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Role of mulches in agriculture: A review

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Abstract
In conservation agriculture crop rotations, mulching, use of cover crops and good crop husbandry are very useful measures. Chemical control of weeds creates environmental hazards and residual effects on crops. Weed management through mulches may be alternative to chemical weed control. Organic weed management through application of different mulches can suppress the weed growth as well as improve soil fertility. The present review describes the role of mulches in improving crop yield, weed control, soil water conservation, physical and chemical properties of soil.

Keywords: Conservation agriculture; weed control; soil fertility; soil properties

1. Introduction

Weeds can be controlled through the following methods such as chemical, mechanical, physical, biological and cultural. Application of herbicides is one of the faster weed control method yet this is an expensive method and has some harmful effects on the surrounding environment, human health and on the domesticated and wild animal health (Robinson, 2009) [40]. The practice of highly use of pesticides and herbicides in agriculture is discouraged due to its un-desirable effects on the surrounding environment and other organisms (Diaz *et al*., 2004) [10]. In conservation agriculture crop rotations, mulching, use of cover crops and good crop husbandry are very useful measures to suppress weeds (Kabambe, 2003) [21]. Therefore, environment friendly weed control methods are required to be used for weed management to avoid the incidences of undesirable effects. Mulching may be one of the best strategy for weed management. Weed control through the application of mulches has been reported in literature. Positive effect of crop residues as mulch has been reported on the next growing crop and control of weeds physically as well as chemically by releasing of allelopathic chemicals (Purvis *et al*., 1985) [36]. Mulch is a material that may be organic or inorganic in nature which spread on the soil surface which provides shelter against raindrop, solar radiation and evaporation. Mulches help to preserve moisture, suppress weeds and improve soil stability and avoid insect pest physical attack. Organic mulches help to moderate soil temperature, provide efficient control on weeds, decrease rate of evaporation and add nutrients and humus in the soil. Mulching prevent soil erosion and has the ability to reduce the soil born-diseases. Mulching can be used as the management strategy for the improvement of water use efficiency (WUE) of soil and decreasing weed growth (McCown, 1996) [27]. In many developed countries like America and Australia straw mulch is used which improve various features of soil i.e. enhance soil moisture retention, reduce wind erosion, improve soil structure, control weeds and add nutrients in soil. Mulch has the ability to increase root growth and improve crop production by enhancing plant efficiency for N utilization. Physical application of mulch improves soil particle aggregation and enhance rate of infiltration of water. Chemical mulch provides a slow release type of nitrogen, add humic acids, phosphorus and potassium in the soil which facilitate to increase their uptake and utilization. Biological mulch is the component of Integrated Pest Management program which provides control to phytophthora root rot, against dual aggressive and competitive microbes (Matava, 2009) [26]. Mulches improve the covered land area and also protect the soil surface from erosion. There are two types of mulching material (organic mulch; living and inorganic mulch; non-living). Additional effects of mulching are also reported that these enhance nutrient availability for plants and ultimately improve growth (Sarno *et al*., 2004) [43]. Mulches decrease soil temperature through proper covering of soil and also reduce the impact of rain drops (Salau *et al*., 1992) [41]. Mulch cover provides shelter to the soil from solar radiations and ultimately reduces the evaporation rate of soil. The area that is covered by mulch its soil biota improved that helps in increasing nutrient cycling and build up organic matter contents of soil for a long period of time (Holland, 2004) [15]. The present review describes the role of mulches in improving crop yield, weed control, soil water conservation and physical and chemical properties of soil.

2. Effect of mulches on crop yield

Mulching is a supreme agronomic practice helps in conservation of soil moisture and regulating soil's physical condition. Under deficit irrigation condition, mulching is helpful in retaining water position in soil which finally results in high yield and better water use efficiency (Chakraborty *et al*., 2008) [8]. Maximum crop yield was `recorded (27.07 t per ha) through application of plastic mulch (Seyfi & Rashidi, 2007) [46]. In another study (Iftikhar & Ali, 2004) [16]. reported that mulches significantly

minimize the losses of water through evaporation. They spread a sheet of 2 cm layer of variant mulches on the soil surface. The results showed minimum loss of water happened in wheat straw mulch that was 50% lesser as compared to control. Qin *et al*. (2006) [37]. revealed that straw mulching having non-continuously flooded condition in rice can considerably enhance the yield by enhancing dry weight per plant, tap root length and leaf area of crop as compare to crop without mulching. Yang *et al*. (2006) [57]. observed that mulching with plastic sheet show positive effects on winter wheat in respect to growth and development. Sharma & Acharya (2000) [49]. observed the joint effect of conservation tillage and mulch on maize in the area of north-west India and reported that yield of maize was expressively enhanced through mulching. Awal & Khan (1999) [4]. conducted an experiment to study the influence of diverse mulches (sawdust rice straw and ash) on grain yield, growth, yield components and days to maturity of maize. The results indicated that tasseling, time to maturity and milking is fastened by rice straw mulch and show positive effects on economic and biological yield when compared with other treatments.

Zamir *et al*. (2013) [61]. conducted a research work to check the impact of tillage practices and organic mulches on quality, yield and growth of autumn planted maize and soil physical characteristics. Four kinds of tillage practices i.e. bar harrow tillage, conventional tillage, sub-soiler tillage and zero tillage and 2 forms of mulching substance i.e. saw dust mulch and wheat straw mulch was used. Results indicated that zero tillage along with wheat straw mulch show maximum grain yield and thousand-grain weight followed by saw dust mulch with conventional tillage. It was suggested that mulching and tillage is vital practices to increase the crop yield and net return. Tolk *et al*. (1999) [53]. reported that mulch significantly improved grain yields up to 17% and 14% higher water use efficiency as compared with un-mulched soil. Availability of water to plant is also enhanced by mulches. They reported that this significant increase in water use efficiency resulted as additional soil water was consumed by crop rather that losses from vaporization. Yi *et al*. (2011) [59]. conducted an experiment and observed the impacts of irrigation and mulch procedures on crop growth and yield properties of spring maize. Four treatments of irrigation and mulching were used which included film mulching (FM), rain-fed (RF), Straw mulching (SM) and supplementary irrigation (SI). Results indicated that the seasonal trends under all treatments were similar in atmospheric and soil temperatures. It is also observed that from silking to physiological maturity the leaf area index (LAI), stem biomass, plant height and crop yield were significantly improved under the supplementary irrigation and straw mulching treatment.

3. Mulches and weed control

Organic mulches are frequently applied to surface of soil in order to conserve soil moisture, reduce weeds density and suppress plant diseases and moderate soil temperature (Hoitink & Boehm, 1999) [14]. Organic mulches minimize weeds by various means. Firstly, by interception of light they lump germination of seed, dropping soil temperature, and prominently diminishing day–night temperature variations. Resulting in germination of lesser seeds beneath mulch than on bare soil. Secondly, mulch hinders the development of those weeds physically that do germinate. If thickness of mulch is enough to avoid light from reaching the confined seedlings they die ultimately. Thirdly some mulch resources like fresh-cut forages and grain straw release natural substances that prevent growth of weed seedling for numerous week period after applying a practice called as allelopathy. Finally, organic mulch has ability to boost crop growth and competitiveness against weeds by soil moisture conservation and moderating soil temperature (Schonbeck, 2012) [45]. Wheat straw mulching has been reported to enhance yield in water limiting situations (Zaman & Choudhuri, 1995) [60]. Weeds are suppressed physically by spreading crop residues as mulch on soil surface (Teosdale *et al*., 1991) [51]. Hand weeding could be one of the most useful practices for weed control in maize. Plastic mulches may be useful weed control method in small maize fields in the areas where the cheaper and plenty of man power is not available (Muhammad *et al*., 2009) [28]. Mulching conserve the soil and water as well as efficiently control the weeds. Mulching reduces the degradation of soil by way of preventing the runoff and soil loss, decreasing the weed invasion and checks the water evaporation. Mulches improve physical, chemical and biological properties of soil and also help in retention of soil moisture and control of temperature fluctuations. Mulches enhance the growth and yield of crops by adding nutrients in soil (Patil *et al*., 2013) [35].

Organic mulches are generally applied to the soil surface to restrain weeds growth, conserve soil water content, moderate soil temperature and reduce plant diseases (Hoitink & Boehm, 1999) [14]. Yenish *et al*. (1996) [58]. reported that although cover crops can significantly suppress weeds but due to their variation these should be used in combination with other control measures. Rakha (1999) [38]. conducted a field experiment and reported that dry weight of all weeds recorded 55 days after sowing (DAS) was suppressed by 38.6% and 47.2%, respectively as compared to control when sorghum mulch was applied @ 10 and 15 t ha^{-1} and yield was also increased with the ratio of 7.2% and 12.8% over control respectively. According to Sangakkara *et al*. (2004) [42]. organic mulches increase yield and their incorporation in the soil had greater beneficial effects on measured parameters, except weed numbers, which were suppress significantly by straw mulch application. In a study, residues of rice, wheat, peas, chick peas and linseed were used as surface mulch and it is reported that they showed selective effect against germination of weeds and dry matter production. Rice residues suppress the density of *Echinochloa colonum* and broad-leaved weeds by 40 and 56 % and biomass production by 39 and 64%, respectively (Khan & Vaishya, 1992) [22]. Evaporation is the main source of soil moisture loss during a fallow period. Rice straw mulching significantly maintain the soil water content and decrease density of weeds (Rehman *et al*., 2005) [39]. Mulching increased maize grain yield as compared to the control (Tian *et al*., 1993) [52]. Jodaugiene *et al*. (2006) [19]. observed the efficiency of different organic mulches such as chopped wheat straw, peat, wood chips and grass on weed emergence. A layer of 5 cm and 10 cm thickness of mulches was spread on the surface of the plots. Results indicated that all organic mulches reduced weed germination. The positive effect of mulches was observed in the intensive period of weeds germination. Mahmood & Cheema (2004) [25]. conducted a field study to evaluate the allelopathic effect of sorghum mulch on purple nut-sedge. Chopped sorghum

mulch @ 5, 10 and 15 t ha^{-1} was either applied on the surface or incorporated into the soil. Results indicated that the suppression of purple nut sedge-density and dry mass dependent on the quantity and method of mulch application. Surface application of sorghum mulch @ 15 t ha^{-1} significantly reduced the purple nut-sedge density and dry mass by 45% and 53% respectively. Similarly, plastic mulch contributed in maintaining the soil temperature, plant height, early growth and yield of plants and provides effective weed control without any herbicide application (Mahajan *et al*., 2007) [24]. Application of crop residues as surface mulch can be helpful in suppressing weeds density and ultimately can reduce dependence on herbicides (Worsham, 1991; Weston, 1996) [56, 55]. Shah *et al*. (2014) [47]. conducted a field experiment to check the efficacy of various available mulches for suppressing weeds in maize crop. They recorded minimum number of weeds and maximum grain yield in black plastic mulch and weeds as mulch respectively as compared to weedy check (control). Khan *et al*. (2011) [22]. conducted a field experiment to investigate the effectiveness of various weeds control measures in maize crop. Maximum grain yield was recorded in Primextra Gold 720SC, polyethylene (black), hand weeding and polyethylene (white) and minimum grain yield was recorded in the weedy check plots.

4. Effect of mulch on physical and chemical properties of soil

Jordan *et al*. (2010) [20]. evaluated the impact of wheat straw mulch on soil physical properties. Results showed that application of mulch reduced the rate of runoff under semi-arid climatic conditions and significantly improved soil physical and chemical properties than control. Change in soil properties depend on mulch rate. Orenes *et al*. (2009) [33]. observed that straw mulch considerably improved soil properties. The soil water content and crop yield benefits can be derived by using mulch cover in the crop rotation. In the semi-arid regions mulching may be a suitable agronomic technique for conserving soil and water and controlling soil temperature regime (Chakraborty *et al*., 2008) [8]. Mulching had a positive effect on temperature regime and soil water content. Organic and in-organic mulches can provide a number of benefits such as weed suppression, retain soil moisture, enhance water infiltration rate, moderate soil temperature, improve water holding capacity, soil porosity, organic matter concentration, cation exchange capacity and reduced diseases. The biological properties of the soil improved by mulching and increased soil water contents (Khurshid *et al*., 2006) [23]. The use of organic waste materials like plant residues, animal dung and sawdust mulch improve the physiochemical properties of the soil and reduce environmental pollution (Nottidge *et al*., 2005) [30]. Ghuman & Sur (2001) [12]. studied the impact of mulching on soil properties and yields of rain fed maize and wheat in a sub-humid sub-tropical climate and reported that mulching reduces bulk density in compacted soils especially in zero tillage system that can resulted in improving soil carbon content and biotic activity. It was reported that mulching reduces the bulk density and improves soil porosity in better way than other ground cover management practices. Oliveira & Merwin (2001) [32]. checked that residual mulching is used to improve organic matter content and soil fertility and reduce soil particle detachment and transferring rate. This practice on ridges improves infiltration rate, water storage ability, crop yield and stability (Ogban *et al*., 2001) [31]. Mulching is one of the techniques used to improve rooting and contribute in increasing the size of the maize grain and yield. This method significantly increases the N uptake by the plant and reduces leaching of the nitrogen. It also showed positive effects on nutrient retention as compared to the un-mulched plots (Aulakh *et al*., 2000) [3].

Asawalam *et al*. (2003) [2] conducted a field research to study the effect of mulches of multipurpose trees on soil properties as well as production of maize. It was found that there was a significant increase in grain yield of maize over the control. Khurshid *et al*. (2006) [23] also examined the effect of mulches on soil physical properties and yield of maize. Treatments include four mulch levels and two application methods. Results indicated that mulches cause significant effect on soil physical properties and yield of maize. Plant parameters including plant height, 1000 grain weight and biological yield were highest when mulch was applied at the @ 12 t ha^{-1}. Mulch application also enhanced the soil moisture and organic matter contents. Mulch @ 8 t ha^{-1} improved soil bulk density and grain yield. Mulumba *et al*. (2008) [29] evaluated the effects of mulching on the soil physical properties of a silty loam soil. Treatments included mulch application @ of 0, 2, 4, 8 and 16 t ha^{-1} per year without crop cultivation. The results showed that mulching rates significantly improved the total porosity, soil moisture retention at low level of suction and available water capacity. It was noted that bulk density of soil was not affected by mulching rate.

Gul *et al*. (2009) [13] evaluated the result of mulching and plant population on biological yield of maize. Data was recorded for the following growth and yield parameters; leaf area of maize per plant (cm^2), fresh weed biomass (kg ha^{-1}), biological yield (kg ha^{-1}) and also leaf area index. Results showed that the crop density and biological yield are co-related. Maximum yield of 9117 kg ha^{-1} was reported in the hand weeding plots as compared to black plastic mulch (8983 kg ha^{-1}) and weedy check (control) (5538 kg ha^{-1}). Yield was not improved by using weeds as mulch (7955 kg ha^{-1}), white plastic (7933 kg ha^{-1}) and living mulch (7541 kg ha^{-1}). Based on two years study it was concluded that it must be supplemented and integrated with other control measures like mulches, hand weeding and herbicides.

5. Mulches and soil water conservation

Xie *et al*. (2005) [57]. evaluated that use of plastic mulching for saving of water is useful practice in many crops. The effect of plastic mulching on soil water conversation in spring maize was recorded in arid region. There was increase of 0.9-30.8 % in evapotranspiration and 4.0-110.3 % in yield for all plastic mulched weed control measures over non-mulched. The water saving with plastic mulch was 2-61% higher than non-mulch and the variation increased with the decreasing soil water content. Finally results showed that under low soil water content, spring maize with plastic mulch maintained high water use efficiency and more profits than non-mulched.

Chakraborty *et al*. (2010) [7]. reported that mulching had a positive effect on duration of growing period, total no of tillers, no of spikelet and no of tillers per spike. It was observed that application of organic mulches showed significant improvement in water use efficiency and nitrogen use efficiency in wheat crop. Bhatt & Khera (2006) [5]. reported that rice straw mulch has the ability to improve

soil moisture retention and grain yield of maize. Jalota & Prihar (1990) [18]. reported that surface application of mulching is an efficient method for controlling runoff and increasing infiltration rate and it nearly removed or significantly reduced runoff as compared with those fallow soils depending on intensity of rainfall or rate of water application. Soil surface mulching with crop residues collectively reduce runoff as well as direct evaporation from wet soil surface and ultimately increase water availability. Borresen & Njos (1990) [6]. found that application of straw mulch on the soil surface reduced temperature and improve both germination and development of spring-sown crops. Parker & Jenny (1995) [34]. conducted an experiment and reported that mulch plays a key role in water conservation as it maintains soil porosity by reducing rain drop effect and ensure continuity of soil pores and ultimately enhance water infiltration and soil hydraulic conductivity. Rate of water infiltration is directly proportional with the quality of mulch applied in the form of manure or cover crops. Shangning & Unger (2001) [48]. concluded the result from study that mulching has the ability to enhance storage efficiency from small amount of precipitation. They studied the effects of straw mulch rate and potential evaporation on water accumulation. Results indicated that mulching application at the rate of 2.0 and 4.0 tonnes ha^{-1} improved storage efficiency of soils.

6. Effect of mulches on soil organic carbon

The soil cover of Earth's is one of the major reservoirs of organic carbon in the biosphere. In accordance with long term international strategies. It is necessary that agricultural land management policies contain detailed information about soil C status, C-sequestration and storage in soils and its potential effects on global climate change. (Smith *et al*., 1997) [50]. For the assessment of Co_2 emission to atmosphere its impact on climate change, it is essential to estimate the global reserves of organic carbon in soils. The actual content of SOC must be periodically measured for soil classification and nutrient management purpose (Abakumov & Popov, 2005) [1]. Soil organic carbon is essential component of soil which affects the soil physical, chemical and biological properties (Chan, 2001) [9]. There are various sources of mulch materials used as organic manures like, Farm yard manure, peat moss or plant fertilizer, Green wastes, Wheat straw, plastic mulching, Biogas Slurry, sugar cane baggas and poultry manure. All these mulches are used as manure in Pakistan among all these we have used the Peat moss, Farmyard manure and green waste as they give the best yields among other material due to their high organic carbon contents. The condition in which these manures may gather it will be an initial place to build SOC and significant improvement in the yield of maize can be achieved by fulfilling soil needs of carbon. Use of farmyard manure in soil improve structure of soil, increase infiltration rate, WHC, increases SOC and reduce bulk density (Edmeades, 2003) [11]. Sharma *et al*. (2000) [49]. observed the effect of integrated mulching and tillage practice with four combinations in maize. Fresh biomass of lantana (*Lantana camara* L.) was applied as mulch in standing crop. Results showed that mulching had significantly improved maize yield and organic carbon content of soil. The results indicated that plots have higher organic carbon contents where mulch was applied as compared to un-mulched plots. Sorghum can be used as cover crop to build the SOC as well as reduce soil erosion. Green waste is additionally utilized as mulch for enhancing the soil organic matter contents. It is another essential modification in the form of mulch material. In Pakistan the extensive part of these crops is utilized in grub form and as fuel making. If we used the organic and inorganic manure in combine way it improves yield and finally enhance status of soil fertility (Jadoon *et al*., 2003) [17]. Khan *et al*. (2007) [22]. reported that impact of CO_2 may be reduced to significant rate by Sequestering carbon (C) in agricultural soils and plant material. It is feasible only when biomass is produced in huge amount during a given time period. Organic fertilizer is another choice to decrease CO_2 by addition of C in soil. Results indicated that application of mulch improved C sequestration, aggregated stability, reduce compaction and surface crusting and enhance infiltration rate and water preservation of soil. Saroa & Lal (2003) [44]. observed that crop residue mulches increase soil organic carbon contents.

7. Conclusions

It is concluded that mulches help to suppress weeds and improve soil stability and avoid insect pest physical attack. Furthermore, application of mulches reduce the rate of evaporation and improves the physiochemical properties of soil.

8. References

1. Abakumov EV, Popov AI. Determination of carbon and nitrogen contents and oxidizability of organic matter and the carbon of the carbonates content in one soil sample. Eurasian J. Soil Sci 2005; 38(2):165-172.
2. Asawalam DO, Enwezor WO, Agbim NN. Mulching effect of Ductylcidenicibarteri (Hook. F. Exoliv.), Leucaena leucocephala (Lam.) De Wit. Gliricidia sepium (Jacq.) and Senna siamea (Lam.) leaves on soil temperature, moisture regime and yield of maize. Niger. Agric. J. 2003; 34:36-43.
3. Aulakh SM, Khera TS, Doran JW, Singh K, Singh B. Yield and nitrogen dynamics in a rice wheat system using green manure and inorganic fertilizer. Soil. Sci. Soc. Am. J. 2000; 64:1867-1876.
4. Awal MA, Khan MAH. Alteration of soil temperature and moisture through mulching on the morpho-physiological differentiation in maize. Pak. J. Biol. Sci. 1999; 2(4):1164-1167.
5. Bhatt R, Khera KL. Effect of tillage and mode of straw mulch application on soil erosion in the submontaneous tract of Punjab, India. Soil Tillage Res. 2006; 88:107-115.
6. Borresen T, Njos A. The effect of three tillage systems combined with different compaction and mulching treatments on soil temperature and soil thermal properties. J. Agric. Sci. 1990; 4:363-371.
7. Chakraborty D, Garg RN, Tomar RK, Singh R, Sharma SK, Singh RK, *et al*. Synthetic and organic mulching and nitrogen effect on winter wheat (Triticum aestivum L.) in a semi-arid environment. Agric. Water. Manag. 2010; 97:738-748.
8. Chakraborty D, Nagarajan S, Aggarwal P, Gupta VK, Tomar RK, Garg RN, *et al*. Effect of mulching on soil and plant water, and the growth and yield of wheat (*Triticum aestivum* L.) in a semi-arid environment. Agric. Water. Manag. 2008; 95:1323-1334.

9. Chan KY. Soil organic carbon and soil structure: Implications for the soil health of agrosystems. In: Soil Health. The foundation of Sustainable Agriculture, Workshop on the importance of soil health in agriculture, Ed. R.L., Wollongbar Agriculture Institute, Australia, 2001; 126-133.
10. Diaz F, Jimenez CC, Tejedor M. Influence of thickness and grain size of tephra mulch on soil water evaporation. Agric. Water. Manag. 2004; 74:47-55.
11. Edmeades DC. The long-term effects of manuresand fertilizers on soil productivity and quality. Nutr. Cycl. Agroecosys. 2003; 66:165-180.
12. Ghuman BS, Sur HS. Tillage and residue management effects on soil properties and yields of rainfed maize and wheat in a sub-humid tropical climate. Soil Tillage Res. 2001; 58:1-10.
13. Gul B, Marwat K, Hassan G, Khan A, Flashimand S, Khan LA. Impact of tillage, plant population and mulches on biological yield of maize. Pak. J. Bot. 2009; 41:2243-2249.
14. Hoitink HAJ, Boehm MJ. Biocontrol within the context of soil microbial communities: a sunstrate-dependent phenomenon. Annu. Rev. Phytopathol. 1999; 37:427-446.
15. Holland JM. The environmental consequences of adopting conservation tillage in Europe, Reviewing evidence. Agric. Ecosyst. Environ. 2004; 103:1-25.
16. Iftikhar F, Ali S. Impact of different types of mulches [wheat straw, paper mulch and sand mulch] on soil moisture. Sarhad J. Agric. 2004; 20(4):571-573.
17. Jadoon MA, Bhatti AU, Khan F, Sahibzada QA. Effect of farmyard manure in combination with NPK on the yield of maize and soil physical properties. Pak. J. Agr. Sci. 2003; 22:47-55.
18. Jalota SK, Prihar SS. Effect of straw mulch on evaporation reduction inrelation to rates of mulching and evaporativity. J. Indian Soc. Soil Sci. 1990; 38:728-730.
19. Jodaugiene D, Pupaliene R, Urboniene M, Pranckietis V, Pranckietiene I. The impact of different types of organic mulches on weed emergence. Agro. Res. 2006; 4:197-201.
20. Jordan A, Zavala LM, Gil J. Effects of mulching on soil physical properties and runoff under semi-arid conditions in southern Spain. Cat. 2010; 81:77-85.
21. Kabambe VH. Weed control opportunities in conservation agriculture among farmers in Malawi Conservation Farming for Sustainable Agriculture Workshop Proceedings, 2003, 21-27.
22. Khan AH, Vaishya RD. Allelopathic effects of different crop residues on germination and growth of weeds. Ind. Soc. All. 1992; 42(1):68-93.
23. Khurshid K, Iqbal M, Arif MS, Nawaz A. Effect of tillage and mulch on soil physical properties and growth of maize. Int. J. Agric. Biol. 2006; 8(5):593-596.
24. Mahajan G, Sharda R, Kumar A, Singh KG. Effect of plastic mulch on economizing irrigation water and weed control in baby corn sown by different methods. Afr. J. Agric. Res. 2007; 2:19-26.
25. Mahmood A, Cheema ZA. Influence of sorghum mulch on purple nutsedge. Int. J. Agric. Biol. 2006; 2004(102):86-88.
26. Matava M. The benefits of mulching Avocados. California Avocado society yearbook, 2009; 92:65-72.
27. McCown RL. Being realistic about no-tillage, ley farming for the Australian semi-arid tropics. Aust. J. Exp. Agr. 1996; 36:1069-1080.
28. Muhammad S, Khan ZU, Cheema TA. Distribution of Weeds in wheat, maize and potato fields of Tehsil Gojra, District Toba Tek Singh. Pak. J. Weed. Sci. Res. 2009; 15(1):91-105.
29. Mulumba LN, Lai R. Mulching effects on selected soil physical properties. Soi. Till. Res. 2008; 98:106-111.
30. Nottidge DO, Ojeniyi SO, Asawalam DO. Comparative effect of plant residues and NPK fertilizer on nutrient status and yield of maize (*Zea mays* L.) in humid Ultisol. Nige. J. Soi. Sci. 2005; 15:1-8.
31. Ogban PI, Ekanem TP, Etim EA. Effects of mulching methods on soil properties and growth and yield of maize in Southeastern Nigeria. Tropical Agriculture (Trinidad). 2001; 78(2):82-89.
32. Oliveira MT, Merwin IA. Soil physical conditions in a newyork orehard after eight years under different groundcover management systems. Plant Soil. 2001; 234:233-237.
33. Orenes-Gareia F, Cerda A, Mataix-Solera J, Guerrero C, Bodi M, Areenegui V, *et al*. Effects agricultural management on surface soil properties and soil water losses in eastern spain. Soil Till. Res. 2009; 106:117-123.
34. Parker ER, Jenny H. Water infiltration and related soil properties as affected by cultivation and organic fertilization. Soil Sci. 1995; 60:353-376.
35. Patil SS, Kelkar TS, Satish AB. Mulching: A Soil and Water Conservation Practice. Res. J. Agri. For. Sci. 2013; 1(3):26-29.
36. Purvis CE, Jessop RS, Lovett JV. Selective regulation of germination and growth of annual weeds by crop residues. Weeds Res. 1985; 25:415-421.
37. Qin J, Hua F, Zhang B, Wei Z. Li H. Role of straw mulching in non-continuously flooded rice cultivation. Agri. Wat. Man. 2006; 83:252-260.
38. Rakha A. Feasibility of using Sorgaab and Sorghum mulch for weed management in mungbean. M.Sc (Hons.) Thesis. Department of Agronomy, University of Agriculture, Faisalabad, 1999.
39. Rehman MA, Chikushia J, Saifizzamanb M. Auren JG. Rice straw mulching and irrigation response of no-till wheat following rice in Bangladesh. Field Crops Res. 2005; 91:71-81.
40. Robinson DW. Re-evaluating the role of herbicide in contemporary urban horticulture. International symposium on urban tree health, Paris France. 2009.
41. Salau OA, Oparanadi OA, Swennen R. Effect of mulching on soil properties, growth and yield of plantain on a tropical ultisole in south eastern Nigeria. Soil Till. Res. 1992; 23:73-93
42. Sangakkara UR, Pietsch G, Gollner M, Freyer B. Effect of incorporating rice straw or leaves of gliricidia (g. sepium) on the productivity of mungbean (vigna radiate L.) and on soil properties. J. Biol. Sci. 2004; 1(4):15-24.
43. Sarno I, Lumbanraja MJ, Sunyoto E, Yuliadi Y, Watanabe A. Soil chemical properties of an indonecian red acid soil as affected by land use and crop management. Soil Till. Res. 2004; 76:115-124.

44. Saroa GS, Lal R. Soil restorative effects of mulching on aggregation and carbon sequestration in a Miamian soil in Central Ohio. Land Degrad. Dev. 2003; 14:481-493.
45. Schonbeck DM. Organic Mulching Materials for Weed Management. Virgi. Ass. Biol. Farm. 2012; 2:1-14.
46. Seyfi K, Rashidi M. Effect of drip irrigation and plastic mulch on crop yield and yield components of cantaloupe. Int. J. Agric. Biol. 2007; 9(2):247-249.
47. Shah FU, Sajid GM, Siddiqui SU. Evaluation of mulching materials as integrated weed management component in maize crop. Pak. J. Agric. 2014; 27(2):118-128.
48. Shangning J, Unger PW. Soil water accumulation under different precipitation, potential evaporation and straw mulch conditions. Soil Sci. Soc. Am. J. 2001; 65:442-448.
49. Sharma PK, Acharya CL. Carryover of residual soil moisture with mulching and conservation tillage practices for sowing of rainfed wheat (*Triticum aestivum* L.) in north-west India. Soil Till. Res. 2000; 57:43-52.
50. Smith P, Powlson DS, Glendining MJ, Smith JU. Potential for carbon sequestration in European soil: preliminary estimates for five scenarios using results from long-term experiments. Glob. Chang. Biol. 1997; 3:67-79.
51. Teosdale JR, Beste CE, Potts WE. Response of weed to tillage and cover crop residues. Weed Sci. 1991; 39:195-199.
52. Tian G, Kang BT, Brussaard L. Mulching effect of plant residues with chemically contrasting compositions on maize growth and nutrients accumulation. *Plant and Soil. 1993; 153:*179-187.
53. Tolk JA, Howell TA, Evett SR. Effect of mulch, irrigation and soil type on water use and yield of maize. Soil Till. Res. 1999; 50:137-147.
54. Weston LA. Utilization of allelopathy for weed management in agro-ecosystems. Agronomy Journal. 1996; 88:860-866.
55. Worsham AD. Allelopathic cover crops to reduce herbicide inputs. South. Weed Sci. Soc. 1991; 44:58-69.
56. Xie Z, Wang Y, Wei X, Zhang Z. Impact of gravel-sand mulch and supplemental drip irrigation on watermelon (Citrullus lanatus [Thunb.] Mats. & Nakai) root distribution and yield. Soil Till. Res. 2005; 89:35-44.
57. Yang YM, Jing, LX, Qiang LW, Zhen LC. Effect of different mulch materials on winter wheat production in desalinized soil in Heiloggang region of North China. J. Zhejiang Univ. Sci. 2006; 7(11):858-867.
58. Yenish JP, Worsham AD, York AC. Cover crops for herbicide replacement in no-tillage corn (*Zea mays* L.) Weed Techn. 1996; 10:815-821.
59. Yi L, Yufang S, Shenjiao Y, Shiqing L, Fang C. Effect of mulch and irrigation practices on soil water, soil temperature and the grain yield of maize (*Zea mays* L) in Loess Plateau. *China.* Afr. J. Agric. Res. 2011; 6:2175-2182.
60. Zaman A, Choudhuri SK. Water use and yield of wheat under un-mulched and mulched conditions in laterite soil of the Indian subcontinent. J Agron Crop Sci. 1995; 175:349-353.
61. Zamir MSI, Javeed HMR, Ahmed W, Ahmed AUH, Sarwar N, Shehzad M, *et al*. Effect of tillage and organic mulches on growth, yield and quality of autumn planted maize (*zea mays* L.) and soil physical properties. Cercetări Agronomice în Moldova. 2013; 2(154):17-26.