Biosc.Biotech.Res.Comm. Special Issue Vol 13 No 12 (2020) Pp-178-184

BBRC
Bioscience Biotechnology Research Communications

Impact of Mulching in Improving Soil Properties and Crop Performance- An Introspect

Lalichetti Sagar[1]*, Sultan Singh[2] and Lalichetti Sindhu[3]

*[1]*Assistant Professor, Department of Agronomy, M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Odisha, India*

[2]MSc Agronomy, Division of Agronomy, Sher-e-Kashmir University of Technology and Management, Jammu, India

[3]PG Scholar, to the Department of Agronomy Science, M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Odisha, India

ABSTRACT

The Green revolution is responsible for paradigm shift in Agriculture in the World ensuring food security. This led to heavy use of synthetic inputs to fulfil the demand of high yielding fertilizer responsive crops which over a long run questioned sustainability of the Agricultural system. Recently, resource conservation technology is gaining popularity due to its potential to manage ill effects of green revolution thereby minimizing the threat to the environment. Among several RCT's mulching is one such practice that is efficient, cheap and easily adoptable. Mulching is a practice of covering the soil with organic or inorganic loose materials. In general, it acts as a barrier to entry of light and suppresses the weed growth. Moreover, this also minimizes the exchange of energy resulting in a significant role in moisture retention and conservation. This impact on soil properties has found to have a significant impact on growth, yield, and quality of many crops under field conditions. However, growth, yield and quality of any crop majorly depends on micro-climate of the crop and significant influence of mulching in microclimatic modification widened the scope of mulching favouring new integrations towards profitable crop production.

KEY WORDS: MULCHING, RCT, SOIL PROPERTIES, GROWTH, YIELD, MICRO-ORGANISMS

INTRODUCTION

Globally, rapid increase in population raised the demand for food. Although the green revolution enhanced production during the initial years, due to unprecedented use of external inputs resulted in poisoning the soil in due course (Singh, 2011). To overcome these negative impacts of the green revolution and to sustain food production to meet the demand of expanding population, inclusion of resource conserving technologies in farming can be viewed as a promising alternative (Pingali, 2012). Among the various resource conserving technologies mulching was found to be a cheap and popular alternative (Hussain et al., 2015).

Mulching is a process of covering the soil surface with certain loose materials either organic or inorganic in nature derived from a german word "Molsch" means "easy to decay" which usually focuses on improving infiltration, minimized fertilizer leaching, restricted weed infestation and thereby resulting in profitable crop production (Chakraborty et al., 2008 ; Aragues et al., 2004). The materials that are used for mulching are called mulches. Keeping the above facts in view, to identify the ultimate potentiality of mulching on Agro-ecosystems through over-viewing the past investigations to help the

ARTICLE INFORMATION

*Corresponding Author: lalichetti.sagar@cutm.ac.in
Received 19th Oct 2020 Accepted after revision 29th Dec 2020
Print ISSN: 0974-6455 Online ISSN: 2321-4007 CODEN: BBRCBA

Thomson Reuters ISI Web of Science Clarivate Analytics USA and Crossref Indexed Journal

Clarivate Analytics

crossref

NAAS Journal Score 2020 (4.31)

Online Contents Available at: http//www.bbrc.in/

researchers understand the pros and cons of mulching this comprehensive review entitled "Impact of mulching in improving soil properties and crop performance- An Introspect" has been initiated.

Types of Mulches

Organic mulching: Organic mulching is the process of using easily decomposable organic materials viz. straw, dry clips, husks, paper, animal wastes, cover crops, etc. for mulching (Kumar et al., 2014 ; Kwambe et al., 2015). Besides soil and water conservation; organic mulches also add up organic matter and some nutrients due to its decomposable nature (Gurjar et al., 2019). Organic mulches can be classified into two types, living (eg: Smothering crops) and non-living (eg: Straw) organic mulches. Increased food grain production subsequently increased the availability of straw besides ensuring food security (Thakur et al., 2018). Deploying straw as a mulching material rather than burning ensued restoration of degraded soils (Jain et al., 2014 ; Singh et al., 2018) due to its role in reducing absorption and transfer of energy within the soil. Consequently, this role is attributed to lower evapotranspiration losses, natural resource conservation, and ultimately in improving crop production (Sharma et al., 2019 ; Raghavendra et al., 2017). Besides, the biodegradable nature of this mulching material contributes towards improving soil fertility (Castillo et al., 2012).

Inorganic Mulching: Inorganic mulching is a process of using slowly decomposable or completely decomposition resistant material such as rocks, gravels, plastic material etc as mulching material (Patil et al., 2013). Although, due to its no decomposition nature of the mulching material used inorganic mulches are unable to add nutrients to the soil but still due to efficient weed suppression character helps in overcoming this deficit (Singh et al., 2018 ; Gerasimova and Yordanova 2015). Commercially, these mulches are of great utility for profitable crop production (Rao et al., 2016). Among different inorganic mulching materials polyethylene based materials are of great use through these mulching materials reduces the evapo-transpiration losses and further helps in weed control (Verma et al., 2017). Further, black plastic mulch is more efficient in controlling weeds due to complete prevention of light entering the soil (Vetter et al., 2017). Similarly, Black coloured polythene increases the soil temperature while white coloured reflects the radiation thereby help in cooling the soil temperature (Laulina and Hasan 2018) and at the same time continuous poly sheet is considered to be more efficient than using pieces of poly mulching materials (Anzalone et al., 2014).

Effect of Mulching on soil properties

Soil organic matter: Soil organic matter was significantly influenced by mulching which in turn resulting in improvement of soil physical, chemical and biological properties upon decomposition (Ampofo 2018 ; Kumar et al., 2015). High organic matter content in the organic mulches attributes to the improvement of soil organic matter upon application while inorganic mulches consists of very low percentage of organic matter but accelerates organic matter decomposition resulting in soil moisture conservation and enhancing microbial gro (Hossen et al., 2017 ; Aragues et al., 2014) Besides, organic mulches act as a nutrient reserve to the soil which upon mineralization adds up to the soil fertility in turn resulting in higher crop yields (Fang et al., 2011). However, rise in temperature due to mulching leads to loss of carbon stocks in the soil under plastic mulching (Swiatkiewicz and Siwek 2018); while under organic mulching this loss of organic matter is moreover balanced by crop residual input (Chowdhury et al., 2015). This clearly highlights its role in improving phyco-chemical and biological properties of the soil upon decomposition resulting in loose, friable and easily malleable soil favouring easy root penetration.

Soil Temperature: The mulches play a significant role in regulating the soil temperature (Donk et al., 2011). Usually, the change in soil temperature depends on duration and intensity of direct exposure of soil surface to solar radiation and exchange of heat between the soil and atmosphere (Pramanik et al., 2015 ; Tongchuan et al., 2017). However, the role of mulches in microclimatic modification is mainly attributed due to its improved insulation from direct solar radiation and increased albedo (Stigter et al., 2018 ; Yi et al., 2011). Depending on the potential of mulching materials in reflecting and transmission of solar radiation determines its efficiency in soil thermal regulation (Haapala et al., 2018). The reflectivity of a mulching material depends on the color of the mulching material (Yordanov and Nikolov 2017) such that dark coloured mulches absorb much of the radiation and keep the underlying soil warm during winters while cool during summer (Mahadeen 2014). Similarly, Aktan et al. 2018 observed that mulching with rice straw efficiently helps to mitigate high temperature losses during grain filling. Mulching regulates soil temperature such that minimizes in summer and rises in winter. 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.

Soil Moisture: The shortage of water resources and undependable rainfall patterns have stressed on adoption of water-saving technology for successful crop production (Patle et al., 2019). In this context, mulching is widely acknowledged as an efficient water-saving option due to its role in protecting the soil from direct exposure to sunlight which reduces surface evapo-transpiration owing to the maintenance of plant water status besides influencing temperature regulation and soil water conservation (Tongchuan et al., 2017 ; Sharma and Bhardwaj 2017). In general, mulched soils store more soil moisture than bare soils (Taparauskiene and Miseckaite 2014) and the amount of moisture conserved varies with the type and thickness of mulching (Dalorima et al., 2014). On the other hand, the role of mulching in minimizing evaporation losses was widely attributed due to checking the flow of energy between the soil and the atmosphere (Biswas et al., 2015 ; Vashisht et al., 2013).

Consequently, retains soil moisture for the growth of plants attributing to the rise in transpiration leading towards maintenance of high plant water status and cooler canopy (Hamerlynck et al., 2011 ; Yu et al., 2015). In an experiment comparing the efficiency of different mulching materials on wheat showed that performance of rice husk mulch to be significantly superior than plastic mulch in terms of water saving potential under sub-tropical soils (Li et al., 2013 ; Inusah et al., 2013). Furthermore, mulching checks surface runoff by retaining the rainwater for a longer period of time thus enhancing the rate of infiltration (Montenegro et al., 2013).

Soil Micro-organisms: In an Agro-ecosystem, soil microbial diversity plays an important role in nutrient cycling and in imparting soil structural stability (Bach et al., 2018). Influence of mulching on physio-chemical properties of soil is significant with the organic mulching practices. In general, soil microbial communities determine the sustainability of soil ecosystems (Manna et al., 2017 ; Ni et al., 2016). Organic mulches being the rich sources of carbon satisfies the dietary requirement of microbes and thus stimulates its growth attributing to rapid multiplication and break down of organic matter resulting in release of essential plant nutrients in available forms through mineralization, enriching the soil quality (Mehraj et al., 2016). On the other hand, cumulative influence of moisture conservation and thermo regulatory impact of mulching further help in providing a conducive environment for microbial development in the soil (Song et al., 2018). Moreover, enhanced microbial development plays an important role in biological nitrogen fixation and on soil reaction owing to increased soil nutrient status upon decomposition (Hamza et al., 2017). However, plastic mulches cannot get decomposed but facilitates rapid decomposition by promoting microbial activity due to its role in raising the soil temperature (Kasirajan and Ngouajio 2012).

Effect of Mulching on Plants

Growth and development: In general, mulching provides a most favourable environment for the growth and development of different crops. Mulching results in more uniform and vigorous growth of the crop owing to improved competitive ability (Das et al., 2018 ; Pramanik et al., 2015). This might be due to its direct influence on efficient suppression of weed population which would otherwise compete for inputs, space and light with crops in turn resulting in poor growth and dry matter distribution Besides this direct role of mulching on other favourable conditions like its in moisture conservation and erosion control further paces up the process of growth. Moisture conservation and erosion control effect of mulching is of prime importance in Agriculture (Ramesh et al., 2017 ; Vashish et al., 2013). Balance of temperature is very essential for the plant development and yield improvement thus due to the positive role in temperature modification, evaporation control etc (Raza et al., 2019). All these factors cumulatively influence the growth of the crops under field conditions.

Grain Yield: Yield of the crop in arid and semi arid areas is usually influenced by limited availability of moisture and nutrients in the soil. In this context, mulching is one of the most popular resource conserving technologies which upon application improves soil water content in the soil (Bana et al., 2016 ; Patil et al., 2013). At the same time mulching also plays an important role in enhancing transpiration rate due to reduced evaporation which in turn attribute to efficient translocation of water and nutrients (Lordan et al., 2015). Further, it also establishes better source-sink relationship and involves improved translocation of photosynthates owing to increased grain filling contributing to higher grain yield (Ali et al., 2010). At same time boosting of grain yield is also indirectly influenced by increased nutrient use efficiency augmented due to reduced leaching of fertilizers (Ghosh et al., 2019).

Quality: Mulching involves covering of the surface with a material either crop residues or plastic mulches. This practice involves varied implications such that mulch materials act as a barrier on soil restricting the leaching of nutrients into the soil ascribing to higher nutrient use efficiency (Mehmood et al., 2015). Adequate nutrient and moisture availability for a sustained period of time provides favourable conditions for growth and yield of crop (Tapiwa 2019). Besides, this enhanced availability also helps in expecting the higher quality product from the same (Alex and Thomas 2011). Mulching materials prevents soil poisoning due to minimization in the application of synthetic herbicides and at the same time they also act as a barrier to these synthetic inputs to reach the soil (Vox et al., 2013). These implications clearly mark the significant role of mulching on the quality of the agricultural produce. In certain cases especially in short statured vegetables or fruits it prevents the fruits or vegetables from contacting the soil thus avoiding rotting and cracking of fruits (Lalitha et al., 2010 ; Ayyogari et al., 2014).

Weed management: Influence of mulching in suppressing weed establishment plays an important role in providing a favourable and less competitive environment to the crop (Matkovic et al., 2015). Several mulching materials like straw, green litter material, bark slices etc usually act as an effective weed suppressors (Li et al., 2013). These mulching materials act as a barrier and prevent the entry of light (red light) thereby inactivating phytochrome system of the seed resulting in poor germination and establishment of weed seedlings (Altland et al., 2016). Mulching materials like saw dust acts more efficiently in soil improvement, moisture conservation and reducing weed growth substantially (Kumar and Dey 2011 ; Ewere et al., 2017) while black polythene mulches effectively control weed growth than white and transparent polythene, comparatively. This might be due to the opacity of the black polythene and its ability to check the entry of light through it.

CONCLUSION

In the present scenario, adopting the mulching as a resource conserving technology is has been identified

to have great potential address vagaries in farming especially through viewing its impact on different soil properties and its subsequent influence on crop growth and development clearly seems to have an extended scope in rainfed ecosystem thus identified as a silver lining for sustainable crop production ensuring food security.

REFERENCES

Akter S Sarker UK Hasan AK Uddin MR Hoque MMI and Mahapatra CK (2018) Effects of mulching on growth and yield components of selected varieties of wheat (*Triticum aestivum* L.) under field condition. Archives of Agriculture and Environmental Science. Vol 3 No1 25-35.

Alex D and Thomas S (2011) Impact of product quality, service quality and contextual experience on customer perceived value and future buying intentions. European Journal of Business and Management. Vol 3 No 2 Pages 307-215.

Ali MA Hussain M Khan MI Ali Z Zulkifal M Anwar J Sabir W and Zeeshan M (2010) Source-sink relationship between photosynthetic organs and grain yield attributes during grain filling stage in spring wheat (*Triticum aestivum*). International Journal of Agriculture and Biology. Vol 12 No 3 Pages 509-515.

Altland JE Boldt JK and Krause CC (2016) Rice hull mulch affects germination of bittercress and creeping woodsorrel in container plant culture. American Journal of Plant Sciences. Vol 7 No 16 Pages 2359-2375.

Ampofo EA (2018) Influence of organic mulches on soil physico-chemical properties and maize (Zea Mays L.) crop performance. Journal of Agricultural Studies. Vol 6 No 2 Pages 1.

Anzalone A Cirujeda A Aibar J Pardo G and Zaragoza C (2014) Effect of biodegradable mulch materials on weed control in processing tomatoes. Weed Technology. Vol 24 Pages 369–377.

Aragues A Medina ET and Claveria I (2014) Effectiveness of inorganic and organic mulching for soil salinity and sodicity control in a grapevine orchard drip-irrigated with moderately saline waters. Spanish Journal of Agricultural Research. Vol 12 No 2 Pages 501-508.

Aragues R Medina ET and Claveria I (2014) Effectiveness of inorganic and organic mulching for soil salinity and sodicity control in a grapevine orchard drip-irrigated with moderately saline waters. Spanish Journal of Agricultural Research. Vol 12 No 2 Pages 501-508.

Ayyogari K Sidhya P and Pandit MK (2014) Impact of climate change on vegetable cultivation - a review. International Journal of Agriculture Environment and Biotechnology. Vo 7 No 1 Pages 145.

Bach EM Williams RJ Hargreaves SK Yang F and Hofmockel KS (2018) Greatest soil microbial diversity found in micro-habitats. Soil Biology and Biochemistry. Vol 118 Pages 217-222.

Bana RS Pooniya V Choudhary AK Rana KS and Tyagi VK (2016) Influence of organic nutrient sources and moisture management on productivity, bio-fortification and soil health in pearl millet (Pennisetum glaucum)+clusterbean (*Cyamopsis tetragonaloba*) intercropping system of semi-arid India. Indian Journal of Agricultural Sciences. Vol 86 No 11 Pages 1418–25.

Biswas S.K Akanda AR Rahman MS and Hossain MA (2015) Effect of drip irrigation and mulching on yield, water-use efficiency and economics of tomato. Plant Soil and Environment. Vol 61 No 3 Pages 97-102.

Castillo MB Mamaril CP Paterno ES Sanchez PB Badayos RB and Cruz PCS (2012) Soil chemical and physical properties with rice straw management during fallow period. Philippine Journal of Crop Science. Vol 37 No 1 Pages 15-26.

Chakraborty D Agarajan S Aggarwal P Gupta VK Tomar RK Garg RN Sahoo RN Sarkar A Chopra UK Sarma KSS and Kalra N (2008) Effect of mulching on soil and plant water status, and the growth and yield of wheat (*Triticum aestivum* L.) in a semi-arid environment. Agricultural Water Management. Vol 95 Pages1323-1334.

Chowdhury S Farrell M Butler G and Bolan N (2015) Assessing the effect of crop residue removal on soil organic carbon storage and microbial activity in a no-till cropping system. Soil Use and Management. Vol 31 No 4 Pages 1-11.

Dalorima LT Bunu A Kyari Z and Mohammed T (2014) Effects of different mulching materials on the growth performance of okra in Maiduguri. International Research Journal of Agricultural Science and Soil Science. Vol 4 No 8 Pages 145-149.

Das H Kundu CK Bandyopadhyay PK Bandyopadhyay S and Bandyopadhyay P (2018) Effect of mulching practices on growth and yield of forage crops under rainfed ecosystem. Journal of Applied and Natural Science. Vo 10 No 1 Pages 266-271.

Donk SJ Lindgren DT Schaaf DM Petersen JM Tarkalson DD (2011) Wood chip mulch thickness effects on soil water, soil temperature, weed growth and landscape plant growth. Journal of Applied Horticulture. Vol 13 No 2 Pages 91-95.

Ewere CO Iseghohi IO and Gold EJ (2017) Effects of different mulch materials on soil properties, weed control, growth and yield of pineapple in Akure, Nigeria. Journal of Agriculture and Human Ecology. Vol 1 No 2 Pages 62-74.

Fang S Xie B Liu D and Liu J (2011) Effects of mulching materials on nitrogen mineralization, nitrogen availability and poplar growth on degraded agricultural soil. New Forests. Vol 41 Pages 147-162.

Gerasimova N and Yordanova M (2015) Effect of mulching on weed infestation and yields of leek (Allium Porrum L.). Agriculture for Life, Life for Agriculture Volume: Series B. Horticulture, Vol. LIX.

Ghosh D Mandal M Das S and Pattanayak SK (2019) Effect of integrated nutrient management on yield

attributing characters and productivity of maize in acid Inceptisols. Journal of Pharmacognosy and Phytochemistry. Vol 8 No 6 Pages 2069-2074.

Gurjar GN Ram V and Swami S (2019) Effect of organic mulches and planting date on soil chemo-biological properties and economics of rice-potato system in Meghalaya: a review. International Journal of Chemical Studies. Vol 7 No 2 Pages 779-783.

Haapala T Palonen P Tamminen A and Ahokas J (2015) Effects of different paper mulches on soil temperature and yield of cucumber (*Cucumis sativus* L.) in the temperate zone. Agricultural and Food Science. Vol 24 No 1 Pages 52-58.

Hamerlynck EP Scott RS Moran MS Schwander AM Connor E and Huxman TE (2011) Inter- and under-canopy soil water, leaf-level and whole-plant gas exchange dynamics of a semi-arid perennial C4 grass. Oecologia. Vol 165 No 1 Pages 17-29.

Hamza TA Hussein Z Mitku R Ayalew P and Belayneh T (2017) Isolation and characterization of nitrogen fixing bacteria from rhizosphere soil collected from shell mele agricultural center, Southern Ethiopia. Journal of Agricultural Science and Food Technology. Vol 3 No 7 Pages 117-124.

Hossen S Shaikh M and Ali MA (2017) Effect of different organic and inorganic mulches on soil properties and performance of brinjal (*Solanum melongena* L.). Asian Journal of Advances in Agricultural Research. Vol 3 No 2 Pages 1-7.

Hussain S Iqbal M Iqbal M Aziz O Murtaza G Iqbal S Mehmood S and Rasool T (2015) Effect of different irrigation practices and plastic mulch on water use efficiency, growth and yield of spring maize. Basic Research Journal of Agricultural Science and Review. Vol 4 No 11.

Inusah BIY Wiredu AM Yirzagla J Mawunya M and Haruna M (2013) Effects of different mulches on the yield and productivity of drip irrigated onions under tropical conditions. International Journal of Advance Agricultural Research. Pages 133-140.

Jain N Bhatia A and Pathak H (2014) Emission of air pollutants from crop Residue burning in India. Aerosol and Air Quality Research. Vol 14 Pages 422-430.

Kasirajan S and Ngouajio M (2012) Polyethylene and biodegradable mulches for agricultural applications: a review. Agronomy for Sustainable Development. Vol 32 No 2 Pages 501-529.

Kumar R Sooda S Sharma S Kasanab RC Pathania VL Singh B and Singh RD (2014) Effect of plant spacing and organic mulch on growth, yield and quality of natural sweetener plant Stevia and soil fertility in western Himalayas. International Journal of Plant Production. Vol 8 No 3 Pages 311-334.

Kumar S and Dey P (2011) Effects of different mulches and irrigation methods on root growth, nutrient uptake, water-use efficiency and yield of strawberry. Scientia Horticulturae. Vol 127 No 3 Pages 318-324.

Kumar V Naresh RK Dwivedi A Kumar A Sahi UP Singh SP Kumar R and Singh V (2015) Tillage and mulching effects on soil properties, yield and water productivity of wheat under various irrigation schedules in subtropical climatic conditions. Journal of Pure and Applied Microbiology. Vol 9 No 2 Pages 217-228.

Kwambe KM Masarirambi MT Wahome PK and Oseni TO (2015) Effect of different organic and inorganic mulches on soil properties and performance of brinjal (*Solanum melongena* L.). Agriculture and Biology Journal of North America. Vol 6 No 3 Pages 81-89.

Lalitha M Thilagam VK Balakrishnan N and Mansour M (2010) Effect of plastic mulch on soil properties and crop growth - a review. Agricultural Research Communication Centre. Vol 31 No 2 Pages 145-149.

Laulina L and Hasan M (2018) Soil temperature variation for different plastic mulches for capsicum crop under greenhouse condition. International Journal of Chemical Studies. Vol 6 No 5 Pages 3339-3342.

Li SX Wang ZH Li SQ Gao YJ and Tian XH (2013) Effect of plastic sheet mulch, wheat straw mulch, and maize growth on water loss by evaporation in dry-land areas of China. Agricultural Water Management. Vol 116 Pages 39-49.

Lordan J Pascual M Villar JM Fonseca F Papio J Montilla V and Rufat J (2015) Use of organic mulch to enhance water-use efficiency and peach production under limiting soil conditions in a three-year-old orchard. Spanish Journal of Agricultural Research. Vol 13 No 4 Pages e0904.

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. American Journal of Agricultural and Biological Sciences. Vol 9 No 2 Pages 202-207.

Manna A Tarafder H.K Dasgupta S and Das NC (2107) Influence of different organic mulching materials on soil fertility and performance of okra in new alluvial zone of West Bengal. The Bioscan. Vol 12 No 1 Pages 663-666.

Matkovic A Bozic D Filipovic V Radanovic D Vrbnica S and Markovic T (2015) Mulching as a physical weed control method applicable in medicinal plants cultivations. Lekovite Sirovine.

Mehmood S Rasool T Iqbal M Iqbal M Haq UI and Sohail M (2015) Effect of plastic mulch and different irrigation practices on soil properties, nutrient contents and their availability in maize. Journal of Environmental and Agricultural Sciences. Vol 3 Pages 35-41.

Mehraj S Qurtulane Peer FA Bisati IA Mir MM and Hassan S (2014) Effect of organic and inorganic mulches on TSS, acidity, TSS/Acidity, yield efficiency, soil hydrothermal conditions and leaf nutrient content under temperate conditions. Ecology, Environment and Conservation. Vol 21 No 3 Pages 2015-1331.

Montenegro AAA Lima JLMP Abrantes JRCBO and Santos TEM (2013) Impact of mulching on soil and

water conservation in semiarid catchment: Simulated rainfall in the field and in the laboratory. Bodenkultur. Vol 64 No 3-4 Pages 79-85.

Ni X Song W Zhang H Yang X and Wang L (2016) Effects of mulching on soil properties and growth of tea olive (*Osmanthus fragrans*). Plos One. Vol 11 No 8 Pages e0158228.

Patil SS Kelkar TS and Bhalerao SA (2013) Mulching: a soil and water conservation practice. Research Journal of Agriculture and Forestry Sciences. Vol 1 No 23 Pages 26-29.

Patil SS Kelkar TS and Bhalerao SA (2013) Mulching: a soil and water conservation practice. Research Journal of Agriculture and Forestry Sciences. Vol 1 No 3 Pages 26-29.

Patle GT Kumar M and Khanna M (2019) Climate-smart water technologies for sustainable agriculture: a review. Journal of Water and Climate Change. Pages 1-12.

Pingali PL (2012) Green Revolution: Impacts, limits, and the path ahead. Proceedings of the National Academy of Sciences. Vol 109 No 31 Pages 12302-8.

Pramanik P Bandyopadhyay K.K Bhaduri D Bhattacharyya R and Aggarwal P (2015) Effect of mulch on soil thermal regimes-a review. International Journal of Agriculture Environment and Biotechnology. Vol 8 No 3 Pages 645-658.

Pramanik P Bandyopadhyay KK Bhaduri D Bhattacharyya R and Aggarwal P (2015) Effect of mulch on Soil thermal regimes - a review. International Journal of Agriculture Environment and Biotechnology. Vol 8 No 3 Pages 645-658.

Raghavendra M Singh YV Das TK and Meena MC (2017) Effect of crop residue and potassium management practices on productivity and economics of conservation agriculture based maize (Zea mays)-wheat (*Triticum aestivum*) cropping system. Indian Journal of Agricultural Sciences. Vol 87 No 7 Pages 855-61.

Ramesh K Matloob A Aslam F Florentine SK and BS (2017) Weeds in a changing climate: vulnerabilities, consequences, and implications for future weed management. Frontiers in Plant Science. Vol 8 No e30569 Pages 1-12.

Rao KVR Bajpai A Gangwar S Chourasia L and Soni K (2016) Effect of mulching on growth, yield and economics of watermelon (*Citrullus lanatus* Thunb). Environment & Ecology. Vol 35 No 3D Pages 2437-2441.

Raza A Razzaq A Mehmood SS Zou X Zhang X Lv Y and Xu J (2019) Impact of climate change on crops adaptation and strategies to tackle its outcome: a review. Plants. Vol 8 No 2 Pages 34.

Sharma B Vaish B Monika Singh UK Singh P and Singh RP (2019) Recycling of organic wastes in agriculture: an environmental perspective. International Journal of Environmental Research. Vol 13 No 1 Pages 409-429.

Sharma R and Bhardwaj S (2017) Effect of mulching on soil and water conservation - a review. Agricultural Research Communication Centre. Vol 38 No 4 Pages 311-315.

Singh P (2011) Economic benefits and ecological cost of green revolution: a case study of Punjab. Journal of Economic and Social Development. Vol 7No 1 Pages 66-74.

Singh R Upadhyay SK and Koma (2018) Ecofriendly management of paddy crop residues for sustainable environment and development. Bio-Science Research Bulletin. Vol 34 No 2 Pages 59-72.

Singh YP Arora S Mishra VK Dixit H and Gupta R (2018) Effect of organic and inorganic amendments on amelioration of sodic soil and sustaining rice (Oryza sativa)-wheat (*Triticum aestivum*) productivity. Indian Journal of Agricultural Sciences. Vol 88 No 9 Pages 1455-62.

Song X Tao B Guo J Li J and Chen G (2018) Changes in the microbial community structure and soil chemical properties of vertisols under different cropping systems in Northern China. Frontiers in Environmental Science. Vol 6 Pages 132.

Stigter K Ramesh K and Upadhyay PK (2018) Mulching for microclimate modifications in farming - an overview. Indian Journal of Agronomy. Vol 63 No 3 Pages 255-263.

Swiatkiewicz ID and Siwek P (2018) Effects of plastic mulches and high tunnel raspberry production systems on soil physicochemical quality indicators. International. Agro-physics. Vol 32 Pages 39-47.

Taparauskiene L and Miseckaite O (2014) Effect of mulch on soil moisture depletion and strawberry yield in sub-humid area. Polish Journal of Environmental Studies. Vol 22 No 2 Pages 475-482.

Tapiwa KA (2019) Assessing the effect of cattle manure and reduced rates of nitrogen (N) and potassium (K2O) as integrated nutrient management options on growth and yield of potatoes. International Journal of Agricultural Sciences and Veterinary Medicine. Vol 7 No 4 Pages 21-27.

Thakur SS Chande R and Narang MK (2018) Studies on straw management techniques using paddy-straw chopper cum spreader along with various tillage practices and subsequent effect of various sowing techniques on wheat yield and economics. Agricultural mechanization in Asia, Africa and Latin America. Vol 49 No 2 Pages 52-67.

Tongchuan L Shao M and Jia Y (2017) Characteristics of soil evaporation and temperature under aggregate mulches created by burrowing ants (*Camponotus japonicus*). Soil Science Society of America Journal. Vol 81 No 2.

Tongchuan L Shao M and Jia Y (2105) Characteristics of soil evaporation and temperature under aggregate mulches created by burrowing ants (*Camponotus japonicus*). Soil Science Society of America Journal. Vol 81 No 2.

Vashish BB Sidhu BS Singh S and Biwalkar N (2013)

Effect of different mulches on soil erosion and carry-over of residual soil moisture for sowing of crop in maize-wheat cropping sequence in rainfed Shivaliks of Punjab. Journal of Soil and Water Conservation. Vol 41 No 2 Pages 136-140.

Vashisht BB Sidhu BS Singh S and Biwalkar N (2013) Effect of different mulches on soil erosion and carry-over of residual soil moisture for sowing of crop in maize-wheat cropping sequence in rainfed Shivaliks of Punjab. Journal of Soil and Water Conservation. Vol 41 No 2 Pages 136-140.

Verma SK Prasad SK Kumar S Singh SB Singh PR and Singh YV (2017) Effect of mulching and herbicides on weeds, yield and economics of green gram (*Vigna radiata* L.) grown under eight-year old agrihorti system. Research on Crops. Vol 18 No 3 Pages 438-443.

Vetter WL Zhang H Ghimire S Watkinson S and Miles CA (2017) Plastic biodegradable mulches reduce weeds and promote crop growth in day-neutral Strawberry in Western Washington. Hort Science. Vol 52 No 12 Pages 1700-1706.

Vox G Santagata G Malinconico M Immirzi B Mugnozza GS and Schettini E (2013) Biodegradable films and spray coatings as eco-friendly alternative to petro-chemical derived mulching films. Journal of Agricultural Engineering. Vol 44 No 2s Pages 221-225.

Yi L Yufang S Shenjiao Y Shiqing L and Fang C (2011) Effect of mulch and irrigation practices on soil water, soil temperature and the grain yield of maize (Zea mays L) in Loess Plateau, China. African Journal of Agricultural Research. Vol 6 No 10 Pages 2175-2182.

Yordanov M and Nikolov A (2017) Influence of plant density and mulching on growth and yield of lettuce (*Lactuca sativa* var. romana L.). International Journal of Environmental & Agriculture Research. Vol 3 No 10 Pages 10-14.

Yu HH Dingh GD Gao LG Zhzo YY Yan L and Sai K (2015) Using plant temperature to evaluate the response of stomatal conductance to soil moisture Deficit. Forests. Vol 6 No 10 Pages 3748-3862.