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IMPACT OF ORGANIC AND INORGANIC MULCHES ON SOIL ATTRIBUTES OF AFRICAN MARIGOLD (*TAGETES ERECTA* L.) FIELD UNDER SEMI-ARID CONDITION OF BUNDELKHAND REGION OF INDIA

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ABSTRACT

This study assessed the influence of organic and inorganic mulches on soil physicochemical properties, growth, flowering, and yield performance of African marigold (*Tagetes erecta* L.) under the semi-arid climate of Bundelkhand during 2023–2024. The experiment utilized a Randomized Block Design with six treatments: silver-black polythene, black polythene, white polythene, straw, dried leaves, and no mulch. Mulching significantly improved soil moisture retention and nutrient availability compared to the control. Silver-black polythene mulch consistently provided the highest soil moisture (29.97% at the initial stage) and the lowest soil pH (8.38) and electrical conductivity (0.63 dS/m). Dried leaves mulch achieved the highest organic carbon content (0.80%), while black polythene mulch maximized the availability of N, P, and K (238.85, 19.99, and 586.03 kg/ha, respectively). The improved soil environment translated into significantly better growth and yield, including greater plant height, number of branches, flower diameter, and overall yield of Pusa Narangi Gaiinda, in black polythene mulch. The findings demonstrate that both inorganic and organic mulches are highly beneficial for African marigold production. However, organic mulching offers a more sustainable and eco-friendly strategy for simultaneously enhancing soil fertility and maximizing productivity under the water-scarce Bundelkhand region.

Keywords: Electric conductivity, pH, Organic carbon.

Introduction

The word marigold is derived from Mary's gold (Raut and Sarawgi, K 2019) and belong to "Asteraceae" family is the marigold having 33 species (Arora *et al.*, 2020). Marigold is an important and popular traditional cut flower crop, grown by urban and rural farmers in India alike. Its adaptability to different soil and climatic conditions make it the crop of choice for smallholder and commercial growers, especially where there are limitations with soil fertility or agricultural resources (Kaur *et al.*, 2023; Sumangala and Babu, 2018; Sharma *et al.*, 2017; Xue *et al.*, 2023)

Recent studies have emphasized the importance of soil physico-chemical properties, including pH, electrical conductivity (EC), organic carbon and nutrient content (N, P K), in marigold productivity and quality (Machnoor *et al.*, 2023; Nirgulkar *et al.*, 2020; Sumangala and Babu, 2018). For illustration, optimal levels of soil nitrogen and organic carbon are strongly correlated with increased flower yield, while balanced pH and EC further enhance plant performance (Nirgulkar *et al.*, 2020; Biswas and Sarkar, 2020). Innovative soil management strategies, including the use of organic amendments, mulching, and fertigation,

have demonstrated significant improvements in soil health and marigold growth (Sharma *et al.*, 2017; Xue *et al.*, 2023). Compost, manure, and efficient microorganism compost as organic amendments enhance soil organic matter and nutrient availability, in addition to adjusting soil pH and EC, allowing for a better plant growth environment (Sharma *et al.*, 2017; Kaur *et al.*, 2023, Thongchai *et al.*, 2021). It has been demonstrated that practices like mulching and fertigation improve nutrient uptake, water retention in the soil, and soil microbial activity which results in increased yield and quality of flowers. In addition to this management practice, intercropping marigold with other crop combinations or following marigold with some crops can also benefit soil microbial communities, control soil-borne diseases, and provide sustainable soil fertility (Xue *et al.*, 2023; Huang *et al.*, 2022). However increased marigold cultivation, particularly with non-conventional inputs, such as wastewater or sewage sludge, raises concerns regarding heavy metal build-up and the long-term quality of soil health. While a short-term application could increase yield and quality of marigold for farmers, monitoring the chemical properties of the soil over time and environmental risks should be assessed with prolonged use (Al-Huqail *et al.*, 2023). Collectively, these findings underscore the importance of integrated soil management approaches in marigold cultivation, emphasizing the need for continued research on optimizing soil attributes to maximize productivity, sustainability, and environmental safety (Huang *et al.*, 2022; Kaur *et al.*, 2023).

The word "mulch" originates from the German term "molsch," which translates to "easily to decaying" Lightfoot (1994). The term 'mulch' denotes any substance, aside from soil or live plants, that serves as a long-lasting or temporary protective layer over the soil's surface. First, it protects the soil against raindrop impact (Prosdocimi *et al.*, 2016). Bundelkhand soil contains more clay in textural composition so, have low infiltration rate and more runoff at initial rain fall stage hence, there is more need of mulching to reduce

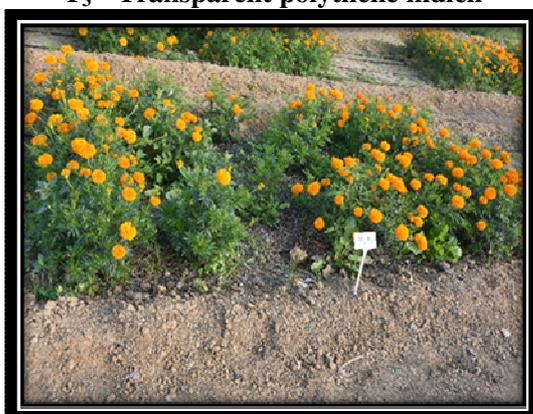
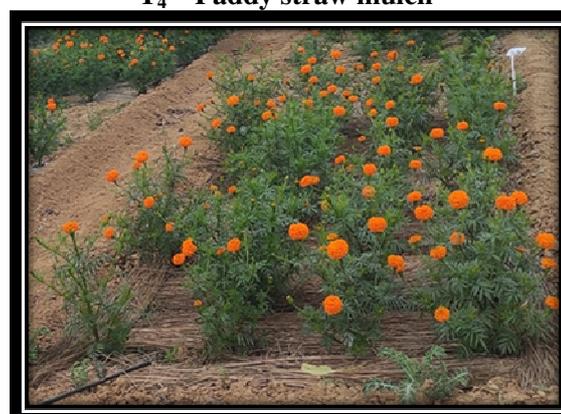
the loos of productive layer of soil and mulch targets to reduce soil erosion. (Nzeyimana *et al.*, 2017). Mulching is a crucial technique extensively employed in orchards, vegetables and flower production to conserve soil moisture, enhance weed control in row crops, (Biwas *et al.*, 2022). There is a serious problem of drought and water shortage in Bundelkhand region and limiting the crop production and decreasing agricultural development. Mulching is most common practice before showing of crop laying plastic material, crop residues, rocks, and manure on the soil surface (Basit *et al.*, 2022).

Materials and Methods

This investigation, Impact of organic and inorganic mulches on soil attributes of African marigold (*Tagetes erecta* L.) field under semi-arid condition of Bundelkhand region was conducted during the Rabi season of 2023, at Instructional Farm, Department of Floriculture and Landscape Architecture, College of Horticulture, Banda University of Agriculture and Technology, Banda. The soil pH was determined in a 1:2.5 soil-water suspension after stirring vigorously for 30 minutes. The pH value was measured using a pH meter. The soil-water suspension used to measure pH was then filtered, and the electrical conductivity (EC) of the resulting solution was measured using an EC meter. The conductivity value was expressed in dS m⁻¹/ deci Siemen per meter (Jackson, 1973). The bulk density of the soil samples collected from the 0-15 cm soil layer was measured using the core sampler technique (Piper, 1966). The organic carbon content in the soil was determined using a method involving potassium dichromate solution. The available potassium in the soil was quantified using the flame photometric technique. The available phosphorus content in the soil was extracted using Olsen's and Bray's reagents (Olsen, 1954) and then quantified using the Vanadomolybdate method. The available nitrogen content in the soil was determined using the Microkjeldahl method (Subbiah and Asija, 1956).

Table 1 : Experimental details

1.	Crop	:	African marigold (<i>Tagetes erecta</i> L.)
2.	Variety	:	Pusa Narangi Gaiinda (PNG)
3.	Design	:	Randomized Block Design (RBD)
4.	No. of Treatments	:	07
5.	No. of Replications	:	03
6.	Total no. of plots	:	21
7.	Spacing	:	45x45 cm
8.	Planting season	:	Rabi season (2023-2024)
9.	Plot size	:	3.5 X 2 m
10.	Gross plot area	:	14.9 X 8 m
11.	Total experimental area	:	119.3 m ²

**T₁ – Black polythene mulch****T₂ – Silver black polythene mulch****T₃ – Transparent polythene mulch****T₄ – Paddy straw mulch****T₅ – Dry leaf mulch****T₆ – Dry grass mulch****Plate 1 : Different mulches used in treatments****Soil attributes**

Soil samples were collected from various random locations within the experimental field before transplanting and after soil preparation. Samples were taken at a depth of 0-15 cm to ensure a representative assessment of soil conditions.

Table 2 : Characteristics of soil in the experimental field before marigold planting

Soil Content	
EC (d Sm ⁻¹)	0.858
pH	8.83
Bulk density (g/cc)	1.225

Organic carbon (%)	0.50
Particle density (g/cc)	0.46
Available N (kg ha ⁻¹)	212.12
Available P (kg ha ⁻¹)	22.52
Available K (kg ha ⁻¹)	480.34

Results and Discussion**Soil moisture content**

Maximum percentage of soil moisture content (29.97), was observed (Table 4) at initial stage in T₂ i.e. 'Silver-black polythene mulch'. Which was statistically equivalent value of (29.31) was recorded in T₃ i.e. 'Transparent polythene mulch'. Whereas,

minimum soil moisture content (19.72) was recorded in treatment T₀ i.e. 'No mulch'. Maximum percentage of soil moisture content (18.88) was observed at growth stage in T₂ i.e. 'Silver-black polythene mulch'. A statistically equivalent value of (18.33) was recorded in T₃ i.e. 'Transparent polythene mulch'. Whereas, minimum soil moisture content (16.13) was recorded in treatment T₀ i.e. 'No mulch'. Soil moisture content at early flowering stage was observed maximum in T₂ i.e. 'Silver-black polythene mulch' (17.85). A

statistical at par (17.32) was recorded in T₃ i.e. 'Transparent polythene mulch'. Whereas, minimum soil moisture content (15.31) was recorded in treatment T₀ i.e. 'No mulch'. Late flowering stage was recorded maximum soil moisture content (16.67) was observed in T₂ i.e. 'Silver-black polythene mulch'. A statistical equivalent to (15.51) T₃ i.e. 'Transparent polythene mulch'. Whereas, minimum soil moisture content (14.09) was documented in treatment T₀ i.e. 'No mulch'.

Table 3 : Effect of different type of mulches on soil moisture content in African marigold field

Treatments	Soil moisture content (%)			
	Initial stage	Growth stage	Early flowering stage	Late flowering stage
T0 - Local control	19.72	16.13	15.31	14.09
T1 - Black polythene mulch	28.16	17.31	17.38	16.12
T2 - Silver-black polythene mulch	29.97	18.88	17.85	16.67
T3 - Transparent polythene mulch	29.31	18.33	17.32	15.51
T4 - Paddy straw mulch	28.81	16.90	16.93	15.33
T5 - Dried leaves mulch	25.24	16.32	16.11	14.92
T6 - Local grasses mulch	27.31	16.62	16.94	15.16
SE(m) ±	0.35	0.217	0.316	0.154
CD (P=0.05)	1.09	0.670	0.974	0.473

Soil pH

A perusal of data presented in (Table 4) revealed significant data was recorded among the different treatments of African marigold. Maximum soil pH (8.64) was mentioned in treatment T₁ i.e. 'Black polythene mulch' followed by T₅ i.e. 'Dry leaves mulch' pH (8.62). Whereas, minimum soil pH (8.34) was observed in T₂ i.e. 'Silver-black polythene mulch'. The soil pH data across different mulching treatments provides insights into how these treatments influence soil acidity. In this experiment pH is non significantly influenced, no mulching (T₀) and dry leave mulch (T₅) both shows slightly alkaline pH levels, with T₀ at 8.62 and T₅ at 8.62. This suggests minimal impact of dry leave mulch on soil pH, maintaining alkaline conditions similar to uncovered soil. Silver-black polythene mulch (T₂) and black polythene mulch (T₄) have pH levels of 8.34 and 8.35 respectively, indicating a slight decrease in pH compared to T₀ and T₅. This suggests these mulches may have a minor acidifying effect on the soil. Transparent Mulch (T₃) and Dry Grass (T₆) exhibit pH levels of 8.51 and 8.54, showing similar alkaline tendencies as T₀ and T₅, though slightly lower. This indicates they have a neutral to slightly alkaline influence on soil pH. Dried Leaves (T₅) demonstrate the highest pH among the treatments at 8.63, suggesting a slightly more alkaline

influence compared to other mulches (Rahmani and Sanker, 2021).

Electric conductivity (EC)

Soil electric conductivity (Table 4) was influenced by different mulch material. The data showed that maximum electric conductivity (0.92 dS/m) was recorded in treatment T₀ i.e. 'No mulch' followed by treatment T₆ i.e. 'Local grass mulch' (0.76 dS/m). On the other hand among organic mulch, the minimum electric conductivity of plant (0.66 dS/m) was recorded within the treatment T₅ i.e. 'Dried leaves mulch'. Before crop showing EC of soil was 0.858 dS/m and Electrical conductivity significantly affects the mulch. Among synthetic mulch black polythene mulch (T₁) demonstrates the lowest conductivity at 0.63 dS/m, indicating reduced salt content, likely due to minimized evaporation and leaching under the plastic barrier. Silver-Black Polythene Mulch (T₂) and Transparent Mulch (T₃) show slightly higher conductivities at 0.74 dS/m and 0.75 dS/m respectively, suggesting slight increases in soil salinity compared to black polythene but still within acceptable limits for most crops. Paddy Straw Mulch (T₄), Dried Leaves (T₅), and Dry Grass (T₆) exhibit intermediate conductivities ranging from 0.66 dS/m to 0.76 dS/m. These organic mulches contribute to maintaining moderate salinity levels, beneficial for soil health and crop growth.

Bulk density

Maximum bulk density of soil (1.23 g/cc), (Table 4) was observed in treatment T₂ i.e. 'Silver-black polythene mulch' followed by treatment T₆ i.e. 'Local grass mulch' (1.157 g/cc) where a minimum bulk density was observed in treatment T₀ i.e. 'No mulch' (1.103 g/cc). This similarity suggests that black polythene mulch does not significantly alter soil compaction compared to uncovered soil, indicating minimal impact on soil structure. Silver-Black Polythene Mulch (T₂), there is a slight increase in bulk density to 1.123 g/cc. This indicates a minor level of soil compaction, likely influenced by the physical properties of the mulching material. Transparent Mulch (T₃) shows the highest bulk density among the treatments at 1.203 g/cc. This significant increase in bulk density suggests considerable soil compaction, potentially due to the weight and physical characteristics of the transparent mulch material. Paddy straw mulch (T₄) exhibits a bulk density of 1.137 g/cc, slightly higher than the no mulching and black polythene mulch treatments. This suggests some level of soil compaction due to the presence of the mulch material.

Organic carbon

The perusal of data presented in revealed (Table 4 revealed) maximum organic carbon (0.66 %) in

treatment T₃ i.e., 'Transparent polythene mulch', followed by T₁ i.e. 'Black polythene mulch' (0.58 %). However, minimum organic carbon (0.48 %) was observed with treatment T₀ i.e. 'No mulch'. Organic mulches significantly increase soil organic carbon, promoting soil fertility, water retention, and microbial activity. While synthetic mulches may stabilize soil conditions, they typically contribute less organic carbon compared to organic mulches. Before crop sowing organic matter content in soil is 0.4 % and Before crop showing vermicompost and FYM incorporated in all plot equally, organic matter content must be increased after crop harvesting. No mulching (T₀) shows the lowest organic carbon content at 0.48%, reflecting the baseline level. Paddy straw mulch (T₄), dried leaves (T₅), and dry grass (T₆) demonstrate higher organic carbon contents, ranging from 0.7 % to 0.8 %. These organic mulches contribute significantly to soil organic matter, enriching the soil with carbon and enhancing nutrient availability over time, Similar results were founded by Sun *et al.* (2021). Black polythene mulch (T₁), silver-black polythene mulch (T₂) and transparent mulch (T₃) exhibit organic carbon contents ranging from 0.57% to 0.66%. These synthetic mulches generally maintain or slightly enhance organic carbon levels compared to uncovered soil, likely due to reduced decomposition rates under the plastic barriers.

Table 4 : Effect of different types of mulch on pH, electrical conductivity, bulk density and organic carbon in African marigold cv. Pusa Narangi Gainda

Treatments	Soil pH	Electrical conductivity (dS/m)	Bulk density (g/cc)	Organic carbon (%)
T ₀ - Local control	8.62	0.92	1.113	*0.48
T ₁ - Black polythene mulch	8.35	0.63*	1.113	0.58
T ₂ - Silver-black polythene mulch	8.34*	0.74	1.123	0.57
T ₃ - Transparent polythene mulch	8.51	0.75	1.203	0.66
T ₄ - Paddy straw mulch	8.40	0.68	1.137	0.70
T ₅ - Dried leaves mulch	8.62	0.66	1.103*	0.80
T ₆ - Local grasses mulch	8.54	0.76	1.157	0.67
SE(m) ±	0.04	0.009	0.017	0.032
CD (P=0.05)	0.11	0.028	0.054	0.098

* Minimum

Available nitrogen

Mulching materials had a significant difference in available nitrogen in different treatment (Table 5). The maximum available nitrogen (238.85 kg/g) was documented in treatment T₁, i.e. 'Black polythene mulch' which was statistically at par with treatment T₆, i.e. 'Local grasses mulch' (228.40 kg/ha). However, a significant minimum available nitrogen (203.54 kg/ ha)

was observed with treatment by T₀ i.e., 'No mulch'. 4.6.7: Black polythene mulch exhibits the highest available nitrogen content at 238.85 kg/ha. Black mulch ones are known for their ability to enhance soil temperature and moisture retention, which can promote microbial activity and accelerate nutrient release from organic matter. Dry grass mulch also shows a significant nitrogen content. Grass mulches decompose relatively quickly, releasing nitrogen into the soil as

they break down. This could explain the higher nitrogen availability compared to some other mulch types. Paddy straw mulch is commonly used in agriculture to improve soil structure and moisture retention. The control treatment (T₀) has the lowest available nitrogen at 203.54 kg/ha. This emphasizes the importance of mulching in retaining and enhancing soil nutrients compared to leaving soil bare. Similar findings have also been documented by Saïdou *et al.* (2003), Olaniji and Ajao (2011), and Aziz *et al.* (2022) black polythene mulch shows the highest available phosphorus content at 19.99 kg/ha. especially black can help conserve soil moisture and moderate soil temperature, which may enhance phosphorus availability by improving microbial activity and nutrient release from organic matter. Grass mulches, like dry grass, decompose relatively quickly and release nutrients such as phosphorus into the soil, thereby contributing to increased availability for plant uptake. Paddy straw mulch improves soil structure and water retention, Control treatment (T₀) has the lowest available phosphorus at 16.51 kg/ha. Similar findings have also been documented by Saïdou *et al.* (2003), Olaniji and Ajao (2011), Aziz *et al.* (2022)

Available phosphorus

The maximum available phosphorus (Table 5) was recorded in treatment T₁ i.e. 'Black polythene mulch' (19.99 kg/g). Followed by treatment T₄ i.e. 'Paddy straw mulch' (19.22 kg/ha). However, a significant minimum available phosphorus (16.51 kg/ha) was observed with treatment by T₀ i.e. 'No mulch'. 4.6.8. The availability of phosphorus is maximum in Bundelkhand region soil. Available phosphorus changes due to long-term effect of mulching but there is a small plot of area for research work hence not effective change in available phosphorus.

Available potassium

The mulching materials had a significant effect on available potassium of different treatment (Table 5). The maximum available potassium (586.03 kg/g) was recorded in treatment T₁ i.e. 'Black polythene mulch'. Followed by treatment T₆ i.e. 'Local grasses mulch' (701.54 kg/ha). However, a significant minimum available potassium (440.49 kg/ha) was observed with treatment by T₀ i.e. 'No mulch'.

Table 5 : Effect of different type of mulches on available nitrogen, available phosphorus, available potassium in African marigold field.

Treatments	N, P, K		
	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
T ₀ - Local control	203.54	16.51	440.49
T ₁ - Black polythene mulch	238.85	19.99	586.03
T ₂ - Silver-black polythene mulch	216.32	18.65	426.86
T ₃ - Transparent polythene mulch	221.71	18.33	482.83
T ₄ - Paddy straw mulch	227.39	19.22	568.10
T ₅ - Dried leaves mulch	216.54	18.54	444.07
T ₆ - Local grasses mulch	228.40	19.24	701.54
SE(m) ±	3.99	0.30	12.19
CD (P=0.05)	12.28	0.93	37.56

Soil temperature

All temperature was recorded at 15 cm depth from soil surface by penetration soil thermometer at 15°C. Generally, lower temperatures are observed, especially in December and early January. Gradual increase in temperature towards February, reaching a peak of 33.70°C. Transparent mulch (T₃) observed temperatures from 16.50°C to 33.70°C was highest temperatures recorded among all mulch treatments during December to February. Transparent mulch allows maximum solar radiation penetration and due to greenhouse effect warming the soil effectively. A similar result discovered by Lamont *et al.* (2005),

black film increased soil temperature by 0.8 °C, whereas transparent film increased it by 2.4 °C. Condensation on the underside of the mulch absorbs long-wave radiation in the evening, thereby slowing down the soil's cooling process. Suitable for colder climates or for crops requiring warmer soil conditions throughout the growing season. During winter nights, its higher permeability to long-wave radiation could potentially elevate the temperature around the plants. Ramakrishna *et al.* (2006), Gosar *et al.* (2011) and Ojha *et al.* (2016), after this black polythene mulch (T₁) recorded consistently higher temperatures compared to other mulching types ranged from 15.70°C to 33.20°C. Provides significant thermal

insulation, leading to warmer soil conditions. Due to the jet black color polythene absorb maximum quality of solar light and make sustain temperature at day night period in root zone of plant. Slightly lower temperatures in silver black polythene (T_2) compared to black polythene mulch (T_1). Reflective properties of silver side moderate soil temperature, providing a balance between warmth and cooling. Moderate to warm temperatures were maintained throughout the

measurement period because all data was recorded at 2:00 pm. Provides a stable thermal environment, beneficial for maintaining optimal soil moisture and temperature balance. Dried leaves (T_5) and Dry grasses (T_6) also provide similar insulation against temperature extremes. Minimum temperature ranged between 13.40°C to 30.30°C across different dates in no mulch condition (T_0). Burg *et al.* (2022), Basit *et al.* (2022) Ye, L *et al.* (2023), Demo *et al.* (2024).

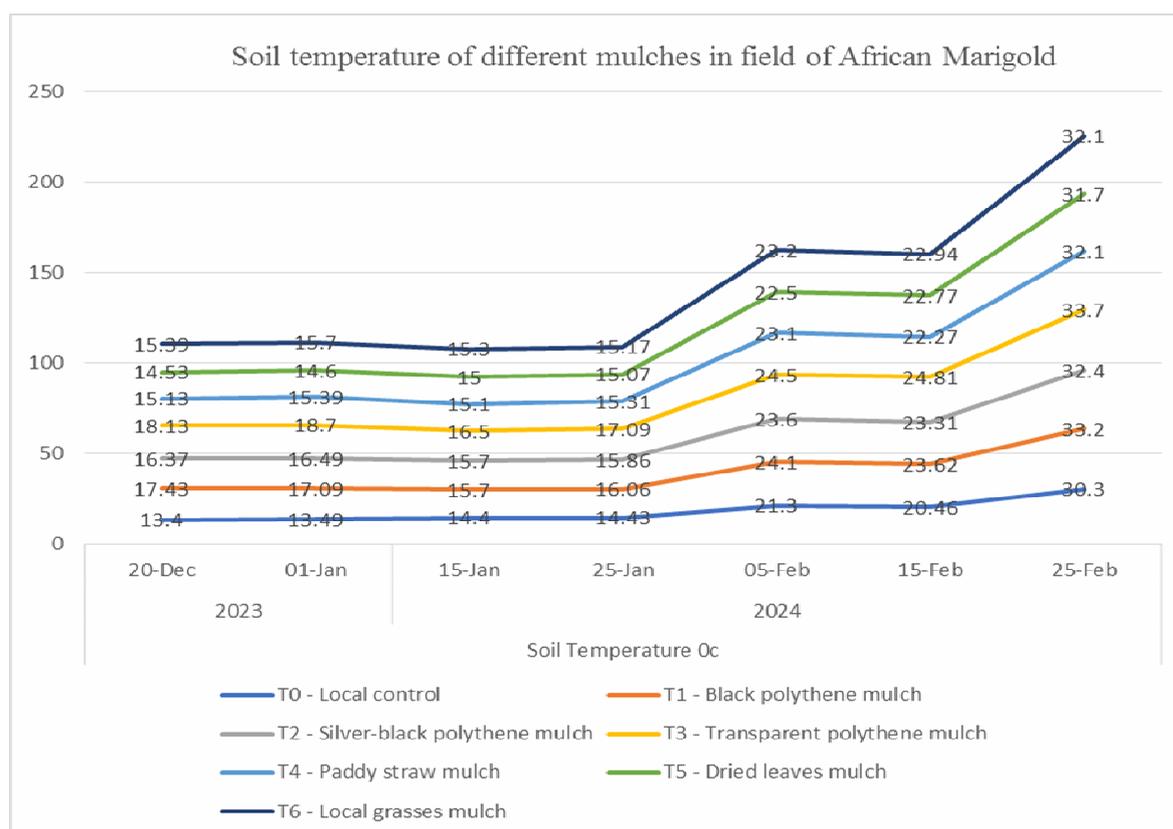


Fig. 1 : Effect of different type of mulches on soil temperature in African marigold cv. Pusa Narangi Gaiinda

Conclusion

The study effectively demonstrated that the application of both inorganic (polythene) and organic mulches significantly improved soil properties compared to the 'No mulch' control. In summary, the use of black and silver-black is scientifically validated as superior for short-term gains in soil moisture retention, temperature regulation, and immediate nutrient availability (N and P). Conversely, organic mulches, especially dried leaves and local grasses, are essential for improving soil organic carbon and boosting available potassium, contributing to better long-term soil health and sustainability. For the target objective of productivity under semi-arid conditions, the polythene mulches appear to offer the most immediate benefits due to superior soil moisture and temperature control.

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