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Effect of Mulching on Chickpea under Low Head Drip Irrigation System

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ABSTRACT
The effect of plastic mulch on chickpea (*Cicer arietinum* L.) cultivation under low head drip irrigation systems was studied at ICAR-Central Institute of Agricultural Engineering, PFDC, Bhopal during 2018-19. Drip irrigation system was operated by placing water tank at a total water deliver height of 3 m and varied heads to 2.5 m and 2.0 m to find out the value of coefficient of uniformity under these heads. The experimental treatments consisted in five levels by varying irrigation methods: Flood irrigation, irrigation with drip laid on raised beds, irrigation with drip laid on raised beds covered with black mulch, irrigation with drip laid on raised beds covered with silver mulch and irrigation with drip laid on raised beds covered with white mulch. Growth and yield parameters of chickpea *viz*., plant height (cm), number of branches per plant, plant dry matter (g/plant), effective nodule per plant and nodules dry weight (mg/plant), number of pods per plant, 100 seed weight, seed yield (kg/ha) and harvest index were highest under silver plastic mulch laid on raised beds, irrigated with drip as compared to black plastic mulch and white plastic mulch treatments. Lowest growth and yield parameters were recorded in the flood irrigated treatment. Water Use Efficiency was highest under silver plastic mulch (17.21kg/ha mm) and lowest under flood irrigated condition (3.74 kg/ha mm). Net returns were higher in the treatment under the silver mulch (Rs/ha 77939) and followed by black mulch (Rs/ha 67179) with lowest net returns in the flood irrigated condition (Rs/ha 32690).

Key words: Chickpea, Drip irrigation, CU (%), Growth, Plastic mulch, Soil and leaf temperature, WUE (kg/ha mm), Yield and economics.

INTRODUCTION
Chickpea (*Cicer arietinum* L.) is the second most important grain legume crop in the world and is internationally cultivated in more than 50 countries with about 13.2 Million hectare area with a production of about 11.6 million tons (FAO, 2013). India ranked first in terms of chickpea production and consumption in the world. About 65% of global area with 68% of global production of chickpea is contributed by India. Chickpea is a good source of protein (12-31%), carbohydrates (60-65%), fat (6%) dietary fiber and minerals (Jukanti *et al*. 2012). It is also a good source of vitamins (rich in B vitamins) and minerals like potassium and phosphorus.

Chickpea is mainly grown during *Rabi* season in India under diverse production systems including both rainfed and irrigated conditions. About 90% of chickpea in the world is grown under rained conditions where drought is one of the major constraints, limiting its production. Water stress has prominent effect on leaf number, total leaf area and secondary branches causing invariable reduction under rainfed conditions (Basu *et al*. 2007). Plastic mulch is used in a similar way as that of organic mulch, to suppress weeds and conserve soil moisture in crop production. In general plastic mulching is used in conjunction with drip irrigation to improve water use efficiency and arrest weed growth. It also accelerates plant growth by maintaining the uniform soil temperature and stabilizing soil moisture. Plastic mulches directly affect the microclimate around the plant by modifying the radiation budget of the surface and decreasing the soil water loss (Rao *et al.* 2017). Providing reflective plastic mulch films on the raised beds for crop cultivation results in higher yield along with quality produce, as the reflected light from these films cause discomfort to the pests and insects (Lamount, 2005). In a micro irrigation system water is discharged to the field through the drippers. Ideally, all drippers in a micro irrigation system should deliver equal flow rate during different irrigation events (Wu and Gitlin, 1973). Bralts *et al*. (1981) reported that in reality discharge from emitter to emitter varies. The actual dripper flow rates along a lateral line may vary considerably depending on several factors including pressure variation, land slope and dripper clogging. Present study was conducted to assess chickpea cultivation under different coloured plastic mulches with drip irrigation under low head system (gravity fed).

MATERIALS AND METHODS
Description of study area: The study was undertaken at ICAR-Central Institute of Agricultural Engineering at Precision Farming Development Centre, Bhopal during

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2018-19. Soils of the experimental site was heavy clay with clay content varying between 49.7 to 53.7 % having the field capacity of 28.5 to 31 %.

Experimental details: In this study the drip irrigation system with laterals having thickness of 250 micron (drip tape) and drippers spaced at 1m x 0.5m were laid to workout the coefficient of uniformity of drippers under different heads of operation (2, 2.5 and 3.0 m). The system consists of a main pipe (40 mm diameter, HDPE) connected to the water storage tank. The water storage tank (3000 l) was fixed at height of 3 m. The slope of the field was 1.5%. Laterals were connected directly to the main pipe at an interval of 1 m spacing. Laterals with inbuilt emitters (punched at 50 cm interval) were used. The expensive filtration system of standard drip system was replaced with a nylon cloth tied around the inlet of the main pipe. Uniformity of water distribution in irrigation system under different operating head conditions was evaluated which is shown in Table 1. The concept of emission uniformity (Eq. 1) as developed and documented by Merriam and Keller (1978) was used in this study:

$$CU = 1 - \frac{\sum_{i=1}^{n} | qi\text{-}qave |}{\sum_{1}^{n} qi} \quad \text{.................. Eq. 1}$$

Where,

CU= Coefficient of Uniformity

qi = individual (i[th]) dripper flow rate, l/h

q_{ave} = mean dripper discharge rate, l/h

(qi - qave) = absolute deviation from the mean.

Under the study, nine catch cans were placed below the drippers in a square grid pattern (10 m x10m) spread over the entire irrigated area. The discharges of drippers at varying heads (2, 2.5 and 3 m) received in different catch cans for 30 minutes duration were recorded. The coefficient of uniformity of drip system was estimated using Eq. 1 for each head.

After optimizing the required head for operating drip irrigation system, the experimental treatments were selected as T_1-flood irrigation, T_2-drip irrigation, T_3-black mulch with drip irrigation, T_4-silver mulch with drip irrigation, T_5-white mulch with drip irrigation were tested in chickpea showing in Fig 1. The thickness of plastic mulch was 25 micron. Each drip irrigated treatments were taken on raised beds and flood irrigated treatment was on natural surface. The bed width was 1 m and the bed length was 21 m. Mulch as per treatments was applied on the raised beds and sides were covered with soil. The experiment was laid out in randomized block design. Sowing of seeds of chickpea was done at a spacing of 40 cm x 40 cm during second week of November. Crop was fertilized with 20: 40:20 kg/ha of N, P_2O_5 and K_2O.

Five randomly selected plants from each plot were used to record average plant height, number of branches per plant, effective pod number, nodules per plant, nodules dry weight (mg/plant), plant dry matter (g/plant), seed index, seed yield (kg/ha) and harvest index(%). To study the soil moisture content under different treatments, soil samples were collects using soil moisture meter in all the treatments at vertical depth of 0-10 cm at the time of sowing, 30 days after sowing and at the time of harvest. The moisture content was determined through gravimetric method.

Operation schedule of drip system was developed for chickpea based on its estimated water requirement to meet out the evapo-transpiration rate of the study area. Irrigation was applied with drip irrigation system on every 5

Fig 1: Experimental field.

Table 1: Coefficient of uniformity of water distribution at 1.5% slope.

Collecting points	Discharge (l/hr) at 2m head	Deviation	Discharge (l/hr) at 2.5m head	Deviation	Discharge (l/hr) at 3m head	Deviation
1	1.7	0.133	1.7	0.222	1.5	0.023
2	1.9	0.067	1.9	0.022	1.55	0.073
3	1.9	0.067	2	0.078	1.5	0.023
4	1.3	0.533	1.8	0.122	1.4	0.077
5	1.9	0.067	1.8	0.122	1.25	0.227
6	2.1	0.267	2.2	0.278	1.7	0.223
7	1.9	0.067	2	0.078	1.5	0.023
8	2.1	0.267	2.1	0.178	1.5	0.023
9	1.7	0.133	1.8	0.122	1.4	0.077
Mean	**1.833**	**1.601**	**1.922**	**1.222**	**1.478**	**0.769**
UC (%)	**90.296**		**92.936**		**94.21**	

day interval with emitters spaced at 0.5 m. Water use efficiency (WUE) was also worked out using following formula (Reddy and Reddi 2002).

WUE (kg/ha mm) =
Grain yield (kg/ha)/Water applied through irrigation (mm)

The cost of cultivation was worked out by including all cost of operations and inputs used for raising of the crop. The net returns were computed by subtracting the cost of cultivation from the gross returns obtained in each treatment. The benefit cost ratio (B: C) was estimated by dividing income obtained from produce by total cost of production for each treatment. The data collected from the experiment were analyzed for the analysis of variance procedure and the test of significance was carried out.

RESULTS AND DISCUSSION

Soil moisture content: Plastic mulch is most efficient when used in combination with drip irrigation. Different mulching materials helped to perform better at water deficits. After providing irrigation either through drip or flood, the soil samples for moisture were collected two days after irrigation event. The moisture content of the soil at 5-10 cm depth was collected at three different locations in each treatment. Using the standard method (gravimetric) the soil moisture was estimated in three different stages of the crop and the average values are presented in Table 2. It can be seen from this table the soil moisture content for all the five treatments followed similar trend during the crop growing period, however, statistical analysis was carried out for moisture content values of 30 days after sowing and analysis is presented in Table 3.

All the drip irrigated treatments including different colored mulches i.e., from T_2 to T_5 were found significant at 1% and 5% level of significance over flood irrigated treatment (T_1). Comparison of treatment means at critical difference of 5% indicated that the T_4 and T_3 treatments are significant over other treatments (T_1, T_2 and T_5), however there was significant difference in the soil moisture content values between T_4 and T_3 treatments. Similar trend was observed by Gorden *et al.* (2010) in okra crop.

Table 2: Effect of treatments on soil moisture content (%).

Treatments	At the time of sowing	30 DAS	At harvest
Flood irrigation	17.02	9.86	6.12
Drip irrigation	17.27	11.09	5.97
Black mulch with drip irrigation	16.78	13.86	6.25
Silver mulch with drip irrigation	17.65	14.26	8.12
White mulch with drip irrigation	16.21	12.56	7.02

Table 3: Statistical analysis of soil moisture content and comparison of treatment means at 5% level of significance.

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F_{cal}	F_{prob}
Treatments	4	41.271	10.318	10.09	0.002
Error	10	10.219	1.022	-	-
Total	14	-	-	-	-
Coefficient of Variation: 8.201					
CD at 1 % : 2.62 and 5% 1.84					
Comparison of treatment means with Critical Difference (5%)					
Treatment	T_4	T_3	T_5	T_2	T_1
Treatment average	14.26	13.86	12.56	11.09	9.86
CD compared	A	A	ab	bc	c

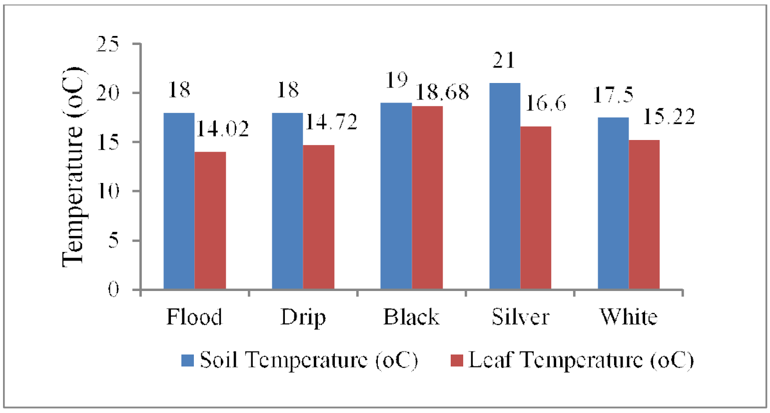

Fig 2: Soil temperature and Leaf temperature influenced under different treatments.

Soil and leaf temperature (^{0}C): Chickpea is cultivated during *Rabi* season in India, during which the night temperatures occasionally will fall as low as 2^{o}C in Central India. During the experimental trial, frost event was occurred in the last week of December in the study area. The frost event coincided with the flowering stage of the crop and is detrimental for the crop. Soil and leaf temperatures (Fig 2) were monitored during the crop growing period on 30 days interval up to 90 days after sowing and were analyzed statistically and presented in Table 4 and Table 5.

All the treatments were found significant for soil temperature at 1% as well as 5% level of significance. Among the treatments T_4 was found significant as compared to T_1, T_2, T_3 and T_5 treatments. The trends were in agreement with the study of Tegen *et al*. (2015) in capsicum crop.

The statistical analysis indicated that treatments were found significant at 1% and 5% level of significance. Among the treatments T_3 i.e., black colored mulch treatment was found more significant over all other treatments, this could be due to the fact that more solar radiation would be observed by black coloured mulch film as compared to other colours might have lead to increased temperature in the ambient micro climate of the crop (Lamount, 2005).

Coefficient of uniformity: After assessing the Uniformity Coefficient under different heads i.e., 2.0 m, 2.5 m and 3.0 m, the Chickpea crop was grown with an operating head of 3 m as this head resulted in maximum uniformity (94.2%) of water application. Since, the drip irrigation system adopted in the study is a gravity fed system, as the head decreases, the discharge of drippers at the farther points of laterals comes down. As a result the coefficient of uniformity of water distribution decreases with decreasing water delivery head. For 2.0 m head the value was 90.01% and at 2.5 m head the uniformity coefficient was 93.24 %.

Growth parameters: Mulches significantly influenced the growth characters such as plant height, number of branches per plant, plant dry matter, effective nodules per plant and nodule dry weight (Table 6). The maximum plant height of

Table 4: Statistical analysis of soil temperature and comparison of treatment means at 5% level of significance.

Source of variation	Degrees of freedom	Sum of squres	Mean sum of squares	F_{cal}	F_{prob}
Treatments	4	23.543	5.886	12.044	0.001
Error	10	4.887	0.489	-	-
Total	14	-	-	-	-
Coefficient of Variation: 3.74					
CD at 1 % : 1.81 and 5% 1.27					
Comparison of treatment means with Critical Difference (5%)					
Treatment	T_4	T_3	T_1	T_2	T_5
Treatment average	21	19	18	17.97	17.5
CD compared	a	B	bc	bc	c

Table 5: Statistical analysis of leaf temperature and comparison of treatment means at 5% level of significance.

Source of variation	Degrees of freedom	Sum of squres	Mean sum of squares	F_{cal}	F_{prob}
Treatments	4	40.782	10.196	17.394	0.001
Error	10	5.862	0.586	-	-
Total	14	-	-	-	-
Coefficient of Variation: 4.83					
CD at 1 % : 1.98 and 5% 1.39					
Comparison of treatment means with Critical Difference (5%)					
Treatment	T_3	T_4	T_5	T_2	T1
Treatment average	18.68	16.60	15.22	14.72	14.02
CD compared	a	B	bc	c	c

Table 6: Effect of mulches on Growth parameters.

Treatments	Plant height (cm)	Number of branches per plant	Total plant dry matter (g/plant)	Effective nodules per plant 75 DAS	Nodules dry weight (mg/plant)
Flood irrigation	41.4	4.3	3.2	15	28
Drip irrigation	42.6	5.0	3.6	21	42
Black mulch with drip irrigation	44.4	5.8	4.5	26	56
Silver mulch with drip irrigation	45.0	6.1	5.0	28	57
White mulch with drip irrigation	43.2	5.2	4.0	26	55
CD (0.05%)	**1.28**	**0.46**	**0.52**	**3.2**	**3.4**

44.9 cm was observed under silver plastic mulch with drip irrigation and lowest plant height was recorded in flood irrigated crop (41.4 cm). Statistically significant plant height was observed under mulching in chickpea might be due to optimum availability of nutrients and moisture. At harvesting highest number of branches per plant and dry matter production were recorded in silver plastic mulch with drip irrigation. The lowest branches per plant and dry matter were recorded in flood irrigation. These findings are in agreement with the results reported by Patidar *et al*. (2015) and Singh (2016). Number of effective nodules per plant showed significant variation at 75 DAS of chickpea under different treatments. Silver plastic mulch with drip irrigation resulted in higher effective nodules per plant (28) and the lowest nodules were observed in flood irrigation condition (15). Drip irrigation along with plastic mulching facilitated better availability of nutrients in plants leading to higher number of effective nodules per plant. Mulches significantly influenced the nodules dry weight in silver plastic mulch with drip irrigation (57 mg/plant) as compared to black plastic mulch with drip irrigation (56 mg/plant) and lowest nodules dry weight was observed in flood irrigated condition (28 mg/plant).

Yield and yield attributes: In general, the drip irrigation method had higher application efficiency over conventional irrigation systems and supplies water to the root zone with a lower discharge rate not more than the infiltration rate of soil (Ramaha *et al*. 2011). Maintenance of ideal moisture in drip irrigated treatments with mulch, resulted in better yield and yield attributes. Significantly higher number of pods per plant were recorded in silver plastic mulch with drip irrigation (326) followed by black plastic mulch (311) and lowest pods per plant were recorded in flood irrigation (28). Highest 100 seeds weight of chickpea was recorded under silver plastic mulch with drip irrigation (24.87 g) and lowest was recorded in flood irrigation condition (22.56 g). Treatments significantly affected the seed yield and harvest index with higher in silver plastic mulch and drip irrigation (2954 kg/ha and 49.68 %) and lowest in flood irrigation condition (1740 kg/ha and 37.83%). Similar trend was observed in other mulch treatments i.e., under black mulch and white mulch. Statistically significant results were obtained for these parameters in drip irrigated treatment also over flood irrigated treatment. However, the drip irrigated crop yield and yield contributing parameters are significantly lower when compared with mulch (black, silver and white) treatments. The higher seed yield under mulch treatments may also be attributed to reduced nutrient losses due to weed control and improved hydrothermal regimes of soil (Singh, 2005, Gangwar *et al*. 2017). The increased yield of chickpea under mulching conditions could be due to higher chlorophyll content with enhanced photosynthetic activity and higher uptake of nutrients (Table 7). This could have helped in increased plant dry matter production at pod setting phase, resulting in more number of pods per plant and finally contributed for higher productivity. These observations were in conformity with the findings of Mahalakshmi *et al*. (2011) and Akbar *et al*. (2011) in other legumes crop.

Water use efficiency: It can be seen from Fig 3 that the water use efficiency under silver color plastic mulch with drip irrigation recorded highest (17.21 kg/ha mm) followed by black color plastic mulch with drip irrigation (16.04 kg/ha mm), silver color plastic mulch with drip irrigation (17.21 kg/ha mm) and in white color plastic mulch with drip irrigation (14.81 kg/ha mm). The lowest value was found under flood irrigated condition (3.74 kg/ha mm). This could be due to the fact that the plastic mulch films prevent evaporation losses. This is in agreement with the results of Kar and Kumar (2007) who reported significantly higher WUE in the straw mulched plots compared to the no mulched plots.

Economics: Drip irrigation system is generally adopted in horticultural crops which have high commercial value. Due to high initial investment in agricultural field crops, this system is seldom practiced. However, in the present study

Table 7: Effect of mulches on seed yield and yield parameters.

Treatments	Number of pods per plant	100 seed weight (g)	Seed yield (kg/ha)	Harvest index
Flood irrigation	62	22.56	1740	37.83
Without mulch with drip irrigation	184	23.58	2452	46.25
Black mulch with drip irrigation	311	24.12	3685	48.04
Silver mulch with drip irrigation	326	24.87	3954	49.68
White mulch with drip irrigation	287	23.96	3403	46.76
CD (0.05%)	**17.6**	**1.03**	**124.6**	**3.52**

Table 8: Economic analysis under different treatment of chickpea cultivation.

Treatments	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net return (Rs/ha)
Flood irrigation	36910	69600	32690
Without mulch with drip irrigation	64936	98080	33144
Black mulch with drip irrigation	80221	147400	67179
Silver mulch with drip irrigation	80221	158160	77939
White mulch with drip irrigation	80221	136120	55899

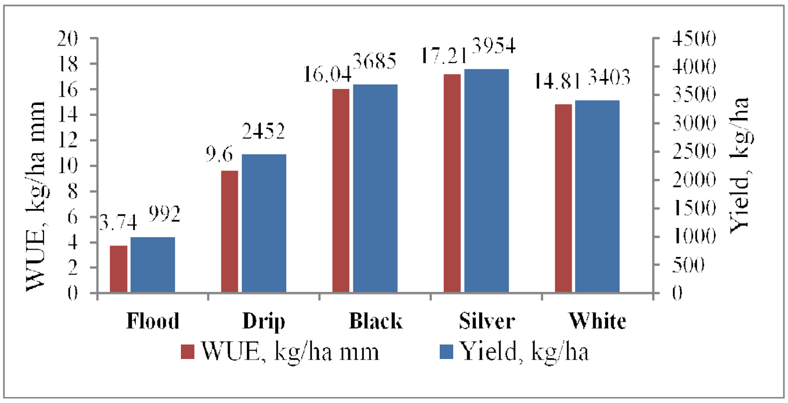

Fig 3: Yield and water use efficiency (kg/ha mm) influenced under different treatments.

looking at the advantages of drip irrigation in terms of water saving, energy saving, quality produce etc., experimental trial was taken up in Chickpea crop by adopting plastic mulching in drip irrigation. Economic analysis of the study was carried out to determine the economic feasibility of drip irrigation and plastic mulching in the cultivation of chickpea crop. The sale price of the chickpea seed considered was Rs.40/kg looking at the wholesale market price.

Higher cost of cultivation (Rs/ha 80221) was recorded with plastic mulch as compared to other treatments (Table 8), whereas, the lowest was in flood irrigation (Rs/ha 36910). Higher net returns were recorded in silver colour mulch (Rs/ha 77939) followed by black colour mulch (Rs/ ha 67179) and white color mulch (Rs/ha 55899). The higher gross returns in these treatments were due to higher seed yield as a result of higher moisture availability and better utilization of nutrients throughout the crop growth period. The lower net returns were obtained under flood irrigated treatment (Rs/ha 32690). The highest benefit cost ratio (1.97) was found for Chickpea cultivated in silver coloured mulch with drip irrigation system, followed by flood irrigated (1.88), black mulch with drip irrigation (1.83), white mulch with drip irrigation (1.69) and drip irrigation (1.51) treatments. The flood irrigated chickpea crop in terms of benefit cost ratio was found higher over two treatments of mulch (black and white) and drip irrigated crop. This is due to the fact that the cost of cultivation of involved in T_2, T_3 and T_5 did not commensurate with the yield values obtained under these treatments.

CONCLUSION

The present investigations were carried out with a purpose to assess the adoption of drip irrigation system in chickpea crop in terms of technical feasibility and economic viability. The findings of the study are encouraging to adopt low head drip irrigation along with plastic mulching in this crop for obtaining higher returns. The highest crop yield (kg/ha 3954) and highest benefit cost ratio (1.97) was obtained under silver mulch with drip irrigation treatment. The yield parameters under black mulch with drip irrigation, white mulch with drip irrigation and drip irrigation treatments were higher as compared to flood irrigated treatment, however, the benefit cost ratio of flood irrigated treatment was higher. It is therefore, the study concludes that adoption of plastic mulch films especially silver colour with drip irrigation system is a techo-economically viable option for chickpea cultivation.

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