2 (176.10 cm) which is at par in I_3 (174.16 cm). The significantly lowest height was registered in I_1 (166.22 cm). Individual and interaction (MXI) effect was found significant at harvest in case of branching. Black plastic mulch registered maximum number of pods (119.34) which is 20.67% higher than without mulch (98.90 However, The number of pods per plant was significantly lowest with I_1 (106.45) and highest with I_2 (113.19) which is at par with I_3 (111.97). Growth and yield attributes of pigeonpea gave better performance under plastic mulch than without mulch. Drip irrigation at 0.8% CPE results satisfactory than at upper and lower side.

Keywords: Pigeonpea, mulching, irrigation, vertisols, CPE, growth and yield

Introduction
Pigeonpea (*Cajanus cajan* (L) MillSp.) is a perennial member of the Fabaceae family and one of the major legume crop of the tropics and subtropics (Vanaja *et al*. 2010) [22]. Pulses are known as unique jewels of Indian farming. Pulses are an integral part of diets across the globe and have great potential to improve human health, conserve soils, protect the environment and contribute to global food security. The United Nations, declared 2016 as "International Year of Pulses". India is the largest producer, consumer and importer of the pulses in the world. Pigeonpea is particularly rich in lysine, riboflavin, thiamine, niacin and iron (Manikandan and Sivasubramaniam, 2015) [8]. Pigeonpea plays an important role in food security, balanced diet and the alleviation of poverty, since it is used in diverse ways as a source of food and fodder.
Pigeonpea grown worldwide in an area of 4.23 m.ha., with a production and productivity of 4.68 MT and 751 kgha^{-1} respectively. More than 85% area of pigeon pea is under rain fed condition (Sanjay *et al.*, 2017) [15]. In India, it occupies an area of 3.71 m.ha. with a production and a productivity of 2.78 MT and 750 kg/ha respectively (GOI Report, 2015). Increasing population resulted in reducing per capita availability of pulses to the masses. (Annual Report 2017-18, IIPR, Kanpur).
Lack of adequate water on a continuous basis is a serious obstacle to stable pigeonpea yields (Reddy and Virmani, 1980) [13]. Water stress affects the final yield due to the reduction in growth attributes i.e. plant height, number of pods, reduction in pod weight. Many researchers have reported that more than 50% of yield loss in pigeon-pea is due to drought (Roder *et al.* 1998; Sharma *et al.* 2012) [14, 17]. The plant's physiological processes get affected because of moisture stress in plant (Patel *et al.* 2001) [11]. Proper use of existing water resources by using suitable irrigation technologies to increase pigeonpea production per unit area is the need of the hour (Jeyjothi *et al.*, 2017).
Mulching as a moisture conservation practice has been widely practiced as a mean of improving yields in water limited environment. It also favourably modifies the soil thermal regime, retards soil erosion and improves soil health. Apart from those the plastic mulching increases the soil temperature and moisture of upper layer of soil (Rao *et al*., 2018) [12]. Swathi *et al.* (2018) [20] reported that the congenial environmental conditions determine the growth and flowering behaviour of pigeon pea.

There is still a scope in research to enhance productivity of the crop with the help of moisture conservation techniques. Drip and mulching are the most important resources and inputs, which have great influence on the productivity of pigeonpea (Solanki *et al*., 2019) [19]. Vision 2050 of IIPR (ICAR) also emphasized on resource conservation techniques in pulses viz., raised bed planting, drip irrigation and mulching to minimize water loss and enhance water productivity. Tiwari *et al*., (2012) [21] and Gireesh *et al*., (2019) [4] studied the yield gap, constraints and economics of pigeon pea production in Madhya Pradesh. Farmers are facing many constraints related with pigeonpea cultivation therefore proper resources management and scientific practices can increase the production and productivity of pigeonpea. Hence, the present work has been taken up to explore growth and yield attributes of pigeon pea through drip with mulching by providing congenial soil and water conditions near the plant root zone.

Materials and Methods

The study area is situated in central part of Madhya Pradesh which falls under agro-climatic zone of Vindhyan plateau. It situated at 23°16'48" N-latitude, 77°21'36" E-longitude. The field trials were conducted during the two consecutive *kharif* seasons 2016-17 and 2017-18 at farmer's field of Sehore district of Madhya Pradesh. Area belongs to sub-tropical climate. The topography of the experimental site was uniform and leveled and the soil is *vertisols*.

TJT-501 pigeonpea variety was used for this experiment. Well treated bold seeds with *Rhizobium* culture and PSB were dibbed on ridge of RF at interval of 25 cm. Black plastic sheet of 25 micron and wheat straw @ 5 t/ha were used as mulch. It was laid out before establishment of the crop by cutting into pieces according to the treatment. Before spreading the plastic sheet on ridge, small circular holes were made with scissors at 25 cm apart. The sheet was spread above the lateral line. Afterwards all the sides of the mulch sheet were buried into the soil to a depth of 4-5 cm. Surface drip irrigation system was installed to irrigate pigeonpea for this field experiment. LDPE pipes of 16 mm diameter were used as lateral keeping lateral spacing 60 cm and inline dripper spacing 30 mm. Irrigation water was applied according to daily crop evapotranspiration of pigeonpea.

The experiment was laid out with combination of three mulching treatments were without mulch (Mo), wheat straw mulch (M_1) and black plastic mulch (M_2) whereas three irrigation treatments were 60% CPE (I_1), 80% CPE (I_2) and 100% CPE (I_3). In present study, a fixed irrigation interval of three days was adopted and amount of water applied was estimated based on previous days evapotranspiration. The irrigation was stopped 15 days before harvesting in all treatments. The observation on growth and yield attributes were recorded using standard procedures. The crop growth attributes i.e. plant height (cm), number of branches per plant and dry matter (g) accumulation were measured at 30, 60, 90, and 120 DAS and at harvest of pigeonpea. Yield attributes such as number of pods per plant, test weight (g), number of seeds per pod were observed very accurately at the time of harvest. The recorded data were statistically analyzed by using technique of analysis of variance for the split plot design given by Gomez and Gomez (1984) [5].

Results and Discussion

The result on the basis of pooled data showed that the crop growth and yield of pigeonpea were significantly affected by different mulching and irrigation treatments. Increase in mean plant height was rather slow up to 30 DAS, there after it increased linearly up to 120 DAS and after that it continued to increase until maturity at a diminishing rate (Table 1). The maximum plant height was obtained in black plastic mulch (181.29 cm) and lowest in without mulch (161.99 cm) which has significantly difference of 11.91%. The maximum plant height was recorded in I_2 (176.10 cm) which is at par in I_3 (174.16 cm). The significantly lowest height was registered in I_1 (166.22 cm). The increased plant height might be due to better availability of moisture and nutrients near root zone during entire crop growth period which favoured the growth attributes. Almost similar trend was observed by Ghosh and Biswas (1984) [3] and Solanki *et al.* (2019) [19].

Data pertaining to number of branches per plant of pigeonpea was recorded and an average value was worked out for each treatment (Table 1). The significantly maximum number of branches registered under black plastic much (13.81) and minimum in without mulch (10.92). The irrigation treatment significantly affects the number of branches and maximum recorded in I_2 (13.10) which is at par with I_3 (11.64). The increased number of branches per plant might be due to better availability of moisture and nutrients during entire crop growth period which favoured the growth attributes. Also, drip irrigation treatment created better micro-climate as compared because of prolonged duration of watering. The above findings are in close conformity with the findings of Yadav *et al.* (2006) [23] and Savani *et al*. (2017) [16].

There was a gradual increment in dry matter accumulation with advancement in the age of the crop till harvest in all the treatments are presents in Table 1. It is obvious from data that the dry matter accumulation was significantly affected by the different treatments. Maximum and minimum value recorded under black plastic mulch (M_2) followed by wheat straw mulch (M_1) and without mulch (M_0). The pooled data clearly indicate at harvest that the maximum average value under M_2 is 118.03 g/plant whereas lowest value registered under M_0 (106.65 g/plant). Rao *et al*. (2018) [12] also found the same trend. It is also revealed that the dry matter accumulation recorded with I_3 (1.0 IW/CPE) throughout the crop life was statistically at par with I_2. The dry matter accumulation per plant are 108.97 g/plant (I_1), 114.21 g/plant (I_2) and 113.83 g/plant (I_3) registered at harvest. The dry matter accumulation variation found maximum due to mulching effect whereas lesser with discharge rate and irrigation treatments. Singh *et al* (2018) [18] and Jadhav *et al.* (2018) also found the same trend in dry matter accumulation.

Different mulching treatments significantly affected the number of pods per plant (Table 2). The pooled data revealed that significantly maximum number of pods (119.34) registered under black plastic mulch (M_2) whereas lowest value (98.90) in without mulch (M_0). Ghose and Biswas (1984) [3] resulted that increase in pods due to increase in branches. The same result reported by Savani *et al.* (2017) [16].

Data on number of pods per plant was found significant due to effect of different irrigation levels. The pooled data revealed that lowest value recorded with I_1 (106.45) and highest with I_2 (113.19) which is at par with I_3 (111.97) as shown in Table 4. These results are conformity with Jadhav *et al.* (2018) [6].

Different mulching treatments significantly influenced the test weight (Table 2). The pooled data indicate that significantly maximum value (10.24) registered under M_2 which is at par

with M_1 (10.11) whereas lowest value (9.16) recorded in M_0. The test weight variation due to different irrigation levels found significant. On the pooled data basis it is clear that lowest weight recorded with I_1 (9.61) and highest with I_2 (9.96) which is at par with I_3 (9.94). Effect of different mulching treatments on number of seeds per pod was found non-significant. The pooled data revealed that maximum number of seeds (3.35) registered under M_2 which is at par with M_1 (3.30) whereas lowest value (3.21) in M_0. Data on number of seeds per pod was found significant due to effect of different irrigation levels. The pooled data indicate that lowest value recorded with I_1 (3.21) and highest with I_2 (3.33) which is at par with I_3 (3.32). Savani *et al.* (2017) [16] and Jadhav *et al*. (2018) [6] reported same trend for yield parameters.

The pooled data in Table 2 revealed that significantly maximum seed yield (17.51 q/ha) registered under M_2 followed by M_1 (16.51q/ha) and M_0 (11.83q/ha). Savani *et al.* (2017) [16] reported 48% higher yield under plastic mulch than no mulch. Rao *et al*. (2018) [12] reported that plastic mulch is far better than without mulch. Contrary result reported by Solanki *et al*. (2019) [19] that higher yield in organic mulch than in plastic mulch. The seed yield was found significant due to effect of different irrigation levels. The pooled data clear that lowest value recorded with I_1 (14.07 q/ha) and highest with I_2 (16.01 q/ha) which is at par with I_3 (15.77 q/ha). Improvement in yield might be due to better proportion of air-soil-water which was maintained throughout the crop life in drip irrigation. These results are conformity with Jadhav *et al*. (2018) [6].

Table 1: Growth attributes of pigeonpea at different DAS and at harvest under different treatments

Treatment	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	Plant Height (cm)	No. of Branches	DMA (gms/ plant)	Plant Height (cm)	No. of Branches	DMA (gms)	Plant Height (cm)	No. of Branches	DMA (gms)	Plant Height (cm)	No. of Branches	DMA (gms)	Plant Height (cm)	No. of Branches	DMA (gms)
Mulch (M)															
M_o	23.86	2.19	4.41	79.14	4.86	14.48	116.56	6.55	41.03	149.67	9.56	81.24	161.99	10.92	106.65
M_1	30.24	2.96	5.42	88.25	6.16	15.90	125.70	8.99	43.07	159.93	12.04	86.45	173.20	12.94	112.33
M_2	32.03	3.16	5.83	91.13	6.55	16.82	129.54	9.49	43.82	167.04	12.87	90.31	181.29	13.81	118.03
SEm (±)	0.56	0.08	0.13	0.38	0.12	0.29	0.81	0.18	0.70	2.48	0.22	1.41	2.74	0.26	1.93
CD at 5%	1.56	0.21	0.36	1.06	0.35	0.81	2.24	0.50	1.94	6.87	0.62	3.90	7.61	0.71	5.36
Irrigation (I)															
I_1	25.99	2.71	4.68	82.99	5.76	12.97	119.92	7.81	39.15	153.96	10.14	10.14	166.22	166.22	108.97
I_2	30.10	2.80	5.63	88.01	5.95	17.36	126.44	8.67	44.68	161.91	12.25	12.25	176.10	176.10	114.21
I_3	30.05	2.80	5.35	87.51	5.87	16.86	125.44	8.56	44.10	160.76	12.08	12.08	174.16	174.16	113.83
SEm (±)	0.25	0.05	0.06	0.50	0.06	0.13	0.67	0.10	0.35	1.24	0.10	0.10	1.36	1.36	0.92
CD at 5%	0.51	NS	0.12	1.02	NS	0.27	1.37	0.20	0.70	2.51	0.21	0.21	2.77	2.77	1.86

DMA-Dry Matter Accumulation

Table 2: Yield attributes of pigeonpea at different DAS and at harvest under different treatments

Treatment	Pods per plant	100 seed weight (g)	Seeds per pod	Seed yield (q/ha)
Mulch (M)				
M_o	98.90	9.16	3.21	11.83
M_1	113.36	10.11	3.30	16.51
M_2	119.34	10.24	3.35	17.51
SEm (±)	1.79	0.21	0.06	0.21
CD at 5%	4.97	0.59	NS	0.58
Irrigation (I)				
I_1	106.45	9.61	3.21	14.07
I_2	113.19	9.96	3.33	16.01
I_3	111.97	9.94	3.32	15.77
SEm (±)	0.90	0.09	0.03	0.12
CD at 5%	1.82	0.18	0.05	0.24

Conclusion

On the basis of results obtained in present study, the drip irrigation as per crop evapotranspiration demand 80% CPE is giving best performance than lower (60%) and upper (100%) level. Black plastic mulch performs best and followed by wheat straw mulch and without mulch. It can be concluded that use of black plastic mulch at the 80% CPE (cumulative pan evaporation) with three days irrigation interval was found better in order to higher growth and yield attributes.

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