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# Adoption of Plastic Mulching Techniques for Enhancing African Marigold (*Tagetes erecta* L.) Production

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***Abstract*:** Production of flowers under plastic mulch films helps in early sowing of the crop and the crops are healthy as the plants are provided with favourable micro climate. The present investigations were carried out at ICAR-Central Institute of Agricultural Engineering, Bhopal during *Rabi* season in 2020-21 and 2021-22 to evaluate the effect of plastic mulch film on water use and plant growth parameters of African marigold. The experiment was conducted by cultivating the crop in four treatments viz., crop cultivation under drip irrigation with silver coloured plastic mulch, black coloured plastic mulch, without mulch and furrow irrigation as conventional practice and each treatment replicated five times. The highest soil temperature was under black plastic mulch. Plant growth parameters viz., plant height, stem girth, number of branches/plants, plant spread and yield contributing characters viz., flower diameter, number of flowers per plant, average fresh and dry weight of flower were significantly higher in plastic mulched compared to no mulch condition. The highest flower yield (32.19 t/ha), water productivity (13.70 kg/m$^3$) and B:C ratio (4.27) was obtained under silver coloured mulch and lowest under furrow irrigation treatment. The plastic mulching is the most productive and profitable method for marigold cultivation in semi-arid areas.

***Keywords:*** Marigold, Growth and yield parameter, Plastic mulch, Water productivity, Economics

Marigold (*Tagetes erecta* L.), a member of the family *Asteraceae* or *Compositae* is a free blooming ornamental crop has lot of demand in National as well as International flower trade (Ahmad et al 2011). Marigold is also an important natural source of xanthophyll used as natural food additive for brightening egg yolks and poultry skin. Marigold is broadly classified into two groups, viz., African marigold (*T. erecta* L.) and French marigold (*Tagetes patula* L.). African marigold (*T. erecta* L.) is a seasonal flowering plant which belonging to the family *Asteraceae* and is a native of South and Central America, especially Mexico. This flower is a prominent and popular flower in India, ranking third in popularity behind roses and chrysanthemums. The area under the marigold cultivation in India is about 64.65 thousand ha with a production of 608.97 thousand MT, whereas Madhya Pradesh is a major marigold producing a state in India with the production of 224.62 thousand MT (National Horticulture Board 2021). Marigold has gained popularity because of its adaptability to various soil and climatic conditions, longer blooming period, economical to major population of India and has good shelf life. Considering the market value, several farmers are now encouraged to cultivate gladiolus, tuberose, marigold, rose, gerbera, and orchid flowers in collaboration with some companies. However, the advanced production technologies are not being widely adopted by the farmers due to lack of knowledge and experimental investigations conducted on this crop with advanced farming techniques are limited. Various factors are to be considered for the high production of marigold, which includes; variety, planting time, amount of fertilizer, spacing of plants, cultural practices like pinching, irrigation, and most importantly having a good quality of soil. Marigold production has been reduced as a result of their lack of expertise and awareness of modern management procedures. The present study is mainly focused on enhancing the flower yield and net return to the farmers by the use of mulching technique.

## MATERIAL AND METHODS

**Study area**: The present study was conducted at ICAR-Central Institute of Agricultural Engineering situated in North of Bhopal at 77°24'10" E, 23°18'35"N. Soils of the experimental site were heavy clay with clay content varying between 49.7 to 53.7%. Field capacity of the soil varied from 28.5 to 31 % (Rao et al 2021). pH value of the soil ranges from 6.5-8.0 (neutral), EC <1.0 (normal) ds/m. The climate of the region is classified as humid subtropical climate with cool, dry winters, a hot summer and a humid monsoon season.

**Experimental details**: The experiment was conducted during *Rabi* 2020-21 and 2021-22, laid out in factorial randomized block design with four treatments each replicated five times. The plot was 21 m long and width was 7 m. The dominate Marigold variety of the region “KMGH-103”

was selected for experimental purpose. In treatment first (T1) and second (T2) the crop was sown on raised bed covered with silver and black coloured 25 micron plastic mulch film respectively with the row to row spacing of 40 cm and plant to plant of 30 cm. Inline drip laterals of 16 mm diameter having discharge rate of 2 lph with emitters spaced at 30 cm were used for irrigation purpose. In treatment third (T3) the crop was sown on raised beds without mulch, while all the other standard cultivation practices of T1 and T2 were followed. In treatment fourth (T4) the crop was sown in ridge and furrow system, wherein crop was sown on ridges and irrigation was provided in furrows. The recommended doses of fertilizers was followed in all the treatments (90:90:75 NPK/ha). On raised beds (treatment first, second and third) 50% of recommended doses of fertilizers were applied as a basal dose, remaining 50% was applied through fertigation using water soluble fertilizers. In treatment fourth (ridge and furrow) 50% doses of nitrogen, 100% of phosphorus and potash were applied at the time of sowing as a basal dose, remaining 50% of nitrogen was applied in two split doses during the crop growing period.

**Data collection:** Five randomly selected plants from each plot were used for recording different plant growth parameters and yield attributing characteristics of plants. In plant growth parameters average plant height (cm), plant spread (cm), number of branches per plant, plant canopy temperature (°c), SPAD values and stem girth (mm) were recorded. The plant height was measured from above ground portion to the flag leaf. Plant canopy temperature values were recorded with the help of infrared thermometer, SPAD values were recorded with the help of chlorophyll meter SPAD-502 plus (Konica, Minolta), which indicates that indirect value of chlorophyll content in plants). For recording stem girth digital Vernier calliper was used. Soil temperature values for each treatment were measured at 5 cm and 10 cm below the soil surface with the help of soil thermometer. These data were recorded at twenty days interval during the crop growing period.

Floral characters like days required to first flower bud emergence, days required to 100 % flowering, flower diameter (cm) and yield attributing parameters such as average number of flowers per plant, flower diameter (cm), fresh and dry weight of individual flower (g) were recorded. For recording average number of flower per plant, flowers were counted from the initial harvest to the last harvest and their mean values are presented in subsequent sections. Diameter of each flower from selected plant was taken with the help of measuring tape at successive growth stages and final mean values were worked out. Values of fresh weight (g) of flower were recorded with the help of weighing balance and dry weight of flower was measured after they were kept in hot air oven at 108$^0$C for 72 hours.

**Water productivity (kg/m$^3$):** Water productivity was also worked out.

$$\text{Water productivity} = \frac{\text{Yield (kg/ha)}}{\text{Water applied (m}^3\text{/ha)}}$$

Irrigation schedules have been finalized in each crop on the basis of crop water requirement to meet the demand of crop evapotranspiration of the study area.

**Economic analysis:** The cost of drip irrigation system included depreciation, interest rate and repair and maintenance cost of the system used in one season of a year was considered. The fixed cost of drip irrigation system for closely spaced crop like marigold is Rs.102879/ha. For calculating depreciation the life of overhead unit and drip laterals was considered to be 10 years and 4 years respectively with salvage values 10% and 5% respectively. Annual interest rate is considered @10% and operation & maintenance cost is considered @ 5% of the initial system cost. The variable cost of cultivation includes expenses incurred in land preparation, manure & fertilizer, plant protection measures, labour, irrigation water and electricity charges. Cost of cultivation was worked out by adding seasonal fixed cost and variable cost. Gross income from produce was calculated using average market price of marigold Rs.15/kg. Benefit-Cost ratio and net profit were determined for economic evaluation.

**Statistical analysis:** The data were subjected to analysis of variance and F-test for determining the significance of the treatments using IBM SPSS Statistics 20 software.

## RESULTS AND DISCUSSION

**Plant growth parameters:** The growth parameters of marigold viz., plant height (51.20 cm), stem girth (15.07 mm) and plant spread (50.62 cm) were maximum and statistically significant under silver coloured plastic mulch over other treatments and at par with black coloured mulch treatment (Table 1). This could be due to maintaining constant soil moisture and favourable temperatures (18 to 25°C) under the mulched condition which enhanced the growth and development of plants during the vegetative period. These findings are in agreement with the soil temperature and moisture recommendations of Sowmeya et al (2017) in marigold when cultivated under protected structures. Canopy temperature significantly influenced by the use of plastic mulch and was recorded highest (24.61°C) under treatment T2 with black coloured mulch followed by silver coloured mulch and lower canopy temperature was recorded under without or no mulch condition (T3, T4). The canopy temperature values were average of the entire crop growing

period. Soil temperatures under black coloured mulch films are higher over silver coloured films that could be the reason for higher values of canopy temperatures under these films over other treatments (Fig. 1). SPAD values were significant under silver coloured mulch compared to other treatments. Number of branches per plants has been significantly varied with different treatments. Though, there is no significant difference in number of lateral branches per plant was observed amongst T1 and T2 treatments, but with other treatments (T3 and T4) the values are significantly different. Findings are in line with the studies conducted by researchers in other crops for example Rao et al (2017) in watermelon, Kumawat et al (2021) in chilli and Yadav et al (2023) in different crops.

In the vegetative growth stage, presence of plastic mulches during *Rabi* season has led to moderating the soil temperature compared with bare soil condition. Soil temperatures were higher under black plastic mulch as compared to other treatments. Plastic mulch increased the soil temperature at 5-10 cm depth by 0.8–2.5°C compared with no mulch condition. Similar observations are being reported by Díaz-Pérez and Batal (2002), Ibarra-Jiménez et al (2008) and Yadav et al (2023).

**Flowering and yield attributing parameters:** Among the different treatments, significant difference was observed in the floral characteristics and yield parameters of marigold. The minimum number of days taken for flower bud initiation (38.74 days) and 100% flowering (71.43 days) was observed under black coloured mulch (TI) and under silver coloured mulch was 39.22 and 72.11 days, respectively. Timely bud initiation may be due to better growth of plants, as result of high soil temperature and favourable moisture under plastic mulch. Solaiman et al (2008) observed similar trend. The number of flowers and yield per plant were significantly influenced by the use of plastic mulching. Number of flowers per plant and yield per plant were non-significant among T1 and T2. However, significant difference was observed when compared with T3 and T4 treatments. The results are in agreement with finding of Bajad et al (2017) in china aster. Maximum number of flowers, flower diameter and yield in case of mulching may be due to cumulative effects of favourable temperatures, soil moisture and no weed growth resulting in better plant growth and physiological activities (Kusuma and Thaneshwari 2021). The average fresh and dry weight of the flower was also significantly superior in mulching treatments (T1 & T2) than in the no mulch condition. The positive effect of mulching on morpho-physiological development of crops was observed by earlier researchers in their studies on different crops (Shinde et al 2021, Rao et al 2018).

**Yield and water productivity:** Combined analysis of two-year data revealed significant difference in yield of marigold under different treatments. The treatment (T1) with silver coloured mulch has maximum flower yield (32.19 t/ha) followed by treatment T2 with black coloured mulch and treatment T3 under drip without mulching. The flower yield per hectare was found to be minimum 15.27 t/ha under treatment (T4) with furrow irrigation. The average flower yield per hectare is significantly affected with use of plastic mulch and irrigation technique. Similar results were also reported by Rajablariani et al (2012) in tomato, Sihombing and Handayati (2017) in tuberose and Islam et al (2021) in different vegetable crops. Water productivity was also significantly superior under treatment T1 with silver colour mulch than rest of the treatments i.e. 13.70 kg/m$^3$ and was at par with T2 under black colour mulch and inferior value was recorded

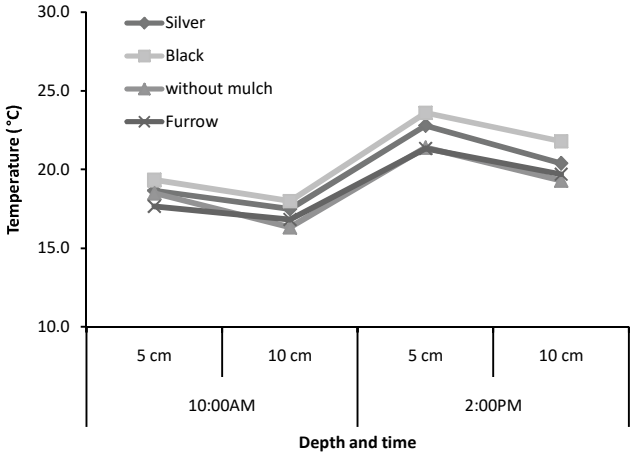


**Fig. 1.** Variation in average soil temperature at 5 cm and 10 cm depth under different treatments

**Table 1.** Growth parameters of marigold influence by use of plastic mulch

| Treatments | Plant height (cm) | Canopy temperature (°C) | SPAD value | Number of lateral branches | Plant spread (cm) | Stem girth (mm) |
|---|---|---|---|---|---|---|
| Silver mulch (T1) | 51.20 | 23.83 | 40.32 | 14.50 | 50.62 | 15.07 |
| Black mulch (T2) | 50.75 | 24.61 | 40.19 | 13.24 | 49.24 | 14.68 |
| Without mulch (T3) | 44.70 | 21.68 | 38.90 | 11.11 | 42.36 | 13.21 |
| Furrow irrigation (T4) | 42.40 | 22.00 | 37.83 | 9.20 | 36.21 | 12.75 |
| CD (p=0.05) | 2.44 | 1.10 | 1.67 | 1.61 | 3.21 | 1.10 |

under furrow irrigation system (Fig. 2). These overall 48.2% saving of irrigation water in plastic mulch condition and 34.8% in drip without mulch over conventional method. Plastic mulching shows a positive impact on yield and water productivity of plants than conventional practices by reducing evaporation from soil surface and provides protection against water loss. Silver plastic mulches are higher in reflecting PAR than black plastic mulches. Such higher reflection of PAR by silver plastic mulches reduces root zone temperature and loss of water.

**Economic evaluation:** The additional expenditure needs to be incurred for adoption of drip irrigation and plastic mulching under marigold cultivation as against the conventional cultivation, economic analysis has been carried out. The maximum cost of cultivation is required under plastic mulch conditions over other treatments; however, additional yields that are obtained under these conditions will compensate the initial investment (Table 3). Treatment T1 with silver mulch was most remunerative with a net return of Rs. 3,91,298/ha and B:C ratio of 4.27 followed by treatment T2. Among all the treatments conventional practices under treatment T4 showed lowest net income and benefit cost ratio. It is

**Table 2.** Yield attributing parameters of marigold influenced by different treatments

| Treatments | Days required for first flower bud emergence | Days required for 100% flowering | Flower diameter (cm) | Number of flower per plant | Flower yield per plant (g) | Average fresh wt. of individual flower (g) | Average dry wt. of individual flower (g) | Flower yield t/ha |
|---|---|---|---|---|---|---|---|---|
| Silver mulch (T1) | 39.22 | 72.11 | 10.16 | 53.63 | 784.32 | 17.38 | 4.38 | 32.19 |
| Black mulch (T2) | 38.74 | 71.43 | 9.78 | 52.60 | 749.20 | 16.63 | 4.29 | 30.65 |
| Without mulch (T3) | 44.80 | 77.80 | 7.43 | 40.25 | 523.40 | 13.84 | 2.76 | 21.34 |
| Furrow irrigation (T4) | 45.82 | 79.40 | 6.46 | 33.60 | 304.43 | 9.22 | 2.43 | 15.27 |
| CD (p=0.05) | 1.73 | 1.37 | 0.60 | 4.31 | 33.39 | 1.32 | 0.34 | 1.80 |

**Table 3.** Economics of marigold crop cultivation

| Particulars | Silver mulch (T1) | Black mulch (T2) | Without mulch (T3) | Furrow irrigation (T4) |
|---|---|---|---|---|
| Initial fixed cost of drip irrigation system, Rs/ha | 102879 | 102879 | 102879 | |
| a. Depreciation | 21165 | 21165 | 21165 | |
| b. Interest on fixed capital @10% | 10288 | 10288 | 10288 | |
| c. Annual operation & maintenance cost @ 5% of drip system cost | 5144 | 5144 | 5144 | |
| Total Annual cost of drip irrigation system, Rs/ha | 36597 | 36597 | 36597 | |
| Seasonal cost of drip irrigation system, Rs/ha | 12199 | 12199 | 12199 | |
| Variable cost | | | | |
| a. Field preparation with machine | 7600 | 7600 | 7300 | 5500 |
| b. Planting material | 16500 | 16500 | 16500 | 20800 |
| c. FYM | 4500 | 4500 | 4500 | 4500 |
| d. Fertilizer | 2550 | 2550 | 2550 | 4870 |
| e. Plant protection | 1752 | 1752 | 2296 | 3248 |
| f. Human labour | 17066 | 16324 | 18921 | 21518 |
| g. Irrigation | 1880 | 1880 | 2820 | 4029 |
| h. Mulching cost | 26400 | 26400 | | |
| i. Electricity @ 6.74 Rs./unit | 1105 | 1105 | 1658 | 3485 |
| Total Variable cost, Rs/ha | 79353 | 78611 | 56545 | 67950 |
| Total cost of cultivation (B + D), Rs/ha | 91552 | 90810 | 68744 | 67950 |
| Yield of flower, t/ha | 32.19 | 30.65 | 21.34 | 15.27 |
| Gross income, Rs/ha | 482850 | 459750 | 320100 | 229050 |
| Net profit, Rs./ha | 391298 | 368940 | 251356 | 161100 |
| Benefit cost ratio (B:C) | 4.27 | 4.06 | 3.66 | 2.37 |

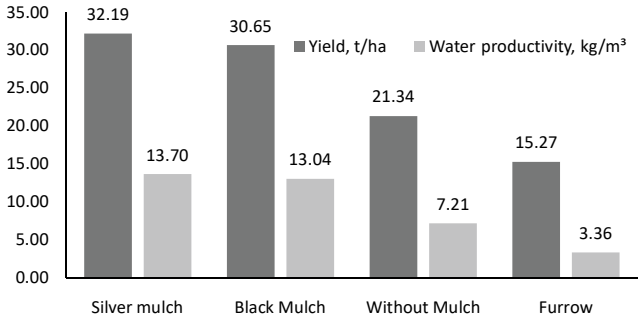


**Fig. 2.** Yield (t/ha) and water productivity (kg/m$^3$) of marigold under different treatments

observed that, the mulched treatments T1 and T2 gave more techno-economic advantage over the other treatments i.e., crop under without mulching and with conventional cultivation practice of irrigation.

## CONCLUSION

Higher flower yield and net profits were observed in marigold crop when cultivated under plastic mulch films with drip irrigation. The standalone drip irrigation system also provided better techno-economic returns over conventional cultivation practice. The adoption of silver coloured mulch had significantly superior effect on the marigold crop in terms of vegetative growth, flower yield and water saving than other treatments. Marigold cultivation under silver colour mulch gave 1.4 times higher net returns over conventional practice.

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