Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(5): 2854-2858
Received: 05-07-2020
Accepted: 10-08-2020

Alongba Jamir
Department of Soil & Water Conservation, Nagaland University, SASRD Medziphema, Nagaland, India

Manoj Dutta
Department of Soil & Water Conservation, Nagaland University, SASRD Medziphema, Nagaland, India

Corresponding Author:
Alongba Jamir
Department of Soil & Water Conservation, Nagaland University, SASRD Medziphema, Nagaland, India

Effect of mulching on important soil physico-chemical properties of Khasi mandarin (*Citrus reticulata* Blanco) orchard under mid-hill region of Nagaland

Alongba Jamir and Manoj Dutta

Abstract

An experiment was conducted during 2016-18 to study the response of different organic (rice husk, saw dust, chopped banana leaves & pseudo-stem, FYM, forest leaves and rice straw) and inorganic (black polythene and transparent polythene of 100µ) mulching materials in Khasi mandarin orchard. Studies on the effect of mulching on soil bulk density was significantly higher under no mulch recording 1.22g cm^{-3} in both the years followed by black polythene mulch recording pooled value of 1.19g cm^{-3}. The lowest bulk density was recorded in saw dust mulch with a pooled recording of 1.11g cm^{-3}. The data pertaining to particle density among various treatments did not show any significant difference. The water holding capacity was significantly higher in black polythene mulch and minimum in no mulch. The test for analyzing the soil pH showed there was no significant difference with the treatments in the first year however, the second year of experiment resulted in significant decrease in various organic mulches. The treatment using FYM mulch gave the highest organic carbon content of 3.07%, significantly highest available nitrogen (525.12kg ha^{-1}), maximum available phosphorus (20.88kg ha^{-1}) and revealed the highest available potassium (320.21kg ha^{-1}) and the lowest was found in treatment devoid of mulch for all parameters tested.

Keywords: Mulching, physico-chemical properties, FYM mulch, black polythene

Introduction

Khasi mandarin is one of the most important citrus cultivar in North-East India. It is a vibrant golden yellow coloured fruit with loose smooth skin possessing more flesh and aromatic juice in comparison to the mandarin varieties with good shelf. The farmers of Nagaland cultivate Khasi Mandarin in an area of 6.52 thousand hectares with production of 47.33 thousand metric tons [1]. Mulching have a significant role in conservation of soil moisture during dry season, as well as enhances biological, physical and chemical properties of soil. It is a practice which helps in proper growth and development of the plants by modifying soil temperature, providing better nutrient availability and by better moisture conservation [2]. Mulching by plastic polyethylene has proved its effectiveness in soil moisture conservation and increasing the growth and yield and enhancing the quality in various citrus cultivars [3,4]. Organic mulches derived from plant and animal materials such as straw, hay, husks, compost, sawdust, wood chips etc. are efficient in reduction of nitrates leaching, prevent erosion, improve soil physical properties, supply organic matter, water retention and regulate temperature, augment nitrogen balance play a part in nutrient cycle and also increase the biological activity [5,6]. Continuous application of organic mulches are advantageous in improving the soil physico-chemical properties, microbial flora and aeration of soil which ultimately resulted into better growth and yield of plant [7].

The crop in the region is mainly dependent on rainfed cultivation and therefore it is important to find ways and means to increase the yield and to improve the soil physico-chemical properties and also to observe the best suitable mulching material. Moreover, the systematic study on the effect of mulching on important soil properties under Nagaland condition has not been carried out. So keeping in view and taking all these into consideration the present investigation was conducted.

Materials and Methods

The experiment was carried out on a established orchard of 15 years old khasi mandarin trees at Chuchuyimlang village under Mokokchung district of Nagaland. The experiment was done in Completely Randomized Design (CRD) and it consisted of nine (9) treatments with three replications. The treatments were as follows: M_0- No mulch, M_1- Rice husk, M_2- Saw dust, M_3- Chopped banana leaves & pseudo stem, M_4- FYM, M_5- Forest leaves, M_6-Rice straw, M_7-Transparent polythene (100μ), M_8-Black polythene (100μ). For treatments M_1, M_2, M_3, M_4, M_5 & M_6 i.e. organic mulches, 5cm layer of rice husk, saw dust, chopped banana leaves and pseudo-stem, FYM, forest leaves & rice straw were applied above the soil surface around the tree trunk up to a distance of one meter radius, respectively. The Recommended dose of fertilizer (RDF) for the investigation was 900g N, 700g P_2O_5, 600g K_2O per plant. The status of the soil was determined after the final harvest of the fruit. The bulk density of the soil was analyzed by the core method as described by Baruah and Barthakur [8]. The particle density of the soil was estimated by the pycnometer method. In analyzing of water holding capacity (WHC), soil sample were packed in Keen Rackzowaski boxes with uniform tapping and saturated overnight. After saturation the samples were weighed and kept in oven for 48 hours at equilibrium temperature of 105˚C. The samples were then cooled and weighed. The water holding capacity was calculated by the weight difference and expressed in percentage [9]. Soil pH was determined in 1:2.5 soil water suspension using glass electrode pH meter. Organic carbon was determined by the Wet Digestion Method of Walkley and Black as described by Jackson [10]. The available N content of the soil was estimated by the Alkaline-Potassium Permanganate method of Subbiah and Asija [11]. The available P in soil was extracted by Bray's method No.1 [12]. The P content in the soil was determined colorimetrically [13]. The available K was extracted from the soil with neutral normal ammonium acetate [10] and determined flame photometrically. The data of the different observations were analyzed statistically following the methods described by Gomez and Gomez [14]. Fisher Snedecor 'F' test was used to determine the significance and non-significance of the variance due to different treatments at 5% level of significance.

Results and Discussion

Effect of mulching on bulk density of the soil

The data on the effect of different mulching materials on bulk density of the soil after harvest of the fruit is presented in table 1. The bulk density of the soil varied from 1.11 g cm^{-3} to 1.22 g cm^{-3} with an average of 1.18 g cm^{-3} in the year 2016 and 1.10 g cm^{-3} to 1.22 g cm^{-3} with an average of 1.17 g cm^{-3} in the year 2017. The highest bulk density was recorded in no mulch (M_0) recording 1.22 g cm^{-3} in both the years followed by forest leaves (M_5) recording 1.21 and 1.20 g cm^{-3} during 2016 and 2017, respectively. The lowest bulk density was recorded in saw dust (M_2) mulch with a value of 1.11 and 1.10 g cm^{-3} during 2016 and 2017, respectively. The data revealed that mulching with organic and inorganic materials had a significant decrease in bulk density over control. The above investigation is in agreement with the findings of Mathews *et al.* [15] who expressed that use of organic materials as mulches decreased the soil bulk density. These results are in accordance with the findings reported by Unger and Jones [16], Ghuman *et al.* [17] and Tiquia *et al.* [18]

Effect of mulching on particle density of the soil

The effect of mulching on particle density of the soil is shown in table 1. In both the years, the highest particle density (2.25 g cm^{-3}) was recorded in no mulch (M_1) followed by black polythene (M_8) and transparent polythene (M_7) which recorded 2.22 and 2.20 g cm^{-3} in 2016 and 2017, respectively. While the minimum (2.02 g cm^{-3}) was observed in treatment saw dust (M_2) and FYM (M_4) mulch during 2016 and 2017. The particle density due to addition of mulching did not show any significant difference after two years of treatment with various organic and inorganic mulching materials.

Effect of mulching on water holding capacity of the soil

The WHC of the soil varied from 27.12 to 33.15% and 28.25 to 34.25% during 2016 and 2017, respectively. The maximum WHC was recorded in black polythene treatment and minimum was recorded in control. The WHC recorded in the second year of experiment further increased in all the treatments. The data revealed that mulching with various materials brought about a significant increase in water holding capacity of soil as compared to control. The application of black polythene, transparent polythene, saw dust and FYM resulted an increase of 21.70, 18.42, 18.20 and 15.89% in water holding capacity of the soil, respectively as compared to control. The increase in water holding capacity of the soil with different mulching materials was due to reduction in evaporation loss and increase in organic matter content and improvement in its physical properties of the soil. These findings are in accordance with the findings of Laxminarayana [19] who reported that, the application of organic manures improved the water holding capacity of the soil. Similar results were also reported by Singh *et al*. [20]

Effect of mulching on soil pH

The data recorded on soil pH of different mulching materials showed that there was variation in the data analysed during the two years of investigation. The highest soil pH was 5.03 and 5.07 observed in no mulch (M_0) during 2016 and 2017 with a mean of 5.05, followed by black polythene (M_8) mulch which showed a pH of 4.95 and 4.93, respectively. Among the different treatments, minimum soil pH was 4.82 and 4.68 which was recorded in treatment FYM (M_4) during 2016 and 2017, respectively with mean value as 4.75. In the first year of experiment the variation in the pH was not significant however in the subsequent year of experiment pH showed a significant decrease in all the treatments except in rice husk (M_1), transparent polythene (M_7) and black polythene (M_8) over control.

The decrease in soil pH could be due release of organic acids which is from the decomposition of mulches. The present findings are in agreement with Lalitha *et al.* [21] who cited that decomposition of organic residues under plastic mulch increases the organic acids to the soil. This was also supported by Hild and Morgan [22], Himelick and Watson [23] and Billeaud and Zajicek [24] as they concluded that use of organic mulches resulted in reduce of underlying soil pH. Use of plastic-film mulch decreased soil pH and the decrease in soil pH was correlated with an increase in soil nitrate concentrations due to the improved nitrogen mineralization as a result of rise in soil temperature and moisture in plastic-film mulch [25].

Effect of mulching on organic carbon of the soil

The organic carbon content of the soil varied from 2.52 to 3.06% and 2.54 to 3.08% with a mean of 2.74 and 2.77% during 2016 and 2017, respectively. The highest organic carbon was found in FYM (M_4) mulch followed by saw dust and forest leaves treatments whereas the lowest was in no mulch treatment in both the years of investigation.

Application of rice husk (M_1), saw dust (M_2), FYM (M_4) and forest leaves (M_5) recorded a significant increase in organic carbon content of the soil as compared to no mulch (M_0). The increase in organic carbon content of the soil could be due to topping of the soil with various mulches, as a result it developed a better habitat for soil organisms by impeding different forms of erosions like water and wind erosion, countering fluctuations in humidity and temperature and also increasing its organic matter content as a source of nutrition thus, enhance the organic carbon content. The present finding was in conformity with Kumar [26], who reported that under different organic mulch treatment the highest soil organic carbon content was observed in FYM mulch. Gu *et al.* [27] found in their study that mulching with straw and grass in the sloping land of citrus orchard showed a significant increased in soil organic carbon content.

Effect of mulching on available Nitrogen (N)

The available N in the soil ranged from 363.88 to 525.95 kg ha^{-1}and 363.17 to 524.28 kg ha^{-1} in 2016 and 2017, respectively. In both the years the highest available N was found in FYM (M_4) followed by forest leaves (M_5) and the lowest was observed in no mulch (M_0). The increase in available nitrogen in soils after the harvest of the fruit maybe due to incorporation of organic and inorganic sources, increased microbial activity and also favourable condition for microorganisms beneath the mulching materials, which may have lead to improve the nitrification process. Das and Dutta [28] studied effect of mulching on soil properties in mango orchard using black polythene and different organic mulching materials and stated that the important soil mineral contents (nitrogen, phosphorus and potassium) were influenced by incorporation of different organic and inorganic mulches. Application of different organic mulching materials under rainfed condition of Shiwalik foothills of Himalayas showed that the highest available nitrogen was found in the treatment FYM mulch [26]. Mahmoud and Sheren [29] also corroborated that use of organic and inorganic mulches increased the soil mineral content.

Effect of mulching on available Phosphorus (P)

The experimental results pertaining to available phosphorus showed that there was a significant difference among the treatments. Perusal of data revealed that, maximum available phosphorus was found under FYM (M_4) mulch during 2016 and 2017 respectively, with a value of 21.20 and 20.57 kg ha^{-1}, which was followed by rice husk (M_2) treatment in the first experimental year (20.10 kg ha^{-1}) however, in the second experimental year the second highest available phosphorus was recorded in the forest leaves (M_2) mulch (20.02 kg ha^{-1}), and the minimum available phosphorus of 10.86 and 10.78 kg ha^{-1} was recorded under no mulch (M_0) during 2016 and 2017, respectively, with mean of 10.82 kg ha^{-1}. The data revealed that addition of organic mulches caused a significant increase in available P content as compared to inorganic mulches and no mulch. Dahiya and Malik [30] opined that the production of organic acids during the decomposition of organic mulching substances complexes the metal cations like calcium, aluminium and iron, which helps in solubilizing native P and reduction in P sorption. In an experiment of comparison of mulched and no mulched treatment the treatment under mulched showed significant availability of phosphorus nutrient [31]. Qu *et al.* [32] also revealed that using of green waste compost as mulching material showed a significant increase in the available phosphorus content.

Effect of mulching on available Potassium (K)

The result recorded during 2016 showed that available potassium was highest in FYM (M_4) mulch (319.88 kg ha^{-1}), which was followed by rice straw (M_6) mulch (308.60 kg ha^{-1}) and the lowest was recorded in no mulch (M_0) (184.60 kg ha^{-1}). In 2017 also, the highest available potassium was found in FYM (M_4) mulch followed by rice straw (M_6) mulch with a value of 320.54 and 309.52 kg ha^{-1}, respectively and the minimum was recorded 182.22kg ha^{-1} in no mulch (M_0).

The data revealed that addition of all the organic and inorganic mulches brought about a significant increase in available K as compared no mulch. The increase in available K in FYM, rice straw, rice husk and black polythene was 42.72, 40.66, 36.72 and 34.19% higher over no mulch treatment, respectively. Alharbi [33] found in his study that available potassium in surface soil for mulched treatment was higher than the soil devoid of mulch treatment by 27.6 and 20% in the beginning and end season. Broschat [34] also reported that plots mulched with organic materials had significantly increased soil K concentrations than the unmulched plots. Increasing amounts of available soil potassium and phosphorus was observed under mulches [35].

Conclusion

Significantly higher bulk density was observed under no mulch in both the years of experiment and the particle density after mulching did not show any variation after two years of treatment. Water holding capacity (WHC) was significantly higher in black polythene mulch and even in the second year of experiment it further increased in all the treatments. The soil pH showed that there was variation during the two years of investigation. The study reveals that available nutrients and organic carbon content were observed to be highest under FYM mulch. Therefore, considering the soil improvement characteristics it would be appropriate and logical suggestion to conclude that using FYM as a mulching material can be considered as a better option.

Table 1: Effect of different mulching materials on bulk density, particle density, water holding capacity & pH of soil on Khasi Mandarin

Treatments	Bulk density (g cm^{-3})		Particle density (g cm^{-3})		Water holding capacity (%)		Soil pH	
	2016	2017	2016	2017	2016	2017	2016	2017
M_0: No mulch	1.22^{a}	1.22^{a}	2.25^{a}	2.25^{a}	27.12^{c}	28.25^{c}	5.03^{a}	5.07^{a}
M_1: Rice husk	1.16^{abc}	1.14^{ab}	2.12^{ab}	2.12^{ab}	30.54^{abc}	31.32^{abc}	4.90^{ab}	4.88^{ab}
M_2: Saw dust	1.11^{c}	1.10^{c}	2.02^{b}	2.03^{b}	32.58^{a}	32.87^{a}	4.83^{b}	4.75^{bc}
M_3: Chopped banana leaves & pseudostem	1.20^{ab}	1.19^{ab}	2.05^{ab}	2.04^{ab}	31.15^{ab}	32.90^{ab}	4.87^{b}	4.83^{bc}
M_4: FYM	1.13^{bc}	1.13^{bc}	2.03^{ab}	2.02^{ab}	31.80^{ab}	32.38^{ab}	4.82^{b}	4.68^{c}
M_5: Forest leaves	1.21^{a}	1.20^{ab}	2.18^{ab}	2.17^{ab}	28.74^{bc}	30.42^{bc}	4.83^{b}	4.70^{c}
M_6: Rice straw	1.17^{abc}	1.17^{abc}	2.17^{ab}	2.16^{ab}	29.62^{abc}	29.56^{abc}	4.86^{b}	4.82^{b}
M_7: Transparent polythene (100μ)	1.18^{abc}	1.16^{abc}	2.22^{ab}	2.20^{ab}	32.35^{a}	33.23^{a}	4.92^{ab}	4.90^{ab}
M_8: Black polythene (100μ)	1.20^{ab}	1.18^{ab}	2.22^{ab}	2.20^{ab}	33.15^{a}	34.25^{a}	4.95^{ab}	4.93^{ab}
SEm±	0.02	0.02	0.06	0.07	1.08	1.03	0.05	0.07

CD (p=0.05)	0.07	0.07	NS	NS	3.20	3.05	NS	0.20

Note: Different small letters within the columns after mean values indicate significant differences among treatments at 5% level of significance. Means within columns were separated by Duncan's multiple range test (DMRT).
NS = Non-significant at 5% level of significance.

Table 2: Effect of different mulching materials on organic carbon, available nitrogen, phosphorus and potassium of soil on Khasi Mandarin

Treatments	Organic carbon (%)		Available Nitrogen ($kg\ ha^{-1}$)		Available Phosphorus ($kg\ ha^{-1}$)		Available Potassium ($kg\ ha^{-1}$)	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
M_0: No mulch	2.52^{d}	2.54^{d}	363.88^{f}	363.17^{f}	10.86^{e}	10.78^{d}	184.60^{e}	182.22^{e}
M_1: Rice husk	2.75^{bc}	2.77^{bc}	489.80^{bc}	488.67^{bc}	20.10^{a}	19.96^{a}	289.82^{ab}	289.85^{ab}
M_2: Saw dust	2.96^{ab}	2.97^{ab}	474.95^{cd}	474.40^{cd}	16.16^{bc}	15.86^{bc}	251.62^{cd}	251.62^{cd}
M_3: Chopped banana leaves & pseudostem	2.68^{bc}	2.70^{bc}	436.67^{e}	437.02^{e}	15.22^{cd}	15.72^{bc}	243.02^{d}	243.69^{d}
M_4: FYM	3.06^{a}	3.08^{a}	525.95^{a}	524.28^{a}	21.20^{a}	20.57^{a}	319.88^{a}	320.54^{a}
M_5: Forest leaves	2.87^{ab}	2.90^{ab}	511.22^{ab}	511.42^{ab}	19.42^{ab}	20.02^{ab}	269.08^{bc}	270.20^{bc}
M_6: Rice straw	2.66^{c}	2.68^{c}	487.18^{bc}	488.32^{bc}	18.40^{ab}	18.53^{ab}	308.60^{a}	309.52^{a}
M_7: Transparent polythene (100μ)	2.64^{cd}	2.66^{cd}	454.10^{de}	453.94^{cd}	11.92^{de}	12.50^{d}	267.94^{bc}	268.26^{bc}
M_8: Black polythene (100μ)	2.56^{d}	2.59^{d}	446.05^{de}	445.77^{de}	13.65^{de}	13.32^{cd}	278.90^{b}	278.48^{b}
SEm±	*0.07*	*0.06*	*10.15*	*11.28*	*1.07*	*1.02*	*7.62*	*7.04*
CD (p=0.05)	*0.20*	*0.18*	*30.17*	*33.51*	*3.18*	*3.03*	*22.65*	*20.93*

Note: Different small letters within the columns after mean values indicate significant differences among treatments at 5% level of significance. Means within columns were separated by Duncan's multiple range test (DMRT).

References

1. Horticultural Statistics at a Glance. Department of Agriculture, Cooperation & Farmers' Welfare Ministry of Agriculture & Farmers' Welfare Government of India. National Horticulture Board. http://nhb.gov.in/statistics/State Level/201819(1st%20Adv).pdf. 2018.
2. Kher R, Baba JA, Bakshi P, Wali VK. Effect of planting time and mulching material on quality of strawberry. Journal of Research SKUAST. 2010; 9(1):54-62.
3. Lal H, Samra JS, Arora YK. Effect of irrigation and mulching on water use, soil temperature, weed population and nutrient losses. Indian Journal of soil Conservation. 2003; 31(3):281-286.
4. Shirgure PS, Singh S, Panigrihi P, Sonkar PK. Evaluation of mulches for improving bearing in acid lime. Indian Journal of Soil Conservation. 2005; 33(1):62-66.
5. Muhammad AP, Muhammad I, Khuram S, Hassan AU. Effect of mulch on soil physical properties and NPK concentration in Maize (*Zea mays*) shoots under two tillage system. International Journal of Agriculture & Biology. 2009; 11:120-124.
6. Sarolia DK, Bhardwaj RL. Effect of mulching on crop production under rainfed condition: A Review. International Journal of Research in Chemistry and Environment. 2012; 2:8-20.
7. Rao VK, Pathak RK. Effect of mulches on aonla (*Emblica officinalis* Gaertn) orchard in sodic soil. Indian Journal of Horticulture. 1998; 55(1):27-32.
8. Baruah TC, Barthakur HP. A text book of Soil Analysis. 1st Edn. Bikash Publishing House, New Delhi, 1997.
9. Piper CS. Soil and Plant Analysis. Hans Publishers, Bombay, 1966.
10. Jackson ML. Soil Chemical Analysis. Printice Hall of India, New Delhi, 1973.
11. Subbiah BV, Asija GL. A rapid procedure for estimation of the available nitrogen in soils. Current Science. 1956; 25:259-260.
12. Brays RH, Kurtz LT. Determination of total organic and available forms of phosphorus in soils. Soil Science. 1945; 59:39-45.
13. Dickman SR, Bray RH. Colorimetric determination of phosphate. Industrial & Engineering Chemistry Analytical Edition. 1940; 12(11):665-668
14. Gomez KH, Gomez AA. Statistical procedures for Agricultural Research. John Wiley and Sons. New York. 1984, 381.
15. Mathews C, Bottell DG, Brown MW. A comparison of conventional and alternative understory management practices for apple production: multi-trophic effect. Applied Soil Ecology. 2002; 21:221-231.
16. Unger PW, Jones OR. Long-term tillage and cropping systems affect bulk density and penetration resistance of soil cropped to dryland wheat and grain sorghum. Soil & Tillage Research. 1998; 45:39-57.
17. Ghuman BS, Sur HS. Tillage and residue management effects on soil properties and yields of rainfed maize and wheat in a subhumid subtropical climate. Soil & Tillage Research. 2001; 58:1-10.
18. Tiquia SM, Lloyed J, Herms DA, Hoitink HAJ. 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. Applied Soil Ecology. 2002; 21:31-48.
19. Laxminarayana K. Effect of integrated use of inorganic and organic manures on soil properties, yield and nutrient uptake of rice in ultisols of Mizoram. Journal of the Indian Society of Soil Science. 2006; 54:120-123.
20. Singh RP, Yadav PK, Singh RK, Singh SN, Bisen MK, Singh J. Effect of chemical fertilizer, FYM and biofertilizers on performance of rice and soil properties. Crop Research. 2006; 32:283-285.
21. Lalitha M, Thilagam VK, Balakrishnan N, Mostafa M. Effect of plastic mulch on soil properties and crop growth- A review. Indian Journals Agricultural Reviews. 2010; 31(2):145-149.
22. Hild AL, Morgan DL. Effects on crown growth of five Southwestern shrub species. Journal of Environmental Horticulture. 1993; 11(1):41-43.
23. Himelick EB, Watson GW. Reduction of oak chlorosis with wood chip mulch treatments. Journal of Arboriculture. 1990; 16(10):275-278.
24. Billeaud LA, Zajicek JM. Influence of mulches on weed control, soil pH, soil nitrogen content, and growth of *Ligustrum japonicum*. Journal of Environmental Horticulture. 1989; 7:155-157.

25. Wang L, Li XG, Lv J, Fu T, Ma Q, Song W *et al*. Continuous plastic-film mulching increases soil aggregation but decreases soil pH in semi-arid areas of China. Soil & Tillage Research. 2017; 167:46-53.
26. Kumar V. Effect of different organic mulching materials on soil properties of NA '7' aonla (*Emblica officinalis* Gaertn) under rainfed condition of Shiwalik foothills of Himalayas India. The Bioscan. 2014; 9(1):561-564.
27. Gu C, Liu Y, Mohamed I, Zhang R, Wang X, Nie X *et al*. Dynamic changes of soil surface organic carbon under different mulching practices in citrus orchards on sloping land. Plos one. 2016; 11(12):e0168384.
28. Das K, Dutta P. Effects of mulching on soil properties and post harvest quality of mango Cv. Himsagar grown in new alluvial zone of West Bengal. International Journal of Agriculture, Environment and Biotechnology. 2018; 11(2):259-264.
29. Mahmoud IED, Sheren EH. Improving growth and productivity of pomegranate fruit trees planted on sandy dunes slopes at Baloza District (N. Sinai) using different methods of drip irrigation, organic fertilization and soil mulching. IOSR Journal of Agriculture and Veterinary Science. 2014; 7(12):86-97.
30. Dahiya R, Malik RS. Trash and green mulch effects on soil N and P availability. www.tropentag.de/2002/proceedings/node19.htm. 2002.
31. Green LKM, Rakow DA. The effect of wood mulch type and depth on weed and tree growth and certain soil parameters. Journal of Arboriculture. 1995; 21(5):225-232.
32. Qu B, Liu Y, Sun X, Li S, Wang X, Xiong K *et al*. Effect of various mulches on soil physio-chemical properties and tree growth (*Sophora japonica*) in urban tree pits. Plos one. 2019; 14(2):e0210777.
33. Alharbi A. Effect of mulch on soil properties under organic farming conditions in center of Saudi Arabia. Scientific Proceedings V International Scientific-Technical Conference "Agricultural Machinery". 2017; 2:230-236.
34. Broschat TK. Effects of mulch type and fertilizer placement on weed growth and soil pH and nutrient content. Hort Technology. 2007; 17(2):174-178.
35. Tukey RB, Schoff EL. Influence of different mulching materials upon the soil environment. Proceedings of American Society for Horticultural Science. 1963; 82:69-76.