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COMPARATIVE ASSESSMENT OF DIFFERENT TYPES OF MULCHING IN VARIOUS CROPS : A REVIEW

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Abstract

In today's world, human and livestock population is steadily increasing while the per capita arable land is shrinking. The farmers have been using various strategies in order to meet the growing demand for food crops. Weeds provide major challenge in the cultivation of any crop, worldwide. There are around 10 weeds that grow in almost every crop and affect the yield. Those extensively growing weeds involve *Cannabis*, *Medicago lupulina*, *Chenopodium*, grasses, dandelion, chickweed, thistle etc. Mulch suppresses the weed growth as it covers the soil surface and the weeds fail to get congenial conditions to grow and compete with the main crop. Among various weed management strategies, one basic practice they follow now days is 'mulching', as it is less expensive, eco-friendly, safe, feasible and show reproducible results as compared to the other techniques. Two types of mulches are used to control weeds (i) inorganic and (ii) organic. Inorganic mulch includes synthetic mulch (plastic mulch). Mulch retains soil moisture and reduces the water requirements of the plant. It also promotes early maturation of the crop by enhancing the yield of the crop. However, site-specific knowledge is a pre-requisite for the use of mulches. The present review focuses on the various kinds of mulches and the advantages and disadvantages of using organic and inorganic mulches.

***Keywords*:** Organic mulching, Synthetic mulching, Weeds, Water conservation

Introduction

Weeds are uninvited guests which are noxious and problematic in the crop fields as they compete with the crop plants for nutrients, water and space (Qin *et al*., 2015; Jaysawal *et al*., 2018; Kumar *et al*., 2019). Mulching technique is primarily used in fields by farmers to reduce the weed growth in the crop. The type of mulch to be used depends on the type of weed, type of soil/topography, prevailing weather conditions of the area, crop to be cultivated and the availability of mulch. In simple terms, mulch is defined as the material which is used in the field to control the growth of unwanted plants. Mulches can be categorized into two types- organic and synthetic mulch. In organic mulching, suitable animal or plant residue is used to cover soil so that it will enhance the growth of crop while in synthetic mulching, materials like plastic/polythene sheets, rubber sheets, glass chips etc. is used to reduce weed growth. Mulching also play role in conserving moisture of soil by decreasing rate of evaporation and altering infiltration capacity of soil surface (Stigter, 1996; Jordan *et al*., 2010). Mulches help in decreasing temperature during summer and increases temperature during winters. Mulches prevent surface run-off and thus decreases soil erosion (Stelli *et al*., 2000 and Mucina *et al.*, 2006).

Following is the table showing different types of organic and plastic mulches in fields

Table 1: Mulches and their impact on various crops.

S. No.	Mulch	Impact	Crops	Yield (% increase)	Year	Reference
Organic mulch						
1	Bark	Moisture content remains high for long duration	Used in vegetation and landscaping	30	2008	RHS, 2008
2	Grass clipping	Enhances percentage of nitrogen in soil as it decomposes easily	Gardens, groundnut, legumes	73-33	1963	Ashrif *et al*., 1963
3	Dry leaves	Enrich soil with nutrients	Natural forest area.	15-20	2007	David, 2007
4	Saw dust	C: N ratio more thus decompose slowly; less nutritive, but retain moisture content for long duration	Conifers, blueberries, strawberries, rhododendrons	45-79	2011	Kumar *et al*., 2011
5	Newspaper	Controls weed; time saving; biodegradable	Vegetable garden Potting cups	12-16	1963	Ashrif *et al*., 1963 and Lal, 1974
6	Alfalfa	Rich in nitrogen; durable for long time	Corn cropping system	34-36	1974, 2017	Lal, 1974
7	Seaweed	Provide minerals; reduce water requirement	Gardens	42-47	1988	Robinson, 1988
8	Ash	Controls weed growth	Garlic	10-35	1940, 2003	Tiedjens, 1940
9	Stubble	Decrease water demand; reduces weed	Stevia, vegetables, wheat	73-78	2002, 2014	Bilalis *et al*., 2002

Synthetic mulch						
10	Plastic mulch	Controls weed; increases warmth	Cauliflower, stevia	10-17	1950	Isenberg *et al.*,1950
10A	Black plastic mulch	Used in large scale Provides warmth to the crop in winters and enhances crop production.	Muskmelon	23-25	1988,2016	Tiffany *et al.*, 2016
10B	Clear plastic mulch	Absorb less solar radiations Reduces soil borne diseases	Muskmelon	44-45	1994	Chakraborty *et al.*, 1994
10C	Red plastic mulch	Reduce effect of early blight in many crops.	Tomato, zucchini honeydews	65-70	2009	Alferd *et al.*, 2009 Angima, 2009
10D	Other colors plastic mulch (yellow, orange, blue, grey mulch).	Insect repellent; Used in winter crops; Resulted in 2nd green revolution into India	Blackpepper, zucchini honeydew	38-46	2005	Penn State Extension, 2005
11	Gravels, pebbles, crushed stones	One inch layer act as good controller of weeds.	Gardens	20	2001	Sanders, 2001
12	Rubber	Easily available; can be applied easily in gardens	Home gardens	5-8	1979	Gupta *et al.*, 1979

From the above given table it is clear that mulch is primarily used in agriculture to increase the yield and to reduce the weed growth in crops. 20% increase in tomato yield was observed using red plastic mulch (Alferd *et al.*, 2009; Angima, 2009). Bark chips are used as mulch in gardens in every season. Pebbles, leaves, bark act as mulch in natural conditions.
Following are the pictures showing different kinds of mulches used in field (Fig.1A-E).

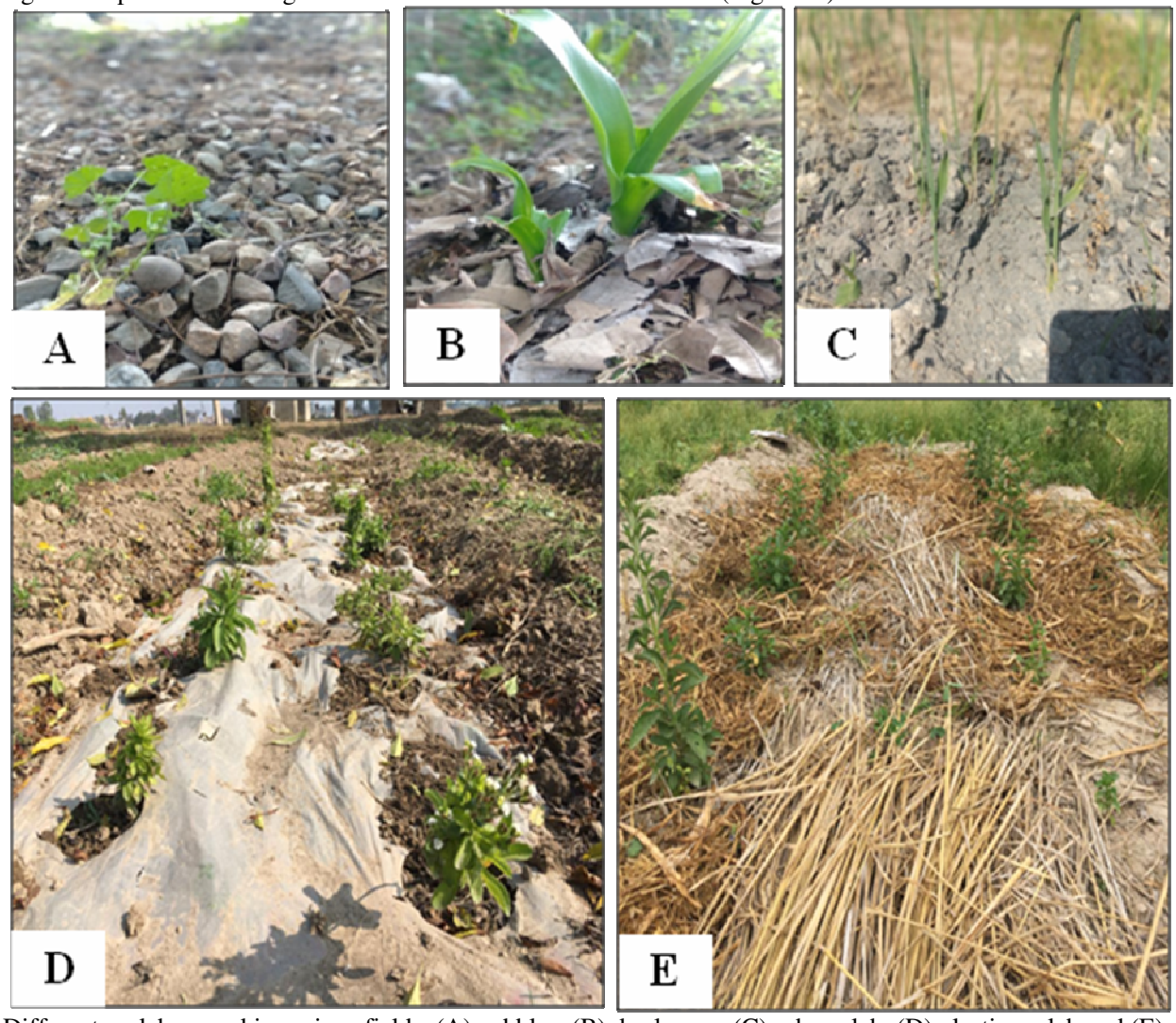

Fig. 1: Different mulches used in various fields. (A) pebbles, (B) dry leaves, (C) ash-mulch, (D) plastic mulch and (E) stubble.
Following table represents the type of mulch used depending on soil condition and weather condition of the area.

Table 2: Type of mulch used depending on the prevailing conditions.

S. No	Type of soil/area	Mulch used	Reference
1	Rainy season	Perforated mulch	Sanders, 2001
2	Plantation and orchard mulch	Thicker mulch	Orzolek *et al*., 2015
3	Soil solarisation	Thin and transparent film	Ngouajio, 2011
4	Weed control in cropped land	Black film plastic mulch.	Penn State Extension, 2015
5	Saline water area	Black film plastic mulch	Sanders, 2001
6	Summer cropped land	White film	Orzolek *et al.*, 2015
7	Insect repellent	Silver color film	Penn State Extension, 2015
8	Early germination	Thinner film	Ngouajio, 2011
9	Sandy soil	Black film	Orzolek *et al*., 2015
10	Weed control through solarisation	Transparent film	Sanders, 2001
11	Nutrient deficient	Stubble	Orzolek *et al*, 2015
12	Water deficient area	Sea weeds	Robinson, 1988
13	Field prone to Soil born diseases	Clear plastic mulch	Chakraborty *et al.*,1994

As already mentioned, choice of mulch is to be done on the basis of weather conditions, the type of soil, and vegetable to be grown. A wrong choice made by farmer may affect the yield of the crop by increasing soil acidity and even pest attack.

Use of mulch in various crops

Mulching is one of the important agronomic practice that has direct influence on hydro-thermal regimes of soils by suppressing the weeds, conserving the soil moisture, reducing water evaporation, modifying physical environment of soil and improving soil fertility (Yoo-Leong *et al*., 2003). Different types of mulches i.e. synthetic or natural mulch is used in different crops to increase the quantity and quality of the crop. Different plastic mulches i.e. red, black, yellow, green, brown etc. are used in vegetables and fruits like banana and strawberry (Orzolek *et al.*, 2015). However, effect of surface-mulch on soil characteristics depend upon the type of mulch used and its quantity and structure (Teasdeal *et al*., 2002). Now a day's organic mulch is used in various medicinal and aromatic crops to enhance the growth and yield of crop, as in *Citronella java* (Singh *et al.*, 2001) and mulberry (Mulamba *et al.*, 2008). Moreover, living mulches be used to reduce and suppress the weed growth by competing for water and nutrients (Mayer *et al.*, 1980) and for light (Teasdeal, 1993). They also suppress weed growth by producing allelopathic compounds, which reduce herbicide application in crop (White *et al*., 1989). During the harvest of the rice crop, stubble is left, which can be used as mulch in the vegetable fields. This is a resource-waste, which farmers usually burn after harvest of crop. So there is dire need to encourage farmers to re-use such waste in their fields to increase the productivity of the crop and to maintain soil fertility in a sustainable way.

Following is the table showing mulching treatment given to various crops in different area along with their results:

Table 3: Mulching treatment in different crops.

Crop	Type of mulch used	Region in which experiment was performed	Outcomes	Year	Reference
Wheat	Plastic and straw mulch	Arid and semi-arid regions	rease in yield; ulch was found to be more effective than straw.	2015	Qin *et al*., 2015
	Legume mulching: Sunhemp, Leucaena twig mulch, Sunhemp + Leucaena	Selakui, Dehradun, India	69.5 kg per hectare increase in nitrogen uptake through sunhemp + Leucaena mulch; 2.38 tonnes per hectare increase in yield.	2009	Sharma *et al*., 2009
Maize	Plastic and straw mulch	Arid and semi-arid regions	60% increases in yield; plastic-mulch is more effective than organic mulch.	2015	Qin *et al*., 2015
	Legume mulching: Sunhemp, Leucaena twig mulch, Sunhemp + Leucaena	Selakui, Dehradun. India	Controlled soil erosin; reduced the number of weeds; 59.3 kg per hectare increase in nitrogen uptake was observed by Leucaena + sunhemp mulch; 2.36 tonnes per hectare increase in the yield.	2009	Sharma *et al*., 2009
Winter Pigeonpea	Paddy straw mulching, sugarcane trash@ 8 tonns per hactare	B.C.K.V, Jaguli, Naida, West Bengal, India.	Sugarcane trash-mulch increased the yield by 2.07 tonnes per hectare.	1998	Gajera *et al*., 1998, Basu et al., 2009.
Brinjal	Straw mulching, 30 micron Bi-colored silver, Black plastic mulch.	Tropical and sub-tropical region. Bhagalpur, Bihar, India	Highest yield-480.24 quintal per hectare was obtained from 30 micron bi-colored silver mulch.	2013-2015	Kumar *et al*., 2019
Cauliflower	Polythene mulch with different concentrations of OPE (open pan evaporation), RD of nitrogen and potassium.	Assam, India	282.53 quintal per hectare was obtained with bilayer polythene mulch when 24.96 liter of OPE was supplemented through drip system per plant; 125% of fertigation of nitrogen and potash was done.	2017	Bhoutekar *et al*., 2017

Musk melon	Black polythene mulch, grass mulch, transparent polythene mulch.	MPKV, Rahuri, India	Grass mulch and black polythene mulch was much effective than transparent mulch; 80.02% increase in yield per hectare.	2004	Johnson *et al*., 2004
Blue berry	Black polythene mulch	Pennsylvania	Black plastic mulch effectively increases the yield.	1979, 2004	Gupta *et al*., 1979 George, 2004.
	Corn cob, wood chips, sawdust	Pennsylvania	Saw dust and wood chips from red maple and beech should retard the growth of the plant.	2004	George, 2004
Strawberry	Black polythene, transparent polythene, plastic mulch	Punjab, India	Black polythene proved to be most useful in attaining 41 percent higher fruit yield.	2006	Rajbir *et al*., 2006
	Paddy straw, Wheat straw, Cut grass, Saw dust, Transparent polythene, Black polythene	Chatha, Jammu, India	Black plastic mulch was found to be highly effective; total sugar increased to 7.0%; fruit weight increased by 11.83g; fruit length increased by 3.93%; 143.38g of total yield per plant got enhanced.	2011	Bakshi *et al*., 2014
Stevia	Pine needles, poplar leaf, silver oak, tree leaf mulch.	Western Himalaya, India	Silver oak mulch and poplar mulch enhances soil nutrition matter, decreases weed growth.	2011	Kumar *et al*., 2011
Tomato	Straw mulch Black polythene mulch, Straw mulch with different combinations of drip system.	Bangladesh	Yield increases in plot with black mulch; carbon content increases to 27.07%.	2002	Cong *et al.*, 2005
Potato	Straw mulch	Northern Hessen, Germany	Reduced weeds and aphid infestation.	2003	Saucke *et al.*, 2003
	Plastic mulch	North China Plain, China	Increased yield	2008	Wang *et al*., 2008
Onion	Rice straw mulch, Water hyacinth.	Dhaka, Bangladesh	Water hyacinth mulch increased the yield; 10.46 tonnes per hectare yield was obtained.	2008	Larentzaki *et al*., 2008
Garlic	Black polythene mulch, grass mulch.	Fiche, Addis Ababa, Africa	Increased yield, soil moisture content.	2012	Mahdiesh Najafabadi *et al*., 2012
Carrot	Sugarcane straw mulch, black polythene mulch, leave mulch, blue polythene mulch, paddy straw mulch, grass mulch, white polythene mulch.	Gwalior, M.P., India	54.69 tonnes per hectare of yield was obtained using black polythene mulch; it is the maximum yield obtained among different mulched plots.	2018	Jaysawal *et al*., 2018
Lemon	Bajra straw, maize straw, grasses, brankad, farmyard manure, black polythene	At rain fed research sub-station, India	Maximum soil content and yield (1848 kg per hectare) was observed with the use of black polythene mulch, followed by farmyard manure mulch (yield: 1780 kg per hectare) and brankad mulch and (yield: 1744 kg per hectare).	2011	Kumar *et al*., 2015
Sugarcane	No straw, straw, and straw burned over the soil	Bandeirantes – Paraná, Brazil	75 and 100% straw-mulch showed highest suppression of weeds.	2017	Hoshino *et al*., 2017

Experiment performed in different areas and different crops have shown povitive effects of mulching. Mulching not only enhances the yield of the crop but also affects the fruit length, fruit size, fruit breadth, total content of soluble sugars in fruit, flavonoids and soil moisture content.
Following is the table showing increase in soil moisture content using different mulches in different crops:

Table 4: Reports on increase in soil moisture content using mulches.

Crop	Type of Mulch used	Non- mulched plot	Mulched plot	Percent increase	Reference
Tomato	Straw	86.1	100	16-27	Cong *et al.*, 2005
Maize	Sunhemp + Leucaena	12.54	14.62	19.90	Sharma *et al.*, 2009
Potted shrubs	Bark chips	9.34	12.17	20-23	Stelli *et al.*, 2003
Gardens	Dry leaves	10.13	12.42	6-8	Ashrif *et al*., 1963
Alium cepa	Grass mulched	17.1	18.20	0.30	Larentzaki *et al*., 2008
Beta vulgaris	Peat	17.5	19.70	2.6-7.3	Lal, 1974
Brassica	Sawdust	17.2	22.70	3.8-6.1	Kumar *et al*., 2011

Significance of organic and synthetic mulches

Organic mulches are decomposable and biodegradable so these are not long lasting. Farmers need to change these mulches at specific intervals. The pH of soil also gets lowered by using organic mulches (increase the acidic level of soil). Moreover, organic mulch plays an important role in deposition of advantageous chemicals into soil. The application of organic mulches enhances soil organic matter content (Paustian *et al*., 1997). For example grass clipping help in providing nitrogen to plant which is required for optimal growth of plant. On the other hand, synthetic mulches are non-decomposable in nature and non-biodegradable hence remains in field for longer period of time. The pH of soil is not affected by these mulches. It provides warmth to the growing crop (Basuki, 1990; Halvin *et al*., 1990; Singh *et al*., 2001; Lal, 2004). Soil moisture is

also conserved by using plastic mulch as rain drop impact decrease and thus prevents soil erosion. Although mulch provides good resistance to weeds but it shows some negative impact on soil and crop also. Rate of evaporation of soil-water reduces and hence soil temperature does not change (Smets *et al*., 2008; Mulumba *et al*., 2008).

Comparison of organic mulch with synthetic mulch

Different mulches play different role in weed control activity and ultimately the yield of the crop. A farmer can choose any kind of mulch depending upon the climatic conditions and their availability. Following table compares the organic mulch with plastic mulch.

Table 5: Comparision of different kinds of mulches.

Plastic mulch		Inorganic mulch	Organic mulch
➢ It includes the synthetic mulches. ➢ It cannot be replenished. ➢ It includes plastic sheet of different colors. ➢ Yield increases by 55-80%.	➢ It includes the materials that do not decompose. ➢ It cannot be replenished. ➢ It includes rocks, stones, lava rock etc. ➢ Yield increases by 75%.	➢ It includes the material that can decompose easily. ➢ It can be replenished. ➢ It includes compost, newspaper, evergreen needles, grass etc. ➢ Yield increases by 65-85%.	

Advantages of mulches

- Mulches warm the soil by trapping solar radiations and thus enhance the early growth of plant. Crops grown on mulches mature 14 to 21 days earlier than crops grown without it (Turkey *et al*., 1963).
- Leaching of nutrients is highly reduced by the use of mulches. Since mulches are impermeable to water them help in retaining moisture content for longer time period.
- Maintain the compactivity of soil which lead to a soil with loose and friable nature. This kind of soil is well-aerated, thus plants grown in mulched field have better root system than grown in un-mulched soil (Krish, 1959).
- Quality and yield of crop enhances by decreasing soil-borne diseases (Turkey *et al.*, 1963).
- Weed and pest growth is controlled by mulches (Krish, 1969 and Grumber, *et al*., 2008).

Disadvantages of mulches

- Special kind of equipment and expertise is required for applying plastic mulches in fields.
- Organic mulches increase the acidity of the soil which further affects the crop productivity.

Conclusion

Mulch plays a key role in agricultural practices. As every coin has two sides, mulches also have positive and negative impact on crop and soil. Mulches, where help in retaining water moisture content, control weed growth and enhances yield of the crop, there it also affect the pH of the soil. It makes the soil acidic which further reduces the soil fertility and decrease the yield of the crop. Thus, choice of mulch made by farmer plays an important in increasing crop productivity, so mulch must be selected taken under considerations the type of soil, climatic conditions of the area, crop to be cultivated.

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