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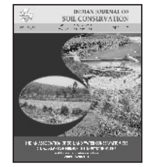

Suitability of different types of used plastic materials as mulches on growth and yield attributes of *rabi* marigold (*Tagetes erecta*)

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ABSTRACT

Field experiments were conducted on clay loam soil at Department of Soil and Water Engineering, SVCAET and RS, FAE, IGKV, Raipur during winter season (November to February) in the year 2015-16 to evaluate the performance of different types of used plastic material as mulches in comparison with conventional Black Plastic Mulch (BPM) under different levels of drip irrigation on growth and yield attribute of *rabi* marigold. Actual Evapotranspiration for *rabi* marigold crop was estimated using modified Penman method. The effect of four irrigation levels *viz.*, 60% ET_c, 70% ET_c, 80% ET_c and 90% ET_c with drip in under BPM and different types used plastic material as mulch *viz.*, used reddish Rice Bag Mulch (RBM), used whitish Wheat Flour Bag Mulch (WFBM), used white Fertilizer Bag Mulch (FBM) were studied. The study indicated that 90% ET_c irrigation requirement met through drip under BPM (90% ET_c + BPM) gave the highest yield (15.12 t ha^{-1}) while it was 13.56 t ha^{-1} for 90% ET_c under RBM. The growth, yield attributes consumptive use of water and benefit cost ratio were found to be highest under the treatment: 90% ET_c + BPM, but very much comparable with those for 90% ET_c + RBM. The study concludes that mulching roll can be prepared from used rice bags, fertilizer bags, wheat flour bag etc. which are available with the farmers in plenty and can be reused as mulching material satisfactorily by small and marginal farmers.

1. INTRODUCTION

In India, the total area under floricultural crops is about 191,000 ha with a production of 1031 thousand metric tonnes (mt) of loose flowers (Lakshmi, *et al.*, 2014). Tamil Nadu is the leading producer with acreage of 32,000 ha contributing about 24% of total production of loose flowers in the country. Jammu and Kashmir has an area of 0.1 thousand ha under flower cultivation with a production of 0.2 thousand mt of loose flowers (Anonymous, 2011).

Marigold (*Tagetes erecta*) is one of the most important commercial flower crops in the global floriculture industry belonging to the family Asteraceae. Marigold is predominantly used as a potted flower crop and as a bedding plant. Besides, it is also commonly used as loose flower and for making garlands. Commercial production of marigold (*Tagetes erecta* L.) flower largely depends upon the availability of assured irrigation. It is important to work out irrigation schedules for the crop for the optimum utilization of irrigation water. In water deficit areas, judicious uses of water and moisture conservation measures are essential for economic production of marigold apart from increasing the area with limited water supply.

Water is one of the most important inputs essential for the production of crops. Furrow irrigation is the conventional method widely used to irrigate most of the vegetable and floriculture crops grown in India. Many researchers have reported higher application efficiency of drip irrigation system over the conventional irrigation methods (Kumar *et al.*, 2012). Sivanappan and Padmakumari (1980) compared drip and furrow irrigation systems and found that about 1/3rd to 1/5th of the normal quantity of water was enough for the drip irrigated plots compared to the normal quantity of water applied to plots under surface irrigation in vegetable crops. Siddapur *et al.* (2014) found the application and distribution efficiencies to be higher with drip irrigation treatments as compared to furrow irrigation. All the drip irrigation treatments recorded higher Benefit:Cost (B:C) ratio (4.88 to 2.30) as compared to 1.73 for furrow irrigation.

Moisture conservation measure such as mulching can be used effectively. Mulch works as an insulating barrier which reduces evaporation, help maintain optimum soil temperature in winter, control salinity and weeds. It also exerts positive effect on growth quality and yield of the crops (Chawla, 2008). Mulching with drip irrigation system is an effective method of manipulating crop growing environment to increase yield and improve product quality by ameliorating soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content (Deshmukh, 2013).

According to thickness of mulch film it is used for different types of crops. Plastic mulch below 40 microns can be used for short duration crops (3-4 months), 50 micron can be used for medium duration crops (1 year) while 100 micron can be used for long duration crops (more than 1 year). There are coloured plastics mulch films, which determine its energy radiating behavior and also influence the micro climate around the plant. It is an established fact now that mulching reduces weed growth and preserve moisture around the root zone of plant but colour and transparency level of mulch also influences growth and other yield attributing parameters of plants. The most common types of mulch is the BPM, which is commercial produced by industry but does create environment problems. Due to extensive and wide spread applications of plastic in all walks of life, every day tons of plastic waste is produced. It is to mention that no authentic estimation is available on total generation of plastic waste in the country however, considering 70% of total plastic consumption is discarded as waste, thus approximately 5.6 m t yr^{-1} of plastic waste is generated in country, which is about 15342 t day^{-1} (CPCB, 2013). Almost every day we heard/read news of suffering of poor animals from being fed of plastic waste as it is thrown with eatables. There is an urgent need to arrest expansion of plastic by means of Refuse or Reduce or Reuse or Recycle. What every individual can do is refuse, reduce and reuse. In all walks of life we utilize plastics extensively and throw it to the dust bin. Food materials and fertilizers etc. are available and sold in plastic bags. Every individual can't recycle plastic waste, but every individual can make reuse of these plastic waste. Can we use these plastic bags as mulch? If yes, then how and with what compromise in comparison to traditional BPM for growing marigold flower in *rabi* season. This study aims at answering these questions.

2. MATERIALS AND METHODS

Location and Layout of Field Plot

The Field experiment was carried out during the year 2015-16 Department of Soil and Water Engineering, SVCAET and RS at Faculty of Agricultural Engineering, Indira Gandhi Krishi Vishwavidyalaya, Raipur (CG), located in the Central part of Chhattisgarh at Longitude 81^{0}42"10"E, Latitude 21^{0}14"9"N and at an Altitude of 302 meters above the mean sea level (msl). The experiment was conducted with four main treatments *i.e.* four irrigation levels on the basis of Evapotranspiration of crop (ETc) *i.e.* 60% (T_1), 70% (T_2), 80% (T_3), and 90% (T_4) and four sub treatments *i.e.* types of mulches *i.e.* BPM (M_1), used whitish WFBM (M_2), used reddish RBM (M_3) and used white Fertilizer bag mulch (M_4). The experiment was laid out in split plot design with three replications as depicted in Fig. 1.

The soil of the experiment site was analyzed in the soil physics and soil science laboratory. A

R_1				R_2				R_3			
T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
M_1	M_2	M_3	M_4	M_1	M_2	M_3	M_4	M_1	M_2	M_3	M_4
M_2	M_3	M_4	M_1	M_2	M_3	M_4	M_1	M_2	M_3	M_4	M_1
M_3	M_4	M_1	M_2	M_3	M_4	M_1	M_2	M_3	M_4	M_1	M2
M_4	M_1	M_2	M_3	M_4	M_1	M_2	M_3	M_4	M_1	M_2	M_3

Fig. 1. Layout of experiment field

composite soil sample (From 3 points) was collected from 0-25 cm depth prior to planting during the study and analyzed for particle size distribution, field capacity, Bulk Density (BD), Organic Carbon (OC), Nitrogen (N), Phosphorus (P), Potash (K), pH and Electrical Conductivity (EC). The soil was clay loam with a pH of 6.2 (1:25, soil : water by Glass electrode pH meter, Piper, 1967) having normal EC (0.05 ds m^{-1} at 25^0C by Solubridge method, Black, 1965) and low in OC (0.29% by Walkley and Black's rapid titration method, Jackson, 1967), medium in available N (188.1 kg ha^{-1} by Alkaline permagnate method, Subbaiah and Asija 1956), low in available P (10 kg ha^{-1} by Olsen"s method, Olsen's 1954) and high in available K (515.2 kg ha^{-1} by Flame photometric method). The soil at the experimental field was clay loam (19.05% clay, 56.42% silt and 44.75% sand by International Pipette method, Black, 1965) having a maximum soil water holding capacity of 28.6% by Pressure plate apparatus method (Black, 1965), BD of 1.44 g cm^{-3} by soil core method.

A field plot 20 m long × 10 m width was divided into three equal parts (20 × 2 m) buffer strip of 2 m left in the middle (*i.e.* R_1, R_2 and R_3) and each part was divided into four strips of 5 m and each strip was again divided into four treatments. Buffer channels were made between two strips of different irrigation levels to control seepage of water from adjacent parts having different irrigation levels. The BPM (27 µ), used whitish WFBM (226 µ), used reddish RBM (240 µ) and used white Fertilizer bag mulch (306 µ) was fixed tightly to cover only the ridges. On both ends of the ridges, mulch sheet was buried into the soil upto a depth of 10 cm. Four weeks old seedlings of *rabi* marigold (*Tagetes erecta*) "Pusa basanti" were transplanted in holes (3 cm) at a spacing of 50 × 30 cm (Row to Row × Plant to Plant). As the plot length was 5 m, hence each plot contained total number of 17 plants with plant to plant spacing of 30 cm. A basal dose of FYM @ 15 t ha^{-1} and fertilizer 150 kg N and 200 kg P_2O_5 ha^{-1} were applied at the time of planting (Jadhav *et al.*, 2014).

The lateral lines were laid parallel to the crop rows and each lateral served one rows of crop. The laterals were provided with `inline' emitters of 1.3 l h^{-1} discharge capacity at 0.3 m interval. Each emitter served the irrigation water requirement of one plants, assuming each emitter wets a strip of 0.5 × 0.3 m^2.

Preparation of Mulching Roll from used Plastic Material

Different types of used plastic materials such as used Wheat flour bags, used Rice bags and used Fertilizer bags were collected from different places such as hostels (used Wheat flour bags and used Rice bags) and farmers residence (used Fertilizer bags). Collection was followed by cleaning and sorting. Sorting was carried out by measuring thickness of used plastic bags with the help of digital vernier calipers. Used plastic bags were sorted in three categories *viz.*, used whitish wheat flour bag (226 µ), used reddish rice bag (240 µ) and used white fertilizer bag (306 µ). Sorting was followed by resizing and fixing. Finally the mulches were assembled in the form of rolls.

Estimation of Irrigation Water Requirement

Reference evapotranspiration (ET_0) was calculated using a modified Penman method (Doorenbos and Pruitt, 1977). The crop coefficient (K_c) for different growth stages of *rabi* marigold were considered based on the unpublished report and local studies carried out in India. The actual evapotanspiration was estimated by multiplying reference evapotranspiration and crop coefficients for different months based on crop growth stages.

The daily irrigation water requirement for the marigold crop was estimated using the following relationship:

$$IR = ET_0 \times K_c - R \qquad \dots (1)$$

Where, IR = Net depth of irrigation (mm day^{-1}); ET_0 = Reference Evapotranspiration (mm day^{-1}); K_c = Crop coefficient; R = Rainfall (mm day^{-1}).

The net volume of water required by the plant can be calculated by the relationship:

$$V = IR \times A \qquad \dots (2)$$

Where, V = Net volume of water required by a plant (m^3 day^{-1}); A = Area under each plant (m^2) {spacing between rows (m), spacing between plants (m)}.

The water requirement was estimated for the growing season of *rabi* marigold (*Tegetes erecta*) *i.e.* from November to February by using equation (2). The daily time of operation of the system was also worked out. Accordingly duration of operating drip irrigation system was worked out for different levels of irrigation (60% ET_c, 70% ET_c, 80% ET_c and 90% ET_c). The duration of delivery of water to each treatment was controlled with the help of lateral control valves provided at the inlet end of each lateral.

Observations of vegetative growth characteristics (plant height and no. of primary branches) were recorded at 110 Days After Transplanting (DAT) and diameter of flower, no. of flower per plant and flower yield per plant were recorded at the time of flower picking. All observations were recorded from ten numbers of tagged plants in each plot.

B:C Analysis

The total cost of marigold production includes cost of seed, nursery preparation, ploughing, FYM application, used plastic bags, preparation of mulching roll, preparation of beds for seedlings, drip irrigation system, mulches, transplanting, crop protection measures, fertilizer and harvesting. The cost of bag was considered ₹ 1 bag^{-1} and cost for preparation of mulching roll of used plastic bags was estimated as ₹ 3.5 m^{-2} (including the cost of labour and fixing). The cost of drip irrigation includes depreciation, prevailing bank rate of interest and repair and maintenance @ 13% $annum^{-1}$ (Rao, 1994). The useful life of the drip system and plastic mulch was considered to be 8 years. The income from produce was estimated using prevailing average market price @ ₹ 20 kg^{-1} of *rabi* marigold. The net seasonal income from produce was estimated by subtracting the total seasonal cost from the income of the produce. The total income from produce over 1 ha area was considered to workout B:C ratio.

3. RESULTS AND DISCUSSION

Effect of Different Irrigation Levels

The effect of different levels of irrigation on different parameters is presented in Table 1. It is apparent from the table that the vegetative growth, flower yield and Water Use Efficiency (WUE) of *rabi* marigold were affected significantly by different levels of irrigation. At 110 DAT the plant height (90.17 cm) and no. of primary branches per plant (12.85) were higher with irrigation scheduled at 90% ET_c as compared to irrigation scheduled at 60% ET_c which recorded lower plant height (69.09 cm) and no. of primary branches per plant (9.93). The present findings are in conformity with the finding of Chawla (2008) in African marigold. Verma *et al.* (2007) also observed that soil moisture content was maintained near field capacity under 100% and 80% ET_c irrigation system. The increase in vegetative growth parameters with irrigation at 90% ET_c was due to fact that adequate soil moisture was provided and reduction in vegetative growth under irrigation at 60% ET_c seems to be due to moisture deficit.

The number of flowers per plant (65.22), flower diameter (4.22 cm), weight of flower per plant (222.22 g) and flower yield (13.33 t ha^{-1}) were highest with irrigation at 90% ET_c while no. of flowers per plant (51.50), diameter of flower (3.11 cm), weight of flower

Table: 1
Effect of different levels of irrigation with different types of mulches on vegetative growth, flower yield and water use efficiency of *rabi* marigold

Treatments	Plant height (cm)	No. of primary branches	No. of flower per plant	Dia. of flower (cm)	Weight of flower per plant (g)	Flower yield (t ha^{-1})	Water use efficiency (q $ha^{-1}cm^{-1}$)
T_1	69.09	9.93	51.50	3.11	155.56	9.33	5.57
T_2	74.61	10.58	55.22	3.46	177.78	10.67	5.46
T_3	82.34	11.73	60.42	3.91	200.00	12.00	5.38
T_4	90.17	12.85	65.22	4.22	222.22	13.33	5.32
CD at 5%	1.63	0.46	4.08	0.18	31.02	1.86	NS
Sub plot treatment (Mulches)							
M_1	80.14	12.15	61.65	3.99	217.56	13.05	6.27
M_2	75.25	10.57	54.18	3.39	164.89	9.90	4.74
M_3	82.80	11.45	59.45	3.75	193.33	11.60	5.56
M_4	77.75	10.93	57.07	3.58	179.78	10.79	5.16
CD at 5%	1.10	0.24	2.37	0.21	7.28	0.44	0.21

CD: Critical difference at 5% level of significance; NS: Non significant per plant (155.56 g) and flower yield (9.33 t ha^{-1}) were lowest with irrigation at 60% ET_c (Table 1). These results corroborate with the findings of Chawla (2008) in African marigold and Verma *et al.* (2007) in apple.

Result of the present investigation showed that consumptive use of water increased significantly with increase in levels of irrigation up to 90% ET_c (Table 1), whereas WUE decreased up to irrigation at 90% ET_c (Table 1). The consumptive use of water (16.76 cm) was lower and the WUE (5.57 q ha^{-1} cm^{-1}) was higher at 60% ET_c, whereas, the consumptive use (25.06 cm) was higher and the WUE (5.32 q ha^{-1} cm^{-1}) was lower at 90% ET_c. The present findings endorse the observation of Tiwari *et al.* (1998) in Okra and Verma *et al.* (2007) in apple.

Effect of Different Types of Mulches

The effect of different types of mulches on different parameters is presented in Table 1. It is apparent from the Table 1 that the vegetative growth, flower yield and WUE of *rabi* marigold recorded were affected by different types of mulches. At 110 DAT the plant height (82.80 cm) was higher with used reddish RBM and no. of primary branches per plant (12.15) was higher with BPM as compared to mulching with used whitish WFBM which recorded lower plant height (75.25 cm) and no. of primary branches per plant (10.57). These endorse the finding of Chawla (2008) in African marigold, Shirgure *et al.* (2005) in acid lime and Lal *et al.* (2003) in kinnow. The reason might be due to the fact that BPM is more effective in checking weeds and ensuring moderate temperature in winter as well as more effective in reducing the evaporation. The performance of used reddish RBM was found very close to BPM.

Various flower quality and yield characteristics of marigold were affected by different types of mulching. The number of flowers per plant (61.65), flower diameter (3.99 cm), weight of flower per plant (217.56 g) and flower yield (13.05 t ha^{-1}) were higher with BPM, while no. of flowers per plant (54.18), diameter of flower (3.39 cm), weight of flower per plant (164.89 g) and flower yield (9.90 t ha^{-1}) were lower with used whitish WFBM (Table 1). These results corroborate with the findings of Chawla (2008) in African marigold. Shirgure *et al.* (2005) also observed higher fruit yield as well as better quality under BPM in acid lime.

Result of the present investigation showed that WUE (6.27 q ha^{-1} cm^{-1}) was higher with BPM whereas, WUE (4.74 q ha^{-1} cm^{-1}) was lower with used whitish wheat flour bag (Table 1). The interaction of different treatments (T) with different sub treatments (M) is presented in Table 2. The significance in terms of highest WUE was found under BPM. The findings authenticate observation of Tiwari *et al.* (1998) in okra. The performance of used plastic bags as mulches (whitish wheat flour bags, reddish rice bags and white fertilizer bags) were also found effective in restricting the growth of weeds.

Cost Economics for Cultivation of *rabi* Marigold with Drip Irrigation System

The economic analysis of cultivation of *rabi* marigold under various treatments is presented in Table 3. The net seasonal income was found to be highest (₹ 1.6 lakh) for drip irrigation with BPM (90% ET_c + BPM) treatment followed by 90% ET_c + RBM treatment (₹ 1.44 lakh), 80% ET_c + BPM treatment (₹ 1.38 lakh) and 90% ET_c + FBM treatment (₹ 1.30 lakh). The net seasonal income was found to be lowest (₹ 0.35 lakh) for drip irrigation with used whitish WFBM (60% ET_c + WFBM) treatment. The B:C ratio was found

Table: 2
Yield of *rabi* marigold, depth of water and water use efficiency under different levels of drip irrigation with different types of mulches

Treatment	Yield (q ha^{-1})	Consumptive use of water (cm)	Water use efficiency (q ha^{1} cm^{1})
T_1M_1	111.73	16.76	6.67
T_1M_2	80.00	16.76	4.77
T_1M_3	95.60	16.76	5.70
T_1M_4	86.00	16.76	5.13
T_2M_1	121.33	19.52	6.22
T_2M_2	94.80	19.52	4.86
T_2M_3	106.67	19.52	5.46
T_2M_4	103.87	19.52	5.32
T_3M_1	137.87	22.30	6.18
T_3M_2	103.20	22.30	4.63
T_3M_3	126.13	22.30	5.66
T_3M_4	112.80	22.30	5.06
T_4M_1	151.20	25.06	6.03
T_4M_2	117.73	25.06	4.70
T_4M_3	135.60	25.06	5.41
T_4M_4	128.80	25.06	5.14
CD at 5%	8.74	-	0.42

CD: Critical difference at 5% level of significance

Table: 3
Economics of production of *rabi* marigold per hectare under different levels of drip irrigation with different types of mulches

Treatment	Fixed cost (₹ lakh)	Drip system Cost (₹ lakh)	Cost of cultivation (₹ lakh)	Total cost (₹ lakh)	Yield of *rabi* marigold (q ha^{-1})	Gross income (₹ lakh)	Net income (₹ lakh)	B:C ratio
T_1M_1	0.73	0.19	1.17	1.36	111.73	2.24	0.88	1.65
T_1M_2	0.73	0.19	1.06	1.25	80.00	1.6	0.35	1.28
T_1M_3	0.73	0.19	1.06	1.25	95.60	1.91	0.66	1.53
T_1M_4	0.73	0.19	1.06	1.25	86.00	1.72	0.47	1.38
T_2M_1	0.73	0.19	1.17	1.37	121.33	2.48	1.06	1.78
T_2M_2	0.73	0.19	1.06	1.25	94.80	1.90	0.64	1.51
T_2M_3	0.73	0.19	1.07	1.26	106.67	2.13	0.88	1.70
T_2M_4	0.73	0.19	1.06	1.25	103.87	2.08	0.82	1.66
T_3M_1	0.73	0.19	1.18	1.37	137.87	2.76	1.38	2.01
T_3M_2	0.73	0.19	1.07	1.26	103.20	2.06	0.80	1.63
T_3M_3	0.73	0.19	1.07	1.26	126.13	2.52	1.26	1.99
T_3M_4	0.73	0.19	1.08	1.27	112.80	2.24	1.00	1.78
T_4M_1	0.73	0.19	1.19	1.38	151.20	3.02	1.60	2.19
T_4M_2	0.73	0.19	1.08	1.27	117.73	2.36	1.08	1.85
T_4M_3	0.73	0.19	1.08	1.27	135.60	2.71	1.44	2.13
T_4M_4	0.73	0.19	1.08	1.27	128.80	2.58	1.30	2.02

to be highest (2.19) for drip irrigation with BPM (90% ET_c + BPM) treatment followed by 90% ET_c + RBM treatment (2.13), 90% ET_c + FBM treatment (2.02) and 90% ET_c + BPM treatment (2.01). The B:C ratio was found to be lowest (1.28) for drip irrigation with used whitish WFBM (60% ET_c + WFBM) treatment.

4. CONCLUSIONS

Based on the result obtained it is concluded that the performance of used plastic bags as mulch is at par as compared to conventional BPM for getting higher production. Small and marginal farmers can develop their own low cost mulching with used reddish Rice bags, used white Fertilizer bags, used whitish wheat flour bags with little efforts and avail the benefits of mulching. It is also concluded that the best irrigation level suitable for farmer is 90% ET_c through drip.

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