Agri. Reviews, **34** (3) : 188-197, 2013
DOI- 10.5958/j.0976-0741.34.3.003

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com / indianjournals.com

EFFECT OF MULCHING ON CROP PRODUCTION UNDER RAINFED CONDITION - A REVIEW

Raju Lal Bhardwaj

Krishi Vigyan Kendra,
M. P. University of Agriculture and Technology, Sirohi-307001, India

Received: 13-03-2012 Accepted:16-01-2013

ABSTRACT

Mulching is an agricultural and horticultural technique in which the use of organic is involved. This technique is very useful in protecting the roots of the plants from heat, cold. Mulch is used to cover soil surface around the plants to create congenial condition for the growth. This may include temperature moderation, reduce salinity and weed control. It exerts decisive effects on earliness, yield and quality of the crop. Mulching is also applicable to most field crops. However, it is preferred in fruit orchard, flower and vegetable production, nurseries and forest where frequent cultivation is not required for raising the crops. Black plastic mulch is most commonly used in agriculture. Clear plastic mulch is used in some areas due to its increased soil warming characteristics. Research has shown that white or aluminum reflective mulch also repels aphids which spread some virus diseases in vine crops such as squash. So, mulching can be effective change in increasing horticultural crop production in water scarcity regions.

Key words: Arid, Crop residue, Microclimate, Mulch, Organic matter, Polyethylene, Semi-arid.

The word mulch has been probably derived from the German word "*molsch*" means soft to decay, which apparently referred to the use of straw and leaves by gardeners as a spread over the ground as mulch (Jacks *et al.,* 1955). Mulches are used for various reasons in agriculture but water conservation and erosion control are the most important objectives particularly in arid and semi-arid regions. Other reasons for use of mulching include soil temperature modification, weed control, soil conservation and after decomposition of organic mulch add plant nutrients, improvement in soil structure, increase crop quality and yield. Mulching reduces the deterioration of soil by way of preventing the runoff and soil loss, minimizes the weed infestation and reduces water evaporation. Thus, it facilitates more retention of soil moisture and helps in control of temperature fluctuations, improves physical, chemical and biological properties of soil, as it adds nutrients to the soil and ultimately enhances the growth and yield of crops (Dilip Kumar *et al.,* 1990). In addition mulch can effectively minimize water vapour loss, soil erosion, weed problems and nutrient loss (Van Derwerken and Wilcox, 1988).

Types of mulching materials

Organic mulches: Organic mulches are derived from plant and animal materials such as straw, hay, peanut hulls, leaf mold, compost, sawdust, wood chips, shavings and animal manures. To achieve optimum advantage from the organic mulch, the mulch should be applied immediately after germination of crop or transplanting of vegetable seedling @ 5 t ha^{-1}. Organic mulch are efficient in reduction of nitrates leaching, improve soil physical properties, prevent erosion, supply organic matter, regulate temperature and water retention, improve nitrogen balance, take part in nutrient cycle as well as increase the biological activity (Hooks and Johnson, 2003; Muhammad *et al.*, 2009; Sarolia and Bhardwaj, 2012). Natural materials can not be easily spread on growing crops and require considerable human labour (Bhardwaj, 2011). Expense and logistical problems have generally restricted the use of organic mulch in horticultural crop production with only limited use on a large commercial scale.

Corresponding author's e-mail: rajubhardwaj3@gmail.com

Inorganic mulches: Inorganic mulch includes plastic mulch and accounts for the greatest volume of mulch used in commercial crop production. The plastic materials used as mulch are poly vinyl chloride or polyethylene films. Owing to its greater permeability to long wave radiation it can increase temperature around the plants during night in winter. Hence, polyethylene film mulch is preferred as mulching material for production of horticultural crops (Bhardwaj *et al.*, 2011). A wide range of plastic films based on different types of polymers have all been evaluated for mulching at various periods in the 1960s. LDPE, HDPE and flexible PVC have all been used and although there were some technical performance differences between them, they were of minor nature. Today the vast majority of plastic mulch is based on LLDPE because it is more economic in use. Now a day's application of black plastic mulch film is becoming popular and very good results have been achieved particularly in arid and semi-arid regions (Bhardwaj *et al.*, 2011). Black polyethylene mulches are used for weed control in a range of crops under the organic system of crop production. The use of black polypropylene woven mulch is usually restricted to perennial crops. Murugan and Gopinath (2001) verified the efficacy of organic mulches (dried leaves, coconut fronds and coir pith) and inorganic mulches (black polyethylene 25, 50 and 100) on growth attributes of Saundarya cv of crossandra at Bangalore. Likewise, different cultivars of carnation in poly house significantly improved plant height, number of branches, flower size and yield with the application of black polyethylene mulch (Arora *et al.*, 2002).

Effect of mulching on soil

Conserve soil moisture: The conservation of soil moisture through mulching due to modification of favourable micro-climatic conditions in soil. When soil surface is covered with organic mulch it helps to prevent weed growth, reduce evaporation and increase infiltration of rain water during growing season. In addition plastic mulch helps in shedding excessive water away from the crop root zone during periods of excessive rain fall. This can reduce irrigation frequency and amount of water used; it may help to reduce the incidence of soil moisture related physiological disorders such as blossom end rot in tomato, fruit cracking in lime and pomegranate (Mohapatra *et al.*, 1999). Chen and Katan (1980) also reported high water content in the top 5 cm of soil (an increase of 4.7 per cent in clayey, 3.1 per cent in loamy and 0.8–1.8 per cent in sandy soil) with polythene mulch. Das *et al.*, 1990 and Purohit *et al.*, 1990 observed that use of polyethylene mulch in the field, increased the soil temperature especially in early spring, reduced weed problems, increased moisture conservation, reduction in certain insect pest population, higher crop yield and more efficient use of soil nutrients. Crop residues or mulch on the soil surface act as shade; serve as a vapour barrier against moisture losses from the soil, causing slow surface runoff and conserves sufficient water in the soil for better development of crops (Rathore *et al.*, 1998). Higher water use efficiency was caused by lower evaporation in *Rosa indica* by using black polythene sheet (0.18 mm thick) as mulch (Rodrigues *et al.*, 1999). Thakur *et al.* (2000) observed that different mulching materials such as grass, lantana leaves and plastic, helped bell pepper (*C. annuum* cv. California Wonder) to perform better at water deficits from 25 to 75 per cent and plastic mulch had highest water use efficiency. Hatfield *et al.* (2001) reported a 34-50 per cent reduction in soil water evaporation as a result of crop residue mulching. Mulch slows down evaporation and reduces the irrigation requirement (Anonymous, 2003). Chawla (2006), Khurshid *et al.* (2006), Muhammad *et al.* (2009) stated the same results that mulching improves the ecological environment of the soil and it avoids decrease in soil water levels.

Reduced infiltration rate: The presence of crop residue mulch at the soil-atmosphere interface has a direct influence on infiltration of rainwater and evaporation. Mulch cover reduces surface runoff and holds rainwater at the soil surface thereby giving it more time to infiltrate into the soil (Khurshid *et al.*, 2006). Abu-Awwad (1999) showed that covering of soil surface reduced the amount of irrigation water required by the pepper and the onion crop by about 14 to 29 and 70 per cent respectively. Trials conducted in the higher potential areas of Zimbabwe indicated that mulching significantly reduced surface runoff and infiltration (Erenstein, 2002).

Maintain soil temperature: Mulching reduces soil temperature in summer, raises it in winter and prevents the extremes of temperatures. In general, the effect of mulching on the temperature regime of the soil varies according to the capacity of the mulching material to reflect and transmit solar energy. White mulches decrease soil temperature while clear plastic mulches increase soil temperature. Chen and Katan (1980) reported that the plastic mulching increased soil temperature by 0.9 to 4.3°C at the seedling stage, 1.6 to 2.3°C at the bud initiation stage and 0.8 to 1.9°C at the flowering stage. The findings of Duhr and Dubas (1990) showed an increase of 2.9–3.3^{0}C in soil temperatures with transparent, photodegradable polythene film mulching. Wheat straw mulch raised the soil temperature by 2–3^{0}C in peak winter season (Sarolia and Bhardwaj 2012). The soil temperature can be higher up to 7°C under clear mulch compared to bare soil (Lamont, 1993). Park *et al.* (1996) observed an increase of 2.4^{0}C in average soil temperature at 15 cm depth under transparent film and an increase of 0.8^{0}C under black film. At night, condensation on the underside of the mulch absorbs the long wave radiation emitted by the soil thereby slowing cooling of the soil (Lamont, 2005).

Reduced fertilizer leaching: As excessive rainfall is shed drained the root zone, fertilizer loss due to leaching is reduced. This is particularly true in sandy soils. This allows the grower to place more pre plant fertilizer in the row prior to planting the crop. Mulching with coconut fronds increased leaf N, P and K content in chilli (Hassan *et al.,* 1994). Vos and Sumarni (1997) indicated faster plant growth, early fruiting, reduced P and increased N concentration in leaves and fruits. Further, they reported that rice straw mulch increased K- content and decreased P- concentration in leaves of bell pepper over no-mulch. Hundal *et al.* (2000) reported that concentration of nitrogen and phosphorus and nutrient uptake was significantly higher in mulched plots over unmulched plots in tomato. According to Worthington (2001), an increase in available nitrogen contents stimulates protein production, in cabbage following serradella and vetch mulches which, living in symbiosis with nitrogen-fixing bacteria, are additional sources of available nitrogen. Mulch protects the surface of the soil against unfavorable factors, reduces nutrient leaching and improves growing conditions for vegetables (Baumann *et al.*, 2000; Kolota and Adamczewska-Sowiňska, 2004). Acharya and Sharma (1994) and Muhammad *et al.* (2009) observed that mulched treatments show significantly greater total uptake of nitrogen, phosphorus and potassium than corresponding unmulched ones.

Add organic matter: Organic mulches return organic matter and plant nutrients to the soil and improve the physical, chemical and biological properties of the soil after decomposition, which in turn increases crop yield. Soil under the mulch remains loose, friable and leading to suitable environment for root penetration. The organic mulches not only conserve the soil moisture, but they also increase the soil nutrients through organic matter addition (Dilip Kumar *et al.*, 1990). Lal *et al.* (1996) reported decrease in bulk density under straw mulch (1.42 g cm^{-3}) compared to bare soil (1.50 g cm^{-3}). Saroa and Lal (2003) and Khurshid *et al.* (2006) concluded that organic matter was significantly higher when more mulch was applied. Higher organic carbon content of soil was recorded with sunhemp mulch (0.71%) followed by silkworm bed waste (0.68%), paddy straw (0.66%) mulched plots and least organic carbon content (0.48%) in non mulched plot (Shashidhar *et al.*, 2009).

Effect of mulching on plants

Plant growth and development: Mulching provides a favourable environment for growth which results in more vigorous, healthier plants which may be more resistant to pest injury. Increase in soil temperature and moisture content stimulate root growth which leads to greater plant growth. Therefore, mulched plants usually grow and mature more uniformally than unmulched plants (Bhardwaj *et al.*, 2011; Sarolia and Bhardwaj 2012). Hassan *et al.* (1994) and Yamaguchi *et al.* (1996) revealed that combination of reflective film mulching and shading treatments increased plant height, length of primary and secondary branches of carnation seedlings. Lourduraj *et al.* (1996) obtained highest plant height (81.5 cm) and number of laterals (8.6 per plant) in tomato with the application of black LLDPE mulch as compared to organic mulch and no mulch. Similar results were also reported by Kim *et al.* (2000) in *Crocosmia crocosmiiflora*, Hong *et al.* (2001) in lilies. Gao *et al.* (2001) the nutrient paper mulch advanced plant growth as compared to plastic mulch and no mulch in tomato. Barman *et* *al.* (2005) recorded significant improvement in number of days taken for first floret opening, spike length and rachis length with the application of paddy straw mulch in gladiolus. Chawla (2006) obtained maximum plant height (70.91 cm), plant spread (53.05 cm) and highest number of branches (18.54) at harvest in marigold cv. Double mix with application of black plastic mulch compared to other mulching treatment.

Promote early harvest: Warm season vegetables such as cucumbers, muskmelons, watermelons, eggplant, peppers, usually respond to mulching in terms of early maturity and higher yields. An early maturity is probably due to maintenance of favourable temperatures during growing season. Black mulch applied to the planting bed prior to planting will warm the soil and promote faster growth in early season, which generally leads to earlier harvest (Tarara, 2000 and Lamont, 2005). Organic mulches induced earliness in flowering, less days to fruit set and harvest in tomato crop over control (Ravinderkumar and Shrivastava, 1998). Applications of polyethylene films as mulch have shortened growing season and enhanced earliness and yield in different vegetable crops (Goreta *et al.*, 2005; McCann *et al.*, 2007). Beneficial effect of polyethylene mulch on early harvest and higher yield was also found for watermelon (Romic *et al.*, 2003), zucchini (Walters, 2003), tomato and pepper (Hutton and Handley, 2007).

Improve quality and yield: Mulch helps keep fruits clean from contacting the ground, reduces soil rot, fruit cracking and blossom end rot in many cases. Fruits tend to be smoother with fewer scars. Properly installed plastic mulch helps keep soil from splashing onto the plants during rainfall, which can reduce grading time. The yield and chemical composition of tomatoes, cucumbers, muskmelons, eggplant, were found to be improved. The yield and keeping quality of early potatoes, cabbage and other vegetables may be improved by straw mulch. Application of straw mulch @ 6 t ha^{-1} increased yield of tomato and okra by 100 and 200 per cent, respectively over control (Gupta and Gupta, 1987). Marketable fruit yield from mulched plot was significantly higher than those produced on bare soil. This difference can be attributed to moisture conservation, higher soil temperature, weed control, and increased mineral nutrient uptake in the mulched plot through improved root temperatures, as reported by Orozco *et al.* (1994). Gollifer (1993) reported that application of organic mulch @ 40 t ha^{-1} produced 2.5 t ha^{-1} of chilli dry fruits. Hassan *et al.* (1994) reported that organic mulch gave higher fruit yield of bell pepper than control. The yield (27.9 per cent) and starch content (18.18 per cent) of potato was increased with paddy straw mulch over unmulched (Dixit and Majumdar, 1995). Aref *et al.* (1996) reported that application of hairy vetch mulch recorded significantly higher yield of tomato (32 per cent) than bare soil. Lourduraj *et al.* (1996) obtained highest number of fruits (42), average fruit weight (31.8 g) and yield (12.73 t ha^{-1}) in tomato cv. CO-3 with application of black LLDPE mulch compared to organic and no mulch. Mulching increased crop weight by 16 per cent compared with non mulched plots in leek (Benoit and Ceustermans, 1998). Black polythene sheet (0.18 mm) mulching also increased 29 and 56 per cent flower yield of Anna and Sari varieties of roses, respectively (Rodrigues *et al.*, 1999). Thakur *et al.* (2000) reported that the use of different mulches on the performance of *Capsicum annuum* L. under water deficit of 75 per cent, the lantana mulch gave the highest fruit yield of 7.34 t ha^{-1} over unmulched plots (3.69 t ha^{-1}). They also reported that yield levels increased by 198 per cent in plastic mulch, 164 per cent in lantana leaves and 141 per cent in grass mulched plants over unmulched plants of capsicum. These findings are in agreement with Gangwar *et al.* (2000) who reported that paddy straw mulch on mulberry showed maximum leaf yield (46%) compared to sorghum (32.4%) and blackgram mulching (23.08%) over control. Murugan and Gopinath (2001) obtained maximum duration of flowering and advanced flowering in crossandra cv. Saundrya by using black polyethylene mulch as compared to organic mulches. Gao *et al.* (2001) reported that the nutrient paper mulching promoted flower bud differentiation enhanced yield and improved fruit quality in tomato as compared to the plastic mulch or no mulching. Uppal *et al.* (2001) observed that mulched tubers of potato contained about 46 per cent less reducing sugars compared to normal crop. Nagalakshmi *et al.* (2002) obtained the maximum number of fruits per plant (97.67), length of fresh fruit (6.93 cm), circumference of fruit (3.57 cm) and yield of chilli (8.60 t ha^{-1}) with the application of black LLDPE mulch compared to organic mulch and no mulch. Gandhi and Bains (2006) reported that the crop under straw mulch produced higher number of branches (8.7), fruit weight (28.08 g) and total yield (49.63 t ha^{-1}) as compared to no mulch (8.1, 27.86 g and 47.85 t ha^{-1}, respectively) in tomato. Chawla (2006) obtained highest number of flowers per plant (53.45), average flower weight (47.21 g/ 10 flowers), maximum flower diameter (5.47 cm) and highest flower yield (11.66 t ha^{-1}) in marigold cv. Double mix with application of black LLDPE mulch compared to white LLDPE mulch, organic mulch and no mulch. Shashidhar *et al.* (2009) reported that the total leaf yield of mulberry was found maximum in paddy straw mulched plots (15.20 t ha^{-1}) as compared to control plots (11.78 t ha^{-1}).

Role of mulching in weed management

Reduce weed growth and clean crop: By providing a physical barrier, mulching reduces the germination and nourishment of many weeds. The mulching operation favours in the reduction of weed seed germination, weeds growth and keeps the weed under control (Vander Zaag *et al.,* 1986). Covering or mulching the soil surface can prevent weed seed germination or physically suppress seedling emergence. Loose materials such as straw, bark and composted municipal green waste can provide effective weed control (Merwin *et al.*, 1995). Saw dust is a soil improver and weed suppressor as it conserves soil moisture, decreases run-off, increases infiltration and percolation, decreases evaporation and weed growth can be substantial under clear mulch (Waterer, 2000). White or clear mulch and green covering had little effect on weeds, whereas brown, black, blue or white on black (double color) films prevented emerging weeds (Bond and Grundy, 2001). Ossom *et al.* (2001) also observed significant differences in weed control between mulched and unmulched plots of eggplant.

Effect of mulching on insect and micro-flora

Insect pest control: Transparent polyethylene mulch reduced whitefly populations, helped in catching aphids in yellow traps and virus diseases incidence, in comparison to bare soil. Transparent mulch reduced the incidence of virus disease, and delayed by two weeks the onset of virus symptoms compared with the bare soil (Nameth *et al.*, 1986). Transparent polyethylene mulch has a repellent effect on pest and vector insects, such as aphids (Jones, 1991), whiteflies (Kelly *et al.*, 1989), and thrips (Greenough *et al.*, 1990). Transparent mulch has a reflective effect and reduces the incidence of virus diseases by confusing aphids, which vector the virus (Orozco *et al.*, 1994). The mode of action of the transparent mulch is probably the result of high reflectance of UV light (Kring and Schuster, 1992). A beneficial effect of clear mulch on reduction of aphid population was recorded by Farias-Larios and Orozco-Santos, 1997. The ability of clear mulches to produce soil temperatures high enough to control weeds, plant pathogens and nematodes forms the basis for the soil solarization process (Sciortino, 2001 and Stapleton *et al.*, 2005).

Stimulate soil micro-flora: Mulching stimulates soil micro-organisms such as algae, mosses, fungi, bacteria, actinomycetes and other organisms like earth worms etc., owing to loose, well aerated soil conditions, uniform moisture and temperatures thus resulting in a more rapid breakdown of organic matter in the soil and release of plant nutrients for crop growth. Under the mulch layer earth worms proliferate and help to improve the soil aggregate stability and infiltration etc. The variation in the microbial load of the different organic mulches on bacterial population could be due to their different chemical composition and their decomposition rates (Mukherjee *et al.*, 1991; Wu *et al.*, 1993). The higher moisture of soil profile under mulch has important implications on the utilization of water by crop and on soil reactions that control the availability of nutrients and biological nitrogen fixation (Surya *et al.*, 2000). Brown *et al.* (2001) mentioned that mulching practices gave positive effect on the soil biota. An important role of mulch is to support existence of most species of soil macro invertebrates. Soil biota increases under mulched soil environment thereby improving nutrient cycling and organic matter build up over a period of several years (Holland, 2004). Organic mulching technology support diversity of beneficial soil macro invertebrates. Crop residue mulch supplied a lot of food for soil macro invertebrates and nutrient to ensure the vegetation growth and created suitable environment for soil macro invertebrates (Sugiyarto *et al.*, 2009). They also reported that application of maize residue as mulch enhanced diversity index of surface and deep soil macro invertebrate, i.e: 0.215 and 0.214 (by 44% and 73% respectively as compared to non mulching). Shashidhar *et al.* (2009) reported more number of bacterial, fungal and actinomycetes colonies found in *Cassia sericea* (32 CFU x 105 g^{-1}), paddy straw (53 CFU x 104 g^{-1}) and sunhemp (53 CFU x 103 g^{-1}) mulched plots over other treatments respectively.

Economic importance of mulch: Besides beneficial effects on earliness, polyethylene film as a mulch can enhance plant growth and development, increase yield, decrease soil evaporation and nutrient leaching, reduce incidence of pests and weeds, and improve fruit cleanliness and quality yield (Lamont, 1993; Farias-Larios and Orozco-Santos, 1997; Walters, 2003; Decoteau, 2007; Diaz-Perez *et al.,* 2007; Hutton and Handley, 2007) and finally increase gross return, net return and benefit : cost ratio of fruit and vegetable crops. Sutagundi (2000) reported that treatment receiving straw mulch recorded significantly higher net returns (Rs. 30,894 ha^{-1}) and benefit: cost ratio (1.80:1) compared to control as result of soil water conservation in chilli. From the year 1986 onwards, Coimbatore Precision Farming Development Centre is continuously conducting experiments on mulching for principal horticultural crops. The mean values of increase in yields (%) and additional income (Rs. /ha) of each crop are tabulated in Table 1.

CONCLUSION

The beneficial effects of organic and synthetic mulches for crop production have been widely discussed by many researchers and farmers. Research has shown that mulch provides many benefits to crop production through soil and water

TABLE 1: **Studies on mulching at various centres of PFDC's all over India.**

Crop	Location of PFDC	Mulch material	Increase in yield (%)	Additional income (Rs./ha)
Chilli	Navasari (Gujarat)	Black plastic (50 micron)	60.1	10140.00
Brinjal	Navasari (Gujarat)	Black plastic (50 micron)	27.1	7400.00
Chilli	Navasari (Gujarat)	Green plastic (50 micron)	59.0	22190.00
Cauliflower	Hisar	Black plastic (50 micron)	31.9	6751.00
Potato	Pantnagar (UP)	Black plastic (50 micron)	35.5	8700.00
Cauliflower	Pantnagar (UP)	Black plastic (50 micron)	71.0	16120.00
Tomato	Pantnagar (UP)	Plastic film (25 micron)	46.5	11250.00
Okra	Pantnagar (UP)	Plastic film (25 micron)	47.85	9250.00
Tomato	Pantnagar (UP)	Plastic film (25 micron)	79.2	22764.00
Tomato	Kharagpur (WB)	Plastic film (25 micron)	65.4	43210.00
Okra	Kharagpur (WB)	Plastic film (25 micron)	55.1	19625.00
Guava	Delhi	Plastic film (100 micron)	26.0	—
Lemon	Delhi	Plastic film (100 micron)	21.6	—
Kinnow	Delhi	Plastic film (100 micron)	46.8	—
Pomegranate	Delhi	Plastic film (100 micron)	33.3	—
Brinjal	Coimbatore	Plastic film (25 micron)	33.3	12062.00
Bhendi	Coimbatore	Plastic film (25 micron)	46.7	9770.00
Bhendi	Coimbatore	Plastic film (25 micron)	54.0	6400.00
Chilli	Coimbatore	Plastic film (25 micron)	18.6	6800.00
Groundnut	Coimbatore	Plastic film (15 micron)	20.5	7300.00
Banana	Travacore (Kerala)	Plastic film (50 micron)	12.6	13906.00
Arecanut	Travacore (Kerala)	Plastic film (50 micron)	28.4	—
Bhendi	Travacore (Kerala)	Plastic film (50 micron)	25.0	18885.00
Maize	Rajendranagar	Plastic film (25 micron)	44.6	9800.00
Brinjal	Rajendranagar	Plastic film (25 micron)	10.0	15100.00
Bhendi	Rajendranagar	Plastic film (25 micron)	67.0	18300.00
Tomato	Rajendranagar	Plastic film (25 micron)	65.3	13800.00
Plum	Solan (HP)	Plastic film (50 micron)	9.2	12000.00
Tomato	Solan (HP)	Plastic film (50 micron)	85.6	18250.00
Pea	Solan (HP)	Plastic film (50 micron)	66.6	25960.00
Apricot	Solan (HP)	Plastic film (50 micron)	33.3	18320.00
Peach	Solan (HP)		31.2	13890.00

(Source – www.google.co.in, Precision Farming Development Centre- Kharagpur, 2012) conservation, enhanced soil biological activity and improved chemical and physical properties of the soil. Transparent polyethylene mulch reduces whitefly populations, helps in catching aphids in yellow traps and reduces virus disease incidence. Thus, it is concluded that mulching has various beneficial effects on horticultural crop production in arid and semi arid regions, including an increase in soil moisture (4.70-12.50%), reduces infiltration rate of water (15.35-18.40%), reduces run off (30.0-70.50%) and soil erosion (70.0-85.0%), reduces weed growth (90.0-95.0%), pest control (15.0-27.35%), maintain soil temperature (0.5^{0}C to 7.0^{0}C higher), increases plant growth (12.30-26.90%) and development (23.0-37.0%), increases quality produce and yield (7.50-22.0%), promotes earlier harvest of the crop (7-15 days), reduces fertilizer leaching, and protects the surface of the soil against unfavourable factors. In addition the organic mulch also adds organic matter (3 -5 t ha^{-1}), stimulates soil microflora and takes part in nutrient cycle as well as increases the biological activity of soil. It is also concluded that different types of organic and inorganic materials are used for mulching in horticultural crop production but black polyethylene mulch was found to be superior to other mulches and preferred by growers or producers. Although mulching has many beneficial effects but on the other side this process increases cost of cultivation (7.5-15.70%) in different crops and also requires technical guidance for maintaining mulch in the field. Organic mulch decomposition may result in a temporary reduction in soil mineral nitrogen also. In view of the available facts, it can be said that water scarcity will be a burning problem for the future and it's most probable solution can definitely be use of mulching for quality production of horticultural crops.

REFERENCES

Abu-Awwad, A. M. (1999). Irrigation water management for efficiency water use in mulched onion. *Journal of Agronomy and Crop Science,* **183**:1-7.

Acharya, C. L. and Sharma, P. D. (1994). Tillage and mulch effects on soil physical environment, root growth, nutrient uptake and yield of maize and wheat on an Alfisol in north-west India. *Soil Tillage Research,* **4**:291–302.

Anonymous, 2003. Commercial flowers Vol-II, 2nd revised addition, Naya Prokashan Calcutta, pp. 351.

Aref, A. Abdulbaki and John, R. S. (1996). Heiry vetch mulch favourably impacts yield of processing tomatoes. *Horticulture Sciences,* **31**: 338-340.

Arora, J. S. Amanpreet Kaur, Sidhu, G. S. and Kaur, A. (2002). Performance of carnation in polyhouse. *Journal of Ornamental Horticulture, New Series,* **5**: 58-63.

Barman, D. Rajni, K. Rampal and Upadhyay, R. C. (2005). Effect of mulching on cut flower production and corm multiplication in gladiolus. *Journal of Ornamental Horticulture,* **8**:152-154.

Baumann, D. T. Kropff, M. J. and Bastiaans, L. (2000). Intercropping leeks to suppress weeds. *Weed Research,* **40**: 359-374.

Benoit, F. and Ceustermans, N. (1998). Soil mulch and drip irrigation in leek plants. *Proeftuinnieuws,* **8**: 36-37.

Bhardwaj, R. L. (2011). Bench mark survey on effect of mulching material on crop production. Krishi Vigyan Kendrs, Sirohi, MPUAT Udaipur, pp.12-15.

Bhardwaj, R. L. Meena, C. B. Singh, N. Ojha, S. N. and Dadhich, S. K. (2011). Annual progress report of Krishi Vigyan Kendrs, Sirohi, MPUAT Udaipur, pp.45-46.

Bond, W. and Grundy, A C. (2001). Non-chemical weed management in organic farming systems. *Weed Research,* **41**: 383-405.

Brown, G. G. Pasini, A. Benito, N. P. De Aquino, A. M. and Correia, M. E. F. (2001). Diversity and functional role of soil macrofauna communities in Brazilian no-tillage agro-ecosystems: a preliminary analysis. *International Symposium on Managing Biodiversity in Agricultural Ecosyatems,* Montreal, 8-10 November 2001.

Chawla, S. L. (2006). Effect of irrigation regimes and mulching on vegetative growth, quality and yield of flowers of African marigold. Ph.D. Thesis, Depatment of Horticulture, Maharana Pratap University of Agriculture and Technology, Udaipur.

Chen, Y. and Katan, J. (1980). Effect of solar heating of soils by transparent polyethylene mulching on their chemical properties. *Soil Science,* **130**: 271-277.

Chung, D. H. (1987). Effect of polyethylene film mulching, sulphur application and different levels of nitrogen and potassium on growth, flower stalk elongation, bulbing and leaf tip yellowing of garlic (*Allium sativum*) cv. Enising. *Journal of Korean Society of Horticultural Science,* **28**: 1-8.

Das, D. K. Choudhury, D. C. Ghosh, A. Mallikarjuna, B. Suryanarayana, N. and Sengupta, K. (1990). Effect of green manuring, dry weed and black polythene mulching on soil moisture conservation, growth and yield of mulberry and their economics under rainfed condition. *Indian Journal of Sericulture,* **20**: 263-272.

Decoteau, D. R. (2007). Leaf area distribution of tomato plants as influenced by polyethylene mulch surface color. *HortTechnoloy,* **17**:341-345.

Diaz-Perez, J. C., Gitaitis, R. and Mandal, B. (2007). Effect of plastic mulches on root zone temperature and on the manifestation of tomato spotted wilt symptoms and yield of tomato. *Science Horticulture,* **114**:90-95.

Dilip Kumar, G. Sachin, S. S. and Rajesh Kumar. (1990). Importance of mulch in crop production. *Indian Journal of Soil Conservation,* 18: 20-26.

Dixit, C. K. and Majumdar, A. M. (1995). Effect of mulching on water use efficiency, yield and quality of potato (*Solanum tuberosum* L.). *Haryana Journal of Horticultural Science,* **24**: 286-291.

Duhr, E. and Dubas, A. (1990). Effect of covering the soil with plastic film on the dynamics of plant development and yield of maize sown on different dates. *Prace Komisji Nauk Rolniczych Ikomisji Nauk Lesnych,* **69**:9–18.

Erenstein, O. (2002). Crop residue mulching in tropical and semi-tropical countries: An evaluation of residue availability and other technological implications. *Soil and Tillage Research,* **67**:115-133.

Farias-Larios, J. and Orozco-Santos, M. (1997). Effect of polyethylene mulch colour on aphid populations, soil temperature, fruit quality and yield of watermelon under tropical conditions. *New Zealand Journal Crop Horticulture,* **25**:369-374.

Gandhi, N. and Bains, G. S. (2006). Effect of mulching and date of transplanting on yield contributing characters of tomato. *Journal Research Punjab Agriculture* University India, **43**: 6-9.

Gangawar, S. K. Sinha, P. S. Singh, B. D. Ramnagina Jayaswal, J. and Griya Ghey, U. P. (2000). Maximization of leaf yield of mulberry (*Morus alba* L.) and economic return per unit area of land from sericulture through mulching. *Sericologia,* **40**: 491-497.

Gao, G. X. Jin, L. Z. Guo, F. C. Gu, Z. H. Yu, Y. and Chen, B. (2001). Effect of nutrient paper mulching on tomato (*Lycopersicon esculantum*) cultivation. *China Vegetables,* **6**: 6-7.

Gollifer, D. E. (1993). Effects of application of mulch and K on *Capsicum annuum*. *Papua New Guinea Journal of Agriculture, Forestry and Fisheries,* **36**: 22-29.

Goreta, S. Perica, S. Dumicic, G. Bucan, L. and Zanic, K. (2005). Growth and yield of watermelon on polyethylene mulch with different spacing and nitrogen rates. *HortScience,* **40**:366-369.

Greenough, D. R. Black, L. L. and Bond, W. P. (1990). Aluminum surfaced mulch: an approach to the control of tomato spotted wilt virus in solanaceous crops. *Plant Disease,* **74**: 805-808.

Gupta, J. P. and Gupta, G. N. (1987). Response of tomato and okra crops to irrigation and mulch in arid region of India. *Agrochemica,* **31**: 183-202.

Hassan, S. A. Ramlan, Z. A. and Inon, S. (1994). Influence of K and mulching on growth and yield of chilli. *Acta Horticulture,* **369**: 311-317.

Hatfield, J. L. Sauer, T. J. and Prueger, J. H. (2001). Managing soils to achieve greater water use efficiency: A review. *Agronomy Journal*, **93**: 271-280.

Holland, J. M. (2004). The environmental consequences of adopting conservation tillage in Europe: Reviewing evidence. *Agriculture Ecosystems and Environment,* **103**: 1-25.

Hong, S. J. Kim, H. K. and Park, S. W. (2001). Effect of mulching materials on growth and flowering of oriental hybrid lilies in alpine area. *Korean Journal of Horticultural Science and Technology,* **19**: 585-590.

Hooks, C. R. R. and Johnson, M. W. (2003). Impact of agricultural diversification on the insect community of cruciferous crops. *Crop Protection,* **22**: 223-238.

Hundal, I. S. Sandhu, K. S. Doljeet Singh and Sandhu, M. S. (2000). Effect of different types of mulching and herbicidal treatments on nutrient uptake in tomato (*Lycopersicon esculentum*). *Haryana Journal of Horticulture Science,* **29**: 242-244.

Hutton, M. G. and Handley, D. T. (2007). Effects of silver reflective mulch, white inter-row mulch, and plant density on yields of pepper in Maine. *HortTechnology,* **17**:214-219.

Jacks, C. V. Brind, W. D. and Smith, R. (1955). Mulching Technology Comm., No. 49, Common Wealth. *Bulletin of Soil Science* Pp.118.

Jones, R. A. C. (1991). Reflective mulch decreases the spread of two non-persistently aphid transmitted viruses to narrow lupin (*Lupinus angustifolius*). *Annals of Applied Biology,* **118**: 79-85.

Kelly, J. W. Adler, P. H. Decoteau, D. R. and Lawrence, S. (1989). Colored reflective mulches surfaces to control whitefly on poinsettia. *HortScience,* **24**:1045-1049.

Khurshid, K. Iqbal, M. Arif, M. S. and Nawaz, A. (2006). Effect of tillage and mulch on soil physical properties and growth of maize. *International Journal of Agriculture & Biology,* **8**: 593–596

Kim, S. T. Ahn, H. G. Jung, W. Y. Chang, Y. D. and Choi, S. T. (2000). Effects of planting times and mulching on growth and flowering of native wild *Crocosmia crocosmiiflora* in cut flower culture. *Journal of the Korean Society for Horticultural Science,* **41**: 311-313.

Kolota, E. and Adamczewska-Sowiñska, K. (2004). The effects of living mulches on yield, over wintering and biological value of leek. *Acta Horticulture,* **638**: 209-214.

Kring, J. B. and Schuster, D. J. (1992). Management of insects on pepper and tomato with UV-reflective mulches. *Florida Entomologist,* **75:** 119-129.

Lal, H. Rathore, S. V. S. and Kumar, P. (1996). Influence of irrigation and mixtalol spray on consumptive use of water, water use efficiency and moisture extraction pattern of coriander. *Indian Journal of Soil Conservation,* **24**: 62-67.

Lamont, Jr. W. J. (2005). Plastics: Modifying the microclimate for the production of vegetable crops. *HortTechnology,* **15**: 477- 481.

Lamont, Jr. W. J. (1993). Plastic mulches for the production of vegetable crops. *HortTehnology*, **3**:35-39.

Lourduraj, A. C. Sreenarayanan, V. V. Rajendran, R. Ravi, V. Padmini, K. and Pandiarajan, T. (1996). Effect of plastic mulching on tomato yield and economics. *South Indian Horticulture,* **44**: 139-142.

McCann, I. Kee, E. Adkins, J. Ernest, E. and Ernest, J. (2007). Effect of irrigation rate on yield of drip-irrigated seedless watermelon in humid region. *Science Horticulture,* **113**:155-161.

Merwin, I. A. Rosenberger, D. A. Engle, C. A. Rist, D. L. and Fargione, M. (1995). Comparing mulches, herbicides and cultivation as orchard groundcover management systems. *Hort. Technology,* **5**:151-158.

Muhammad, A. P. Muhammad, I. Khuram, S. and Anwar-UL-Hassan. (2009). Effect of mulch on soil physical properties and NPK concentration in Maize (*Zea mays*) shoots under two tillage system. *International Journal of Agriculture & Biology,* **11**:120-124.

Mukherjee, D. Mitra, S. and Das, A. C. (1991). Effect of organic matter cakes on changes in carbon, nitrogen and microbial population in soil. *Journal of Indian Society Soil Science,* **39**: 121-126.

Murugan, M. and Gopinath, G. (2001). Effect of organic and inorganic mulches on growth and flowering of crossandra (*Crossandra undulaefolia* Salisb) cv. Saundarya. *Research on Crops,* **2**: 346-350.

Nagalakshmi, S. Palanisamy, D. Eswaran, S. and Sreenarayanan, V. V. (2002). Influence of plastic mulching on chilli yield and economics. *South Indian Horticulture,* **50**: 262-265.

Nameth, S. T. Dodds, J. A. Paulus, A. O. and Laemmlen, F. F. (1986). Cucurbit viruses of California: An ever changing problem. *Plant Disease,* **70:** 8-12.

Orozco, S. M. Lopez, A. O. Perez, Z. O. and Delgadillo, S. F. (1994). Effect of transparent mulch, floating row cover and oil sprays on insect populations, virus diseases and yield of cantaloup. *Biological Agriculture and Horticulture,* **10**: 229-234.

Ossom, E. M. Pace, P. F. Rhykerd, R. L. and Rhykerd, C. L. (2001). Effect of mulch on weed infestation, soil temperature, nutrient concentration, and tuber yield in *Ipomoea batatus* (L.) Lam. *In Papua New Guinea. Tropical Agriculture (Trinidad),* **78**: 144–151.

Park, K. Y. Kim, S. D. Lee, S. H. Kim, H. S. and Hong, E. H. (1996). Differences in dry matter accumulation and leaf area in summer soybeans as affected by polythene film mulching. *RDA Journal of Agricultural Sciences,* **38**: 173–179.

Purohit, K. M. Ray, D. and Subbarao, G. (1990). Effect of mulches on soil temperature, soil moisture, growth and yield of mulberry during winter and rainfed condition in West Bengal. *Indian Journal of Sericulture,* **29**: 64-71.

Rathore, A. L. Pal, A. R. and Sahu, K. K. (1998). Tillage and mulching effects on water use, root growth and yield of rainfed mustard and chickpea grown after low land rice. *Journal of Science & Food Agriculture,* **78**: 149–161.

Ravinderkumar and Srivatsava, B. K. (1998). Influence of different mulches on flowering an fruit setting of winter tomato. *Crop Research,* **12** : 174-176.

Rodrigues, E. J. R. Minami, K. and Farina, E. (1999). Mulching in soilless systems of the rose crop: Productivity, water consumption, temperature and solarisation. *Scientia Agricola,* **56**: 785-795.

Romic, D. Borosic, J. Poljak, M. and Romic, M. (2003). Polyethylene mulches and drip irrigation increase growth and yield in watermelon (*Citrullus lanatus* L.). *European Journal of Horticultural Science,* **68**:192-198.

Saroa, G. S. and Lal, R. (2003). Soil restorative effects of mulching on aggregation and carbon sequestration in a Miamian soil in Central Ohio. *Land Degradation Development,* **14**: 481–493.

Sarolia, D. K. and Bhardwaj, R. L. (2012). Effect of mulching on crop production under rainfed condition: A Review. *Int. J. Res. Chem. Environ.,* **2**: 8-20.

Sciortino, A. (2001). Mulching, in what conditions. *Colture Protette,* **30**: 39-43.

Shashidhar, K. R. Bhaskar, R. N. Priyadharshini, P. and Chandrakumar, H. L. (2009). Effect of different organic mulches on pH, organic carbon content and microbial status of soil and its influence on leaf yield of M-5 mulberry (*Morus indica* L.) under rainfed condition. *Current Biotica,* **2**:405-412.

Stapleton, J. J. Molinar, R. H. Lynn-Patterson, K. McFeeters, S. K. and Shrestha, A. (2005). Soil solarisation provides weed control for limited resource and organic growers in warmer climates. *California Agriculture,* **59**: 84-89.

Sugiyarto, M. (2009). The effect of mulching technology to enhance the diversity of soil macro invertebrates in sengon-based agro-forestry systems. *Biodiversitas,* **10**:129-133.

Surya, J. N. Puranik, J. B. Zadode, S. D. and Deshmukh, S. D. (2000). Effect of wheat straw incorporation on yield of green gram and wheat, soil fertility and micro-biota. *Journal Maharashtra Agricultural University,* **25**: 158–160.

Sutagundi, R. H. (2000). Effect of mulches and manures on growth and yield of chilli (*Capsicum annuum* L.). M. Sc. (Agri.) Thesis, University Agricultural Sciences, Dharwad.

Tarara, J. M. (2000). Microclimate modification with plastic mulch. *HortScience,* **35**: 169-180.

Thakur, P. S. Thakur, A. Kanaujia, S. P. and Thakur, A. (2000). Reversal of water stress effects. Mulching impact on the performance of *Capsicum annuum* under water deficit. *Indian Journal of Horticulture,* **57**: 250-254.

Uppal, D. S. Khurana, S. M. P. and Pandey, S. K. (2001). Influence of pre-harvest mulching for curing of tubers on potato chip colour and processing parameters. *Journal of the Indian Potato Association,* **28**: 176-177.

Van Derwerken, J. E. and Wilcox, L. D. (1988). Influence of plastic mulch and type and frequency of irrigation on growth and yield of bell pepper. *Horticultural Science,* **23**: 985-988.

Vander Zaag, Demagante, A. Acasi, R. Domingo, A. and Hagerman, H. (1986). Response of solanum potatoes to mulching during different seasons in an isohyperthemic environment in the Philippines. *Tropical Agriculture* (Trinidad), **63**: 229-239.

Vos, J. G. M. and Sumarni, N. (1997). Effects of mulch on crop performance and prediction. *Journal of Horticultural Sciences,* **72**: 415-424.

Walters, S. A. (2003). Suppression of watermelon mosaic virus in summer squash with plastic mulches and row covers. *HortTechnology,* **13**:352-357.

Waterer, D. R. (2000). Effect of soil mulches and herbicides on production economics of warm-season vegetable crops in a cool climate. *HortTechnology,* **10:** 154-159.

Worthington, V. (2001). Nutritional quality of organic versus conventional fruits, vegetables and grains. *The Journal of Alternative and Complementary Medicine,* **7/2:** 161-173.

Wu, J. Donnell, A. C. and Syers, J. K. (1993). Microbial growth and sulphur immobilization following the incorporation of plant residues into soil. *Soil Biology and Biochemistry,* **25**: 1567-1573.

Yamaguchi, T. Ito, A. and Koshioka, M. (1996). Effect of combination of reflective film mulching and shading treatments on the growth of carnation (*Dianthus caryophyllus*). *Japan Agricutlrual Research Quarterly,* **30** : 181-188.