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Impact of various mulches on growth and soil properties of sweet orange CV. Mosambi

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Abstract
The field experiment on influence of various mulches on soil properties and growth of one year old sweet orange plants was conducted for two consecutive years during April, 2018 to March, 2020 at the Department of Fruit Science, College of Horticulture and Forestry, Jhalawar. The experiment consisting of five mulches (no mulch, black polythene mulch, transparent polythene mulch, coriander straw mulch and dry grass mulch) was laid out in Randomized Block Design with three replications. The study revealed that growth attributes of plants being significantly higher with black polythene mulch whereas the growth of plants recorded lower without mulching. The maximum per cent increase in scion girth and number of nodes shoot^{-1} were recorded with black polythene mulch. Similarly, analysis of soil physical properties indicated better moderation in soil pH (7.25), electrical conductivity (0.39 dSm^{-1}), bulk density (1.33 mg.m^{-3}), besides obvious increase in porosity (49.93%) and water holding capacity (43.67%) as compared to other treatments in soils of rhizosphere of sweet orange orchard soil with black polythene mulch.

Keywords: Growth, mulch, soil physical properties, black polythene mulch, sweet orange

Introduction

Citrus contribute major group of fruit crops grown over 9.68 million hectares area with production of 94.02 million tonnes fruits across the world (USDA, 2020) [20]. In India these fruits rank second in area after mango and occupied third position in production (after mango and banana). Citrus fruit crops cover about 1.03 million hectares area with a production of 13.02 million tonnes in which 26.29 per cent share relates to sweet oranges. Its production is of the order of 2.87 million tonnes from 1.79 lakh hectares area put under cultivation (Anon., 2019) [2]. Maximum area under sweet oranges is in Andhra Pradesh followed by Maharashtra and Karnataka. It is highly productive and good net profit is obtained over most of other fruit crops (Jakhar *et al.*, 2013) [7]. Sweet orange is an evergreen fruit crop of tropical and subtropical regions (40°N and 40°S latitudes) (Meena *et al.*, 2018) [11] which requires water all-round the year compared to the other subtropical fruits since the sap flow never entirely ceases and transpiration take place throughout the year. For last few years, water availability is being witnessed as one of the major constraints in fruit production. Conservation of soil moisture by application of mulches becomes essential for cultivation under rainfed condition of semi-arid regions.

Mulches have been found effective in minimizing requirement of water, reduction in soil erosion, improvement in soil structure, reduction in soil salinity, improvement in water infiltration, addition of organic matter, improvement in soil aeration, regulation of soil temperature, suppression of weed growth and reduction in weed competition with crop for water and nutrients (Shirgure *et al*., 2003; Kaur and Kaundal 2009) [16, 8]. Enhanced microbial activities in the field are added benefits of mulch. Soil water storage increases due to mulching which enhance the availability and uptake of nutrients by plants (Tan *et al*., 2009) [18]. The silver-black mulch is used when planting is done during hot weather. The upper silver surface of silver-black mulch, reflects the sun energy and the soil is not get heated, keeping it comparatively cooler, while lower black surface of this mulch prevents weed growth. The reflective silver colour mulch has benefits of reducing the incidence of certain diseases and through its use fumigant rates can be reduced to 50 per cent (Olson, 2011) [12]. Besides polythene mulches, organic mulches can also be used with the same benefits. These are easily available and economically very cheap. Living plant waste such as dry grasses, crop stump, straw, bark clipping, compost, saw dust, onion and garlic scales, leaf litter etc. can be used as organic mulch.

These materials decompose over time and add organic matter and nutrients to top layer of soil.

Technique of water saving holds prime importance especially in the scenario when availability of irrigation water is aggravating day by day in many regions of the country. It is likely to prove useful in sustainable cultivation of sweet orange vertisol condition of S-E Rajasthan and in other regions experiencing similar horti-ecological conditions. Keeping the utility of mulches into account, present investigation was planned to observe the effects of mulches on growth and development of sweet orange plants and soil properties of orchard soil.

Materials and Methods

Site Description

The present experiment was conducted for two successive years with effect from April, 2018 to March, 2020 at the College of Horticulture and Forestry, located in Jhalawar district of India. The site is situated at 23º4 and 24º52 N-Latitude and 75º29 to 76º56 E-Longitude in South-Eastern part of the state. Agro-climatically, the average rainfall in the district is 950 mm. Humidity in the region remains more than 90% during rainy season and mostly cloudy weather prevails during rainy months of the year. Maximum temperature range during the peak summer is 45-47 ºC and minimum 2 ºC during winter. No drop of water available during scorching peak summer season in the month of May-June, meanwhile the area experiences high evaporation. The water conservation experiment holds its utility for such area especially.

Treatments detail and experimental design

The experiment was carried out at the instructional farm of the college which has spread of black cotton soil with 49.9% clay, 40.0% silt and 10.1% sand. Physical and chemical properties of experimental orchard soil are shown in Table I.

The experiment was carried out with 1-year old sweet orange (C*itrus sinensis* Osbeck) plants. It was continued for two consecutive years starting from April, 2018 – March, 2019 and April, 2019 – March, 2020 with the same plantation. Area of the experimental block was accommodating 90 sweet orange plants. Treatment comprises five kinds of mulches.

The details of treatment evaluated under the study are as under:

M_0: Without mulch
M_1: Black polythene mulch
M_2: Transparent polythene mulch
M_3: Coriander straw mulch
M_4: Dry grass mulch

The mulch treatments were applied during first week of April 2018-19 and same during the nextward repetitive year 2019-20 after recording initial (base) growth and development parameters of plants as well as soil parameters. Polythene mulches of 20 micron were used as a part of experiment. The thickness of coriander straw and dry grasses mulches were kept to 10 cm for the experiment.

Growth parameters were recorded at monthly interval during both years of observations. Scion girth (mm) was measured with the help of vernier caliper. The number of nodes per shoot was counted manually at monthly interval from the tagged shoots and average increase in number of nodes per shoot was computed on the basis of cumulative increase in initial value.

For analyzing soil parameters, the pH of the soil samples was determined with the help of glass electrode pH meter. Soil EC was determined using digital EC meter.

The Bulk density ($Mg.m^{-3}$) (Piper, 1950) [13] of soil in 0-15 cm depth was determined. Soil sample was collected with the help of core sampler. These soil samples were oven dried (105°C) upto a static weight then cooled and weighed. BD ($Mg.m^{-3}$) was computed as per the formula:

$$\text{BD } (Mg.m^{-3}) = \frac{\text{Mass of soil (oven dried)}}{\text{Volume of soil with pore space}}$$

The soil porosity was calculated at the end of experiment as per the formula given:

$$\text{Porosity (\%)} = 1 - \frac{\text{Bulk density}}{\text{Particle density}} \times 100$$

The water holding capacity (WHC) of soil was calculated as per the formula given:

Water holding capacity (%) = Total water held by the soil/ Total weight of soil × 100

Statistical Analysis

The data generated during the experiment carried out during April, 2018 to March, 2020, were subjected to analysis of variance (ANOVA) in order to evaluate the effect different mulches on plant growth and soil properties of sweet orange and separation of means was done at $P < 0.05$ by using Duncan multiple range test (DMRT) with the help of WASP (version 2) statistics software.

Result and Discussion

Growth Parameters

Scion girth (mm): The effect of differential mulches on the critical growth and development was monitored with periodical investigation of plant. There had been progressive increase over different span of observation period varying from April, 2018 to March, 2020 in scion girth as reflected from pooled analysis of data obtained from the experiment (Table 2). It is reflected from the analysis of pooled data that the per cent increase in scion girth due to different mulch treatments (38.95%) was recorded in M_1 treatment (Black polythene mulch) which was found significantly higher over all other treatments. The minimum per cent increase (23.48%) in scion girth at the end of experiment was observed in treatment M_0 (No mulch). Further, the maximum increase in scion girth was reported in consecutive period between June to September and March during both years (April, 2018 to March, 2020).

Number of nodes/shoot: From the perusal of the pooled data pertaining to effect of mulches on number of nodes/shoot of sweet orange plants cv. Mosambi presented in Table 2 it is reflected that the number of nodes/shoot was increase regularly with the progression of the growth period of the observation right from April, 2018 to March, 2020. The maximum per cent increase in number of nodes/shoot (73.00%) was registered in treatment M_1 (black polythene mulch), which was significantly higher over all other treatments. However, minimum percentage increase in number of nodes/shoot (46.70%) was recorded from the treatment M_0 (no mulch). Moreover, the maximum increase in number of nodes/shoot was reported higher in successive period between June to September and March.

The higher growth of plants under M_1 treatment (black polythene mulch) may be explained in the light of improvement of water conservation, minimization of loss of soil moisture due to evaporation, improvement of soil structure turning it loose and well aerated, reduction of soil salinity (Shrestha and Shukla, 2014) [17] due to formation of humic acid (Tiwari *et al.,* 2014) [19], regulation of soil temperature (Ramkrishna *et al.,* 2006) [14], complete suppression of the weed growth (Bahadur *et al.*, 2018) [3] due to no light penetration curtailing weed competition with plant, besides better absorption of nutrients under moderated microenvironment (Bakshi *et al*., 2015) [4] among many other benefits. The better microclimate in the rhizosphere, stimulation of surface rooting, enhanced nutrient absorption from the surface soil (Russell, 1975) [15] might favour higher increase in shoot parameters in M_1 treatment.

Similar explanations for encouraging results with black polythene mulch have been cited by Haneef *et al.* (2014) [6] in pomegranate and Adnan *et al.* (2017) [1] in strawberry.

Soil parameters

Soil pH: The pooled data regarding soil pH as influenced by different mulches in sweet orange cv. Mosambi orchard soil are exposed in Table 3. The pooled data indicated that pH of sweet orange cv. Mosambi orchard soil was significantly influenced by different mulches at the end of experiment. The minimum soil pH due to different mulch treatments (7.25) was noted in treatment M_1 (Black polythene mulch) which was significantly superior over other treatments. The maximum increase in soil pH (7.48) was recorded in treatment M_0 (No mulch) at the end of experiment (March, 2020).

Soil electrical conductivity (dSm^{-1}): From the perusal of the pooled data pertaining to effect of mulches on soil electrical conductivity (dSm^{-1}) of sweet orange cv. Mosambi orchard presented in Table 3, it was exhibited that there was significant difference in soil electrical conductivity at the end of experiment. The minimum soil electrical conductivity due to different mulch treatments (0.39 dSm^{-1}) was noted in M_1 (Black polythene mulch) treatment which was statistically superior over all other treatments. The maximum increase in soil electrical conductivity (0.51 dSm^{-1}) was recorded in treatment M_0 (No mulch) at the end of experiment (March, 2020).

Bulk density (mg.m^{-3}): The pooled data pertaining to soil bulk density as influenced by different mulches of sweet orange plants cv. Mosambi orchard soil are presented in Table 3. From the data it is reflected that the minimum bulk density of soil due to different mulch treatments (1.33 mg.m^{-3}) was recorded in M_1 treatment (Black polythene mulch) which was significantly superior over all other treatments. However, the maximum bulk density of soil at the end of experiment (1.43 Mg.m^{-3}) was observed in treatment M_0 (No mulch).

Porosity (%): The pooled data pertaining to soil porosity as influenced by different mulches of sweet orange plants cv. Mosambi orchard soil are presented in Table 3. From the data it is reflected that the maximum porosity of soil due to different mulch treatments (49.93%) was recorded in M_1 treatment (Black polythene mulch), which was significantly superior over all other treatments. However, the minimum soil porosity at the end of experiment (45.49%) was observed in treatment M_0 (No mulch).

Water holding capacity (%): The pooled data pertaining to soil water holding capacity (%) as influenced by different mulches of sweet orange pslants cv. Mosambi orchard soil are presented in Table 3. From the data it is reflected that the maximum water holding capacity of soil due to different mulch treatments (43.67%) was recorded in M_1 treatment (Black polythene mulch), which was significantly superior over all other treatments. However, the minimum soil water holding capacity at the end of experiment (34.43%) was observed in treatment M_0 (No mulch).

In long duration fruit crops based experiments, the better affectivity of black polythene mulch in better moderation of pH, EC and bulk density, improvement in porosity and water holding capacity may be attributed due to continuous accumulation of higher organic substances and humic acid, that is the stock house for the supply of nutrients to plants. Black plastic mulch cover on soil owing to its better durability over organic mulches perhaps had better cumulative accumulations of the organic matter from structural carbon present in reserve pool of the soil.

Relatively better soil pH and EC values in treatment M_1 (Black polythene mulch), due to reduction in enzymatic oxidation of carbon dioxide and the accumulated CO_2 on soil surface, it reacts with soil moisture and formed carbonic acid. Thus, pH of soil covered with black polythene mulch is slightly decreased compared to other treatments. The improved soil structure (bulk density, porosity) might be due to soil get loose as the plant under black polythene mulch treatment, the bulk density was decreased and corresponding increase in porosity of soil (Khan, 2002; Lalitha *et al.,* 2002) [9, 10]. Plastic mulch directly affects the soil microclimate around the plant by modifying the radiation budget and soil physical environment and conserving soil moisture (Chakraborty *et al.*, 2008) [5].

Table 1: Physical and chemical properties of soil of experimental orchard

S. No.	Soil properties	Content
1.	pH	7.36
2.	Electrical conductivity (dSm^{-1})	0.45
3.	Organic Carbon (%)	0.49
4.	Bulk Density (Mg.m^{-3})	1.38
5.	Porosity (%)	47.62
6.	Water holding capacity (%)	38.68
7.	Available N (kg.ha^{-1})	305.92
8.	Available P (kg.ha^{-1})	25.13
9.	Available K (kg.ha^{-1})	282.06

Table 2: Effect of mulches on scion girth and number of nodes/shoot (percentage increase) of sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi during two years growth period (April, 2018 to March, 2020)

Treatments	Pooled values	
	Scion girth (mm)	Number of nodes/shoot
M_0	23.48[e] (35.13)	46.70[e] (24.51)
M_1	38.95[a] (40.15)	73.00[a] (28.85)
M_2	26.50[d] (36.35)	50.33[d] (24.29)
M_3	30.38[c] (36.27)	55.43[c] (26.65)
M_4	33.70[b] (38.48)	61.59[b] (27.30)
SE (m) ±	0.60	0.775
CD at 5%	1.76	2.244

Note:
1. Data in parentheses indicate Scion girth in mm and number of nodes/shoot.
2. CD value has been calculate on the basis of *Arc sine* transformed values. The variation not varying between 0 to 30 or 70 to100 were subjected to *Arc Sine* Transformation (Gomez and Gomez, 1984)
3. M_0- No Mulch (Control), M_1- Black Polythene mulch, M_2- White Polythene mulch, M_3- Coriander Straw Mulch, M_4 – Dry grass mulch
4. Means with same letter are not significantly different at $P \leq 0.05$

Table 3: Effect of mulches on soil parameters of sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi field during two years growth period (April, 2018 to March, 2020)

Treatment	Soil Parameters (Pooled values)				
	pH	EC (dS m^{-1})	BD (Mg m^{-3})	Porosity (%)	WHC (%)
M_0	7.48	0.51	1.43	45.49	34.43
M_1	7.25	0.39	1.33	49.93	43.67
M_2	7.44	0.49	1.41	46.42	35.85
M_3	7.32	0.45	1.38	47.47	40.19
M_4	7.31	0.44	1.37	48.01	41.09
SE (m) ±	0.009	0.004	0.002	0.16	0.32
CD at 5%	0.027	0.010	0.006	0.48	0.94

Note: Means with same letter are not significantly different at $P \leq 0.05$

Conclusion

Among different treatment of mulches, scion girth (38.95%), number of nodes/shoot (73.00%), were noted significantly maximum under M_1 treatment (Black polythene mulch). Soil parameters such as pH (7.25), electrical conductivity (0.39 dSm-1), bulk density (1.33 Mg.m-3) moderated better, besides significantly higher water holding capacity (43.67%) reported in treatment M_1 (Black polythene mulch) as compared to all other treatments in rhizosphere soil of sweet orange plants.

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