BRJ BASIC RESEARCH JOURNALS

Basic Research Journal of Agricultural Science and Review ISSN 2315-6880 Vol. 6(8) pp. 79-86 December 2018
Available online http//www.basicresearchjournals.org

Review

Effect of mulching practice on crop performance and soil properties: A review

Sharma Sujeeta and Ghimire Binod*

[1]Department of Agriculture, Ministry of Agricultural and Livestock Development (MoAD), Government of Nepal,

*Corresponding Author email: sujitasharma2013@gmail.com

Acceptance 11 December 2018

ABSTRACT

The aim of this review was to evaluate the effect of mulching practices on crop performance along with its impact on soil properties. The reader would get knowledge regarding mulching and its effects on crops and soil. Besides intensive research this paper collected major findings and results derived from research activities carried out in different countries. Review of papers from 1955 to 2015 was done. Desk review of the articles, thesis, review papers etc. was done. The practice of applying mulches to soil is possibly as old as agriculture itself. Mulching is an agricultural cropping technique that involves placing organic or synthetic materials on the soil around plants to provide a more favorable environment for growth and production. Mulching improve water retention, reduce erosion, moderate soil temperature, reduce competition from weeds, bring added nutrients to the soil and also help to retain existing nutrients by avoiding leaching. Retaining the soil moisture by checking evaporation, controlling temperature fluctuation, minimizing the effect of weed infestation and helping in uptake of nutrient along with its addition are some of the positive effects of mulching that promotes vegetative growth of crops enhancing crop yield and quality production. This paper deals with the review and discussion of different published paper from on different aspects of mulching and its effect on the performance of crops and properties of soil. Reading this paper thoroughly one can understand the effects of mulching and its relationship with soil and crops.

Keywords: Mulching, Soil temperature, Weed, Vegetative growth, Crop yield.

INTRODUCTION

Farmers all around the world are adopting the practice of mulching traditionally although the benefits from it are unknown to them. The word mulch has probably derived from the German word “molsch” means soft to decay, which apparently referred to the gardener’s use of straw and leaves as a spread over the ground (Jack et al., 1955). Mulch is a protective layer of material that is spread 3-6 inches deep on top of exposed soil between plants. Mulch can be almost anything: straw, grass clippings, corn cobs, river stones, pea gravel, and chipped bricks, bark chips, leaves, peat moss, seaweed, wood ashes, sawdust and so on. Similarly, the practice in which mulch materials are used to cover the ground, much like layers of leaves on the forest floor and a method in which any material used or spread at surface or vertically in soil to assist soil and water conservation and soil productivity is called mulching.

Mulching is one such process that can help us in producing quality food in quantities (Patil et al., 2013). Mulches are used for various reasons but water

Table 1. Effect of different mulching materials on vegetative characteristics of summer squash (Pooled)

Treatments	Plant height (cm)	Collar diameter (mm)	Plant Spread (cm)	Number of leaves per plant	Days to 50% flowering (female)	Days to 50% flowering (male)	Root length (cm)
Clear plastic	35.20	17.94	125.27	36.35	26.33	32.67	35.34
Black plastic	38.11	20.15	142.39	41.85	27.17	32.00	36.83
Pine needles	29.14	17.71	116.93	33.85	33.33	35.00	33.73
Dry leaves	28.47	17.40	117.02	32.19	33.83	36.83	33.38
FYM	28.31	21.04	117.31	33.04	32.67	36.67	33.64
Green twigs	25.83	19.23	115.60	31.03	35.00	38.83	33.03
Forest litter	33.02	20.79	121.30	32.19	28.00	36.67	34.59
Control	24.87	17.47	102.35	29.62	31.50	36.67	30.02
CD at 5%	1.87	1.57	9.10	1.74	1.71	1.33	1.98

Source: Bhatt et al., (2011)

conservation and erosion control are the most important objects in agriculture in dry regions. Mulches when properly managed definitely aid wind and water erosion control along with vegetative growth and productivity. Other reason for mulching includes soil temperature modification, soil conservation, nutrient addition, improvement in soil structure, weed control and crop quality control. Mulches are commonly applied to the soil surface to conserve soil moisture, moderate soil temperature, reduce evaporation and salt accumulation (Pang et al. 2010). Mulching practice in crops provides positive effect on crop vegetative characteristics like plant height, collar diameter, plant spread, number of leaves, days to 50% flowering, root length etc. and yield attributes compared to control condition.

Mulching also suppresses weed infestation effectively. Furthermore, it stimulates microbial activity in the field soil through increasing soil temperature which improves agro-physical properties of soil. Also, mulching reduces unproductive evaporation from the soil surface so more water is available for transpiration, which is of benefit in water limited condition and plant water status is maintained (Chakraborty et al., 2008).

RESULTS

A. Effect of mulching on crop performance

Mulching reduces the deterioration of soil by way of preventing the runoff and soil loss, minimizes the weed infestation and checks the water evaporation. Thus, it facilitates for 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.

Growth of crop

The effects of mulches on plants are operative through the effects of mulches on soil water, soil temperature, structure and erosion. According to Mahadeen (2014) on using polyethylene plastic mulch produced earlier seedling emergence, more vigorous plant, earlier and higher yield as compared to non-mulched treatment (Table 2). Bananuka *et al.* (2000) found a larger number of functional leaves at flowering and harvest with different mulches on bananas. The increase in yield could partly be due to this effect on the leaves. Lang *et al*. (2001) announced that a more active growing root system formed under mulch consisting out of perforated black polyethylene with 15cm of sawdust on top. They reported that the mulched trees produce 1.5 times more feeder roots due to the stimulation of the growth of fine roots and to a reduction in death of fine roots. Devi Dayal et al. (1991) observed early flowering (by 5 days) in mulch treated groundnut crop. Hu et al. (1995) recorded earlier seedling emergence, improved crop growth and nodule development in groundnut. Hu et al. (1995) also reported increased crop growth (3.2–4.0cm), dry root mass (12.2–50.1%), nitrogen-fixing activity (3.3–128.7%), chlorophyll content of the fresh leaves (41–78%) and more reproductive buds (63.3–94.1%) in polythene mulched plots than unmulched plots. Chawla (2006) obtained maximum plant height (70.91cm), plant spread (53.05cm) 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 and control. Likewise, Bhatt et al. (2011) studied effect of mulching materials on vegetative characters, yield and economics of Summer squash under rainfed in mid-hill condition of Uttarakhand, India and resulted positive effect of different mulching materials on plant height, collar diameter, plant spread, number of leaves, days to 50% flowering and root length compared to control condition (Table 1). Loy and Wells (1990) reported that black plastic mulch made the harvest earlier by 7-14 days, while clear plastic may advance the harvest date by 21 days. The results of Ei-Shaikh and Fouda (2008) showed that soil temperature increased by using plastic mulches which permits early germination, flowering and harvesting. Also, the average yield increased by 67, 109, 129, and 124% with straw,

Table 2. Effect of polyethylene black plastic mulch on vegetative growth, seedling emergence and flowering times of okra and squash grown under rain-fed conditions

Treatments	Seedling emergence (days)	Flowering time (days)	Plant length (cm)	Branch no.	Fresh wt. (gm/plant)	Dry wt. (gm/plant)
Okra						
Black plastic mulch	15.44a*	44.4a	87.9a	14.9a	255.6a	58.6a
No mulch	19.00b	48.0b	68.4b	11.4b	152.1b	35.6b
Squash						
Black plastic mulch	11.00a	35.0a	n.d**	n.d	626.2a	96.7a
No mulch	13.90b	38.4b	n.d	n.d	356.3b	59.0b

*means having different letter within each column and crops are significantly different at 5% level of probability **n.d: Not determine. Source: Mahadeen (2014)

Table 3. Effect of different mulching materials on yield and yield attributes of Summer squash (Pooled)

Treatments	Number of harvestings	Fruits per plant	Total yield (t/ha^{-1})	% increase in yield over control	B:C ratio
Clear plastic	12.33	6.01	55.85	55.09	2.43
Black plastic	13.00	6.75	62.72	74.17	2.61
Pine needles	12.00	5.41	49.15	36.49	2.47
Dry leaves	11.00	5.67	45.93	27.54	2.32
FYM	11.33	5.18	44.03	22.27	2.11
Green twigs	09.66	5.51	44.75	24.27	1.23
Forest litter	12.33	5.82	49.33	36.99	2.44
Control	09.66	4.96	36.01	-	1.79
CD at 5%	1.59	0.77	3.39	-	-

Source: Bhatt et al., (2011)

black, transparent and yellow mulch respectively compared with the control. Table 2.

Yield of crop

Mondal et al (2008) resulted that with the application of polythene mulch produced significantly highest straw yield, siliquae/plant, seeds/siliqua, 1000-seed, seed yield and straw yield of mustard followed by rice straw mulch. The lowest yield of mustard was recorded in no-mulch treatment. The reason for high yield in polythene and straw mulch treatments might be due to lower soil temperature and conserves more moisture. Yield of mustard increased in black polythene and rice straw mulch over no mulch to the extent 39% and 30%, respectively. The yield of potato was the highest under paddy straw mulch (27.9%) and also starch content was highest in paddy straw mulch (18.18%) than unmulched plot (Dixit et al., 1995). Abu-Bakr et al., (2003) resulted that the black, clear and green plastic mulches increased total yield of okra by 84.9%, 46.0% and 46.9%, respectively, compared to the control. Szewczuk and Gudarowska (2004) found that mulching with both organic – and inorganic material increased the yield and fruit size in apples. Despite the increased fruit size, these fruit also showed an increase in Ca concentration. When the firmness was investigated, they found apple fruit to be firmer immediately after harvest when the trees were mulched. Similarly, Forge *et al*. (2003) indicated that, a large variety of organic materials can be used as mulches to improve crop performance in various ways. He found that the yield and growth was increased in apples in high density productions systems by using a simple mulch like shredded office paper. Ghimire *et al.* (2016) also reported that the mulching and soil sustainability measures results positive effect on crop yield in a long run.

The experiments of Kar and Kumar (2007) showed that higher potato yield and better crop growth were observed in plots with straw mulch. Grass mulching increased grain yield by 15–22 per cent in maize and about 10 per cent in millet in northern Guinea and Sudan savanna regions of Nigeria (Adeoye, 1984). 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, 1986). Thakur et al. (2000) reported that the use of different mulches on the performance of Capsicum annum L. under the water deficit of 75 per cent, the lantana mulch gave the highest fruit yield of 73.36 quintals per hectare over un-mulched plots (36.90q/ha). Also Bhatt et al (2011) resulted higher yield and higher B:C ratio in Summer squash production using different mulching materials compare to control or non mulched plot (Table 3). Similarly, Mahadeen (2014) showed

Table 4. Effects of polyethylene black plastic mulch on yield and average fruit weight of okra and squash grown under rain-fed conditions

Treatments	Total yield (ton/ha.)	Average fruit weight (gm)
Okra		
Black plastic mulch	6.759a	6.307
No mulch	2.822b	5.985
Squash		
Black plastic mulch	25.670a	102.600a
No mulch	15.900b	83.120b

Source: Mahadeen (2014)

Table 5. Effects of mulches on total yield, corm ash, TSS, Vitamin C and flavonoids in garlic.

Mulches	Total yield (t·ha-1)	Corm ash (%)	TSS (^{o}Brix)	Vit. C (mg/100g FW)	Flaveonoids (mg/100g FW)
Control	15.26ab	3.33b	17.5b	1.93b	19.80a
Rice husk	17.42ab	3.48ab	20.12ab	2.21ab	7.10b
Transparent polyethylene	18.46a	3.77ab	22.98a	2.44a	15.24ab
Black polyethylene	13.73b	4.12a	23.00a	2.32ab	7.26ab

Values in a column followed by the same letter are not significantly different. Source: Najafabadi et al., 2012

increased yield and fruit weight of okra and squash under black plastic mulched compare with bare soil (Table 4).

Djigma et al. (1986) found that the black polyethylene mulch yielded 3.3 times higher than soil without mulch in eggplant and 2.3 times in tomato, when grown during the relatively cool season sown in September and harvested in January. Similarly, Sajjapongese et al. (1989) revealed that tomato yield increased by 67.5% when the crop mulched with black plastic and by 15% when rice straw used as a mulch. Also, Singh and Ahamad (2008) resulted highest tuber yield of 35.2 t/ha recorded with black polythene mulching was significantly superior to 31.5 t/ha obtained with white polythene mulching and 26.6 t/ha with no mulching. Table 5.

Weed control

Weed control is another important benefit of using mulch. A thick layer of mulch substantially blocks the sunlight from reaching the soil. This inhibits underlying seeds from germinating or young plants from growing, leading to fewer weeds. To ensure that the plants you grow have proper access to sunlight, the mulch can be pushed aside in areas where seeds are sown or young plants are transplanted. Essien et al., (2009) showed that the frequency of weeding was more in non-mulched than in mulched plots since mulches have the ability to smother weeds depending on their thickness. On soils where herbicides are used to control the weeds, a crust may form on the bare surface.

Trisdal (1989) indicated that weeds can also be controlled effectively with organic mulches that compete with main crop for water and minerals. Walsh et al. (1996) found that organic mulches control weeds by smothering and preventing their seed from establishing in the soil. Mulches applied at 10 cm (4 in) or 15cm (6 in) were effective in weed control (Horowitz and Thomas, 1994). Wilen et al. (1999) found a 92% reduction in weeds of container plants that were mulched rather than left bare. Nearly all mulches reduce light, which will stress existing weeds and prevent the germination of many weed species, especially those with small seeds. The silver/black and black plastic mulch controlled weeds by 95 to 98% (Rajablariani et al., 2012).

B. Effect of mulching on soil properties

Soil water conservation

Mulches add an extra layer between the soil and the sun, reducing evaporation and helping to retain water. The need to water is considerably reduced or eliminated, and the plants experience more consistent levels of moisture. Rajput and Singh (1970) reported that the straw mulch conserved higher soil moisture to an extent of 55 per cent more compared to control. When soil surface is covered with mulch helps to prevent weed growth, reduce evaporation and increase infiltration of rain water during growing season. The water infiltrated in soil can be utilized by crops there by crop yields are increased.

Table 6. Effects of polyethylene black plastic mulch on soil moisture content grown with okra and squash under rain-fed conditions

Treatment	Soil Moisture Content (SMC)		
	30 days	60days	90days
Okra			
Black plastic mulch	27.0a*	18.1a	14.6a
No mulch	22.9b	15.5b	12.4b
Squash			
Black plastic mulch	25.7a	16.3a	12.6a
No mulch	20.2b	13.0b	11.8a

*Means having different letter within each column and crops are significantly different at 5% level of probability. Source: Mahadeen (2014)

Mulches obstruct the solar radiation reaching to soil. This can be attributed to the fact that the thick mulch layers protected the soil surface against solar radiation thereby reduced evaporation and enhanced favorable moisture storage (Wicks *et* al., 1994).

The higher moisture conservation under the plastic mulch was mostly due to prevention of evaporation from soil surface (Pusztai, 1972). An early study (Russell, 1939) demonstrated that a layer of straw only 3.8cm (1.5 in) thick reduced evaporation by about 35% compared to bare soil. Hatfield et al. (2001) reported a 34-50 per cent reduction in soil water evaporation as a result of crop residue mulching. Ei-Shaikh and Fouda (2008) reported mulching treatments led to saving in irrigation water for all mulching types compared with the control treatment. The water use efficiency was 6.22, 7.76, 8.51, 8.34, and 2.32 kg/m3 under straw, black, transparent, yellow and bare soil treatments respectively. Also, Singh and Ahamad (2008) studied effect of mulching on potato production in high altitude cold arid zone of ladakh and concluded that the use of polythene mulching reduces water requirement in potato crop by 33.3%. table 6.

Soil structure

Crop residues when applied at adequate level increase infiltration rate. Decomposition of these residues results in improving soil aggregation and suability. Mulch slows (reduce) velocity of runoff. The results of plastic film mulches increased the total porosity, decreased bulk densities also were found by Mbah et al. (2010). Straw mulch, one of organic materials, could increase soil organic matter content and aggregation, which were more beneficial soil structure improvement (Duiker and Lal, 1999). Mulumba and Lal (2008) reported that straw mulch was an effective soil physical environment modifier, which decrease the bulk density, increase the total porosity, stable aggregates percent, available water capacity and soil moisture retention significantly.

Broschat (2007) reported soil pH was not affected by four type mulches (Pine bark, Eucalyptus, Cypress and Pine needles); however other studies have shown that soil pH decreases when organic mulches are used. The potassium concentration in plants in mulched plots was two times higher than in no-mulched plots and higher K uptake in the mulched plots could be attributed to the higher K supply through the mulch material (Gaiser et al., 1992). Under optimum conditions the nitrate concentration was more than five times higher in soil from mulched compared to un-mulched plots (Engel, 1934). the addition of organic mulches decreased the fertilizer requirements (Evanylo et al., 2008), decreased soil bulk density, and increased soil carbon and cation exchange capacity (Tiquia et al., 2002), as well as improved soil structure (Pinamonti et al., 1995).

Soil erosion

Soils from dry region are nightly susceptible to water erosion and wind erosion because rainfall occurrence is frequent during intense storms and surface is adequately protected by vegetation effectively retard runoff. Therefore to reduce erosions by wind and water is an important reason for using mulches in dry regions. Organic mulches can reduce the impact of raindrops on surface sealing and thereby increase the infiltration tempo. This way erosion is reduced by the increased water infiltration rate and the decrease in runoff velocity (Smets *et al*., 2008). A partial covering of mulch residue on the soil can strongly affect runoff dynamics, and reduce runoff amount (Findeling et al., 2003). Borst and Woodburn (1942) found that a 1.5cm (0.6 in) layer of straw mulch reduced soil erosion by 86%. Crop residues when applied at adequate level increase infiltration rate. Decomposition of these residues results in improving soil aggregation and suitability for crop production. Mulching the soil surface reduce velocity of runoff, evaporation and increase the amount of water stored in the soil profile (Bennett, 1966).

Soil temperature

Plastic mulches absorb comparatively large amounts of

Table 7. Soil temperature at 10 cm depth in mulched treatments and bare soil

Treatments	Soil Temperature 0c		
	8:00	14:00	Mean
Clear	25.8a	33.1b	29.5b
Black	24.5b	31.0c	27.6c
Red	26.3a	34.0ab	30.1ab
Blue	26.4a	35.0a	30.7a
Silver/Black	24.1b	30.7c	27.4c
Bare soil/Control	21.3c	26.8d	24.1d
Weedy	20.4c	25.7d	23.0d

In a column, figures bearing same letter(s) do not differ significantly at 5% level of probability by DMRT. Source: Rajablariani et al., 2012

Table 8. The effect of 0.45m (18In.) of wood chip mulch on properties of soil beneath it.

Soil properties	Mulched soil	Un-mulched soil
Soil ODR (ug/cc/min)	0.38	0.46
Average soil temp. (0c)	22.3	22.7
Soil moisture (%dry wt.)	19.4-25.2	18.3-30.2
Soil pH	7.6	7.6
Soil nitrates (ppm)	2.8*	4.2

*Significant different at 0.5 level. Source: Watson and Kupkowski, 1990

the incoming radiation and transmit a considerable part of it to the soil underneath (Tarara 2000). The temperature of the soil changes over the course of the season, during cold snaps and heat waves, and also from daytime to nighttime. Mulches provide a layer of insulation, keeping soil temperatures more moderate. Mulches results in greater water content and lower the evaporation. However effects on soil temperature are highly variable. White mulches decrease soil temperature while clear plastic mulches increase soil temperature. Black plastic mulches are more effective in increasing soil temperature due to a greater net radiation under the mulch compared to bare soil (Streak et al., 1994). Pinamonti *et al*. (1995) found a compost mulch to regulate the temperature of soil by reducing the daily range and creating a more constant temperature suitable for root activity.

Temperature regulation is achieved by the mulching layer buffering the soil layers from direct radiation and thereby reducing the evaporation of soil water (Haynes, 1980). In summer months or in hotter geographical regions, organic mulches have been shown to lower soil temperature nearly 10^{o}C (50F) compared to unprotected soil (Martin and Poultney, 1992). Chen and Yin (1989) reported that the plastic mulching increased soil temperature by 0.9 to 4.3ºC at the seedling stage, 1.6 to 2.3ºC at the bud initiation stage and 0.8 to 1.9ºC at the flowering stage. The findings of Duhr and Dubas (1990) showed an increase of 2.9–3.30C in soil temperatures with transparent, photodegradable polythene film mulching. Toshio (1991) also reported that the difference in soil temperature between mulched and bare soil in early May reached 7ºC in case of transparent film and 5ºC in case of black film. (Rajablariani et al., 2012) indicated that soil temperature increased under the various colored plastic mulches about 3 to 6 °C more than it in bare soil (Table 7).

Soil compaction

The mulch acts as a protective mat over the ground, reducing compaction from footsteps or heavy rainstorms. Simple mulches such a straw has shown to increase soil aggregate stability, which improved the soil permeability for water penetration and aeration to the deeper layers (Pinamonti et al., 1995). Adding organic mulch such as bark disperses the direct impact of water droplets, feet, and tires, thus restoring soil aggregation and porosity. It is better to apply mulch before compaction occurs rather than after the fact (Oliveira and Merwin, 2001). In soil management relationships, mulching has been reported to influence organic matter content, activity of microorganisms, availability of soil nutrients, control of erosion and soil compaction and regulating soil temperature (Stowell, 2000).

Soil nutrient

By providing a protective layer between the soil and the elements, mulch helps retain existing soil nutrients and a healthy soil structure. Similar to this, Bell et al., (1960) reported that under black polythene mulch, movement and leaching of nutrients were reduced and utilization by

the bean crop was increased. The improvement in soil physical condition such as porosity and water availability enhanced absorption of minerals (Pinamonti *et al*., 1995); Tiquia et al. (2002) reported that, mulching with composted yard waste increased the total microbial biomass together with the soil cat ion exchange capacity (CEC), nutrient levels ((P), potassium (K), calcium (Ca)) and soil organic matter when compared to bare surfaces. By the data of Saroa and Lal (2004), mulching increased total phosphorus concentration in the soil after 4 years of mulching from 601–658mg kg-1 and from 491–694mg kg-1after 11 years of mulching. Table 8 above.

CONCLUSION

Different studies in different geographical area showed the positive effect of mulching in the performance of crop as well as different properties of soil as it depends upon mulching materials and climatic conditions. Germination, seedling emergence, vegetative growth and yield attributes of crops are found favored by the use of mulching materials compared with bare soil. Plastic mulches are recommended to obtain high soil temperature in the cold conditions; meanwhile, the organic mulches are better than plastic mulching in a hot climate due to its ability for reducing soil temperature. Also, black plastic mulches are recommended for highly weed infested area as mulching effectively suppresses its growth reducing competitiveness. Mulching of crop is also suggested for dry conditions as it plays significant role in conservation of moisture. Soil moisture content and nutrient availability in soil increases with the use of organic mulches compared to bare soil. This study tested the effect of mulching only from the aspect of crop performance and soil properties that were conducted in different climatic conditions and geographical situations, other effects, methods of application, type of mulching materials and insect pest and disease aspect were not covered.

REFERENCES

Abu-Bakr AG A, El-Balla MMA (2003). Use of Plastic Mulch for Better Performance and Yield of Okra During Winter in Sudan. U. of K. J. Agric. Sci. 11 (2), 2003.165-178.

Adeoye KB (1984). Influence of grass mulch on soil temperature, soil moisture and yield of maize and gero millet in a savanna zone soil. Samaru J. Agric. Res. 2, 87–97.

Bananuka JA, Rubaihayo PR, Zake JYK (2000). Effect of organic mulches on growth, yield components and yield of east African highland bananas. Acta Hort. 540: 293-300.

Bell GDH, Evans HREJ, Keen B, Russell JE, Schofield RK, Yates F (Eds.), (1960). Effect of black polythene mulch on soil microclimate and temperature and nitrate level. Agron. J., 52: 307-309.

Bhatt L, Rana R, Uniyal S, Singh V (2011). Effect of Mulch Materials on Vegetative Characters, Yield and Economics of Summer Squash (Cucurbitapepo) under Rainfed Mid-hill Condition of Uttarakhand. J. Veget. Sci. 38 (2), 165-168.

Borst HL, Woodburn R (1942). The effect of mulching and methods of cultivation on runoff and erosion from Muskingham silt loam. Agric. Eng. 23:19–22.

Broschat TK (2007). Effects of Mulch Type and Fertilizer Placement on Weed Growth and Soil pH and Nutrient Content. Hort Technol., 17(2): 174-178.

Chakraborty D, Nagarajan S, Aggarwal P (2008). Effect of mulching on soil and plant water status, and the growth and yield of wheat (Triticum aestivum L.) in a semiarid environment. Agricultural Water Management, 95:1323–1334.

Chawla SL (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 QE, Yin JS (1985). Effect of plastic mulch on soil properties and cotton growth in saline-alkali soils. J. Soil Sci. China 20, 1-3.

Devi D, Naik PR, Dongre BN (1991). Effect of mulching on soil temperature and groundnut yield during rabi-summer season. Groundnut News 3, 4-5.

Dixit CK, Majumdar AM (1995). Effect of mulching on water use efficiency, yield and quality of potato (Solanum tuberosum L.), Haryana J. Hortic. Sci., 24, 286-291.

Djigma A. Diemkouma D (1986). Plastic mulch in dry tropical zones. Trials on vegetable crops in Burkina Faso .Plasticulture 69, 1: 19-24.

Duhr E, 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.

Duiker SW. Lal R (1999). Crop residue and tillage effects on carbon sequestration in a Luvisol in central Ohio. Soil and Tillage Research, 52, 73–81.

El-Shaikh A, Fouda T (2008). Effect of different mulching types on soil temperature and cucumber production under Libyan conditions. Misr. J. Ag. Eng. 25:160–175.

Engel H (1934). Zur Physiologie der Nitrifikations organismen in natürlichen Böden. Zbl. Bakt. II, 90: 384.

Essien BA, Essien JB, Nwite JC, Eke KA, Anaele UM, Ogbu JU (2009). Effect of organic mulch materials on maize performance and weed growth in the derived savanna of south eastern Nigeria. Niger. Agric. J. 40(1):255-262.

Evanylo G., Sherony C, Spargo J, Starner D, Brosius M. Haering K (2008). Soil and water environmental effects of fertilizer-, manure, and compost- based fertility practices in an organic vegetable cropping system. Agr. Ecosys. Envr. 127, 50-58.

Findeling A, Ruy S, Scopel E (2003). Modeling the effects of partial residue mulch on runoff using a physically based approach. J. Hydrol. 275, 49–66.

Forge TA, Hugue E, Neilsen G, Neilsen D (2003). Effects of organic mulches on soil microfauna in the root zone of apple: implications for nutrient fluxes and functional diversity of soil food web. Appl. Soil Ecol. 22, 39 – 54.

Gaiser T, Stahr K, Kang BT (1992). Mulching effect on Puptake by maize in a Ferrali-Haplic Nitosol in the subhumid tropics. Proceedings of the Forth Conference of the World Phosphate Institute, 8-11 September (1992), Ghent, Belgium, pp.610-612.

Ghimire B, Dhakal SC, Sharma S (2016). Prospects of adopting eco-friendly measures of soil sustainability among vegetable producers in Dhading, Nepal. Universal Journal of Environmental Research and Technology 6(4):195-202.

Gupta JP, Gupta GK (1986). Effect of soil tillage and mulching on soil environment and cowpea seedling growth under arid conditions. Soil Tillage Research 7, 233-240.

Hatfield JL, Sauer TJ, Prueger JH (2001). Managing soils to achieve greater water use efficiency: A review. Agron. J. 93, 271-280.

Haynes RJ (1980). Influence of soil management practice on the orchard agro-ecosystem. Agro-Ecosys. 6, 3-32.

Horowitz, M. and JM Thomas. (1994). Couverture du sol pour la gestion des mauvaises herbes (Soil cover for weed management), pp. 149–154. Maitrise des adventices par voie non chimique. Communications de la quatrieme conference international I.F.O.A.M. 2nd Edition.

Hu W, Duan S, Sui Q (1995). High yield technology for groundnut. Int. Arachis Newsletter 15, 1–22.
Kar G, Kumar A (2007). Effects of irrigation and straw mulch on water use and tuber yield of potato in eastern India. J. Agric. Water Manag. 94(109), 116.
Lang A, Behboudian MH, Kidd J, Brown H (2001). Mulch enhances apple fruit storage
Loy, B. and Wells, O. (1990). Effect of IRT mulches on soil temperature, early vegetative development in muskmelon and weed growth. Proceedings, National Agricultural Plastics Congress 22: 19-27.
Mahadeen AY (2014). Effect of polyethylene black plastic mulch on growth and yield of two summer vegetable crops under rain-fed conditions under semi-arid region conditions. Ame, J. Agric. Biol. Sci, 9(2): 202.h p://dx.doi.org/10.3844/ ajabssp.202-207.
Martin PJ, Poultney R (1992). Survival and growth of clove seedlings in Zanzibar. 1. Effects of mulching and shade crops. Tropical Agric. 69:365–373.
Mbah CN, Nwite JN, Njoku C, Ibeh LM, Igwe TS (2010). Physical Properties of an Ultisol under Plastic Film and No-Mulches and Their Effect on the Yield of Maize. World J. Agric. Sci. 6, 160–165.
Mondal NA, Hossain SMA, Bhuiya SU, Jahiruddin M (2008). Productivity of rainfed mustard in relation to tillage and mulching. Bangladesh J. Agril. Res. 33(3): 597-606.
Mulumba LN, Lal R (2008). Mulching effects on selected soil physical properties. Soil and Tillage Research, 98, 106–111.
Najafabadia MMB, Peyvasta GM. Hassanpour A, Olfatia JA, Rabieeb M (2012). Mulching effects on the yield and quality of garlic as second crop in rice fields. Intern. J. Plant Prod. 6 (3):279-290.
Oliveira MT, Merwin IA (2001). Soil physical conditions in a New York orchard after eight years under different groundcover management systems. Plant and Soil 234:233–237.
Pang HC, Li YY, Yang JS, Liang YS (2010). Effect of brackish water irrigation and straw mulching on soil salinity and crop yields under monsoonal climatic conditions. Agricultural Water Management, 97, 1971–1977.
Patil SS, Kelkar TS, Bhalerao SA (2013). Mulching: A Soil and Water Conservation Practice. Res. J. Agric. Fores. Sci. Vol. 1(3), 26-29.
Pinamonti F, Zorzi G, Gasperi F, Silvestri S, Stringari G (1995). Growth and nutritional status of apples trees and grapevine in municipial solid-waste-amended soil. Acta Hort. 383: 313-321.
Pusztai A (1972). Effect of mulching on soil and plant. Plastic in Agriculture, 5th International Colloquium, Budapest 1, 584-590. quality. Acta Hort. 557: 433-439.
Rajablariani HR, Hassankhan F, Rafezi R. (2012). Effect of Colored Plastic Mulches on Yield of Tomato and Weed Biomass. Intern. J. Environ. Sci. Dev. 3, 590- 593.
Rajput RK, Singh M (1970). Efficiency of different mulches on conserving soil moisture in cotton, Indian J. Agron. 15, 41-45.
Russell JC (1939). The effect of surface cover on soil moisture losses by evaporation. Proc. Soil Sci. Soc. Amer. 4:65–70.
Sajjapongese A, Ota Y, Roam YC, Wu CL (1989). Some aspects of cultural management in tomatoes at AVRDC. Asian Vegetable Research and Development Center, Shanhua, Tainan, Taiwan. pp. 349-357.
Saroa GS, Lal R (2004). Mulching effects on phosphorus and sulfur concentrations in a Miamian soil in central Ohio, USA. Land Degrad. Develop. 15, 351–365.
Singh N, Ahmed Z (2008). Effect of mulching on potato production in high altitude cold arid zone of Ladakh. Potato J 35(3-4): 118-121
Smets T, Poesen J, Knapen A (2008). Spatial scale effects on the effectiveness of organic mulches in reducing soil erosion by water. Earth-Sci. Rev. 89: 1-12.
Stowell B (2000). Organic kiwifruit production–maintaining soil fertility and yields. Kiwifruit, 139: 18–21.
Streak NA, Schneider FM, Buriol GA (1994). Modificacoes fisicas causadas pelo mulching. Revista Brasileira de Agrometeorologia, 2: 131-142.
Szewczuk A, Gudarowska E (2004). The effect of soil mulching and irrigation on yielding of apple trees in ridge planting. J. Fruit Ornam. Plant Res. 12 (Special ed.): 139145.
Tarara JM (2000). Microclimate modification with plastic mulch. HortScience 35, pp:169-180.
Thakur PS, Thakur A, Kanaujia SP, Thakur A (2000). Reversal of water stress effects. I. Mulching impact on the performance of Capsicum annuum under water deficit. Indian J. Hort. 57, 250-254. http://www.gifre.org/admin/papers/gjbahs/Organic-Vol-2-3-GJBAHS.pdf
Tiquia SM, loyed J, Herms DA, Hoitink HAJ, Michel FC (2002). Effects of mulching and fertilization on soil nutrients, microbial activity and rhizosphere bacterial community structure determined by analysis of TRFLPs of PCR amplifications 16S rRNA genes. Appl. Soil Ecol. 21, 31-48.
Toshio HC (1991). The effect of mulching and row covers on vegetable production . Agr. Exp. Stn. Ueno 200, ayabe city, kyoto pref. 623, japan. tree nutrition of ground cover management systems. Acta Hort. 564, 201-207.
Trisdal JM (1989). Soil management. Acta Hort. 240: 161-168.
Walsh BD, Salmins S, Buszard DJ, MacKenzie AF (1996). Impact of soil management systems on organic dwarf apple orchards and soil aggregate stability, bulk density, temperature and water content. C. J. Soil Sci. 76, 203-209.
Watson GW, Kupkowski G (1990). Effects of a deep layer of mulch on the soil environment and tree root growth. J, Arboriculture 17(9):242-245.
Wicks GA, Crutchfield DA, Burnside OC (1994). Influence of wheat (Triticum aestivum) straw mulch and metolachlor on corn (Zea mays L.) growth and yield. Weed Sci. 42:141-7.
Wilen CA, Schuch UK, Elmore CL (1999). Mulches and sub irrigation control weeds in container production. J. Environ. Hort. 17:174– 180.