

Effect of Organic Compost Mulching on Orchard Soil Property

 Yumin Wang^a, Pengcheng Wang^{*b}
^a Bozhou University, Bozhou 236800, Anhui, China;

^b Institute of Horticulture, Anhui Academy of Agricultural Sciences, Anhui, China.

wangpengcheng@163.com

In order to increase the fruit yield and economic benefit, pesticides and fertilizers are overused in Chinese orchards, which leads to a series of environmental problem and food safety issues like water body pollution, organic content decrease. The effect and influence of various organic compost mulching on orchard soil property are discussed here, to improve soil ecological structure, utilize and circulate wastes resource rationally and increase the reservoir storage of orchard. The results showed that the mulching of the organic compost can decrease the surface soil bulk density apparently, loosen the soil and optimize its air permeability. Meanwhile, it can increase the nutrient elements in the soil, improve soil property and thus to boost the grow of the tree fruit and root as well as to improve the physical, chemical and biological property of soil. Along with the ever-increasing length of the compost substrate mulching, the organic content of the soil has been increased apparently, and the orchard soil property has been improved obviously, which has eased a series of environmental issues, increased the crop yield and improved the crop quality at the same time. It has increased the economic efficiency to some extent.

1. Introduction

In the past decades, along with the economic development and the improvement of people's living standard, agriculture in our country has kept developing rapidly, which has resolved the issue of crop yield. But keeping pursuing the crop yield also leads to a variety of problems. For example, many agricultural waste resources, instead of being utilized, has been discarded without any disposing, which resulted in many environmental issues. Agricultural disasters has become more and more frequent. Soil erosion and quality decline have made the crop yield decreased and crop quality influenced (Swanepoel et al., 2015). These phenomenons and problems restrict the sustainable development of rural economy, environment and biology. As a result, we should vigorously develop the beneficial utilization of organic agricultural resources, and boost sustainable development.

Organic agricultural wastes can be classified into 4 categories: plant waste, household garbage, animal excrement and agricultural products processing wastes. But the agricultural wastes we discussed here include crop straws and livestock's excrement (Bindraban et al., 2012). Although the agricultural wastes has been discarded, they still belong to reproducible resources and share a common character, that is: they are renewable and recyclable resources. They can be restored and pollute environment. The main component of the agricultural waste is organic material, if being utilized reasonably, it can be changed from waste material into things of value and improve agricultural biological environment (Jayathilakan et al., 2012).

In recent years, along with the arising of intensive aquaculture enterprises, there emerges a large quantity of organic waste like excrement of birds and livestock, providing a wide resource to the production of compost from organic waste. Organic fertilizer can promote the reproduction of microorganism and improve the soil property effectively. It is also the main nutrient resources to produce green food. Utilizing organic fertilizers for a long time is known to increase land utilization rate influentially, optimize soil fertility and keep water fertility, thus to boost the grow of crop and increase the yield and quality of crop. The objects we researched here are fruit trees. We aim at researching the different effects of different waste compost substrates mulching on the improvement of orchard soil as well as on the grow and quality of fruits. The results showed that the mulching of organic compost can not only improve the soil quality, but also ease environmental problems. In addition,

this research served as a solid theoretical base for researching on orchard management measures and improving fruit quality.

2. Material and method

There are two kinds of experimental materials used during the research, all of which come from the agricultural experimental base in Shandong province. One is Feicheng peach, with the experimental soil of brown soil, the other material is apple tree. When fertilizing, the apple trees consistent in line weight were choose.

- (1) The experimental rotten chicken and cow manure was stocked with the volume ratio of 3:1 of the fresh chicken and cow manure to saw dust;
- (2) Regulate the water content to 55% or so. Add microorganism inoculation of 3% of the material. Conduct aerobic composting;
- (3) During the process of rotting and decomposing, conduct artificial composting regularly;
- (4) When the composting temperature was below 50°C, dry and smash it as a preparation of the final bagging.

3.Result and discussion

3.1 The effect of different organic waste compost substrate on the soil in mulching area in peach orchard

- (1) The effect on the water content of the soil in mulching area in peach orchard

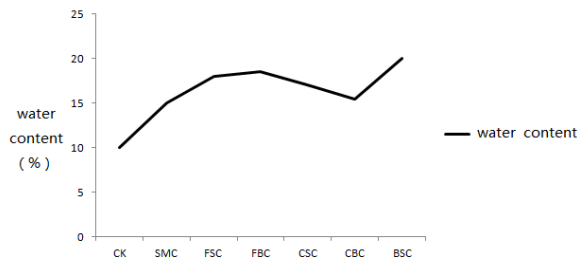


Figure 1: The effect of different organic waste compost substrate on the water content of soil in mulching area in peach orchard

From figure 1, it can be seen that the water content rate of the BSC group was as high as almost 20%, which is of the best water conservation effect. While the water content rate of the Ck group was only 10%. The data above showed that the different organic waste compost substrate have different effects on decreasing the water loss in the soil and thus to increase the water content of the soil, conserve enough water, and increase fruit quality and yield.

- (2) The effect on the soil bulk density in the mulching area in the peach orchard

The bulk density of the soil is the index to judge the looseness and firmness of the soil, the higher the bulk density is, the worse the structure is. The lower bulk density means the soil is loose, and the soil structure is better.

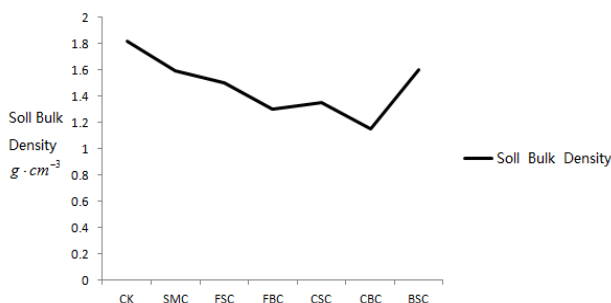


Figure 2: The effect of different organic waste compost substrate on the bulk density of soil in mulching area in peach orchard

Figure 2 shows that the soil bulk density situation was: CK>SMC>FSC>BSC>CSC>FBC>CBC. The soil bulk density of group SMC was higher, just 15% lower than the group CK. The possible reason for that may be that the method of sewage sludge compost (BSC) has minimized the porosity of the sewage and sludge. In addition, the bulk density of group fowl manure and bark compost(FBC), cow dung and saw dust compost(CSC) and cow dung and bark compost (CBC) were all about 30% lower than group CK, which showed, after processing by different waste compost substrate, the porosity of the soil has become bigger, which made the permeability of the soil strengthened. And also, the water can permeate in the soil easier than before, which can conserve and restore water better. All these data showed that the organic waste compost substrate can improve soil porosity apparently, decrease soil bulk density and enlarge soil porosity. It can improve the soil to some extent.

2.1.3 The effect on the organic material of soil in mulching area in the peach orchard

Table 1: The effect of different organic compost mulching on the organic material of soil in mulching area in peach orchard

Number	2014.9.30	2015.5.30	2015.9.30
	Organic material content ($g \cdot kg^{-1}$)		
CK	13.5	11.0	12.3
SMC	20.3	24.5	24.0
CSC	23.7	28.5	27.6
CBC	22.4	27.6	26.7
FSC	26.8	30.2	28.8
FBC	29.7	31.2	29.6
BSC	20.2	24.8	22.3

From Table 1, it can be seen that compared with group CK, the organic material content of all the other groups has been increased obviously. In September in the first year, the organic material content of CSC, CBC, FSC, FBC were higher, while that of group SMC and BSC is lower. After the re-mulching the next year, only some of them were decomposed by microorganisms, so the organic material content was higher than the previous year. Till the September in the second year, the organic material content of the soil decreased slightly, but still higher than the previous year. Based on the data, we can see that different organic waste compost substrate can increase the organic material content of the soil obviously, and also can improve the soil quality.

(3) The effect on rapid available phosphorus of soil in the mulching area of the peach orchard

Rapid available phosphorus means the phosphorus that can be absorbed by the plants, soil available phosphorus (rapid available phosphorus) is the index showing the supplying level of the soil phosphorus nutrient. Soil phosphorus content reflects the storage and supplying ability of the phosphorus in soil, playing a very important role in the respiratory and photosynthesis of the plant.

Table 2: The effect of different organic compost mulching on the rapid available phosphorus of soil in mulching area in peach orchard

Number	2014.9.30	2015.5.30	2015.9.30
	rapid available phosphorus content ($mg \cdot kg^{-1}$)		
CK	118.5	139.4	127.4
SMC	143.1	304.5	306.5
CSC	197.2	387.0	305.7
CBC	188.0	333.2	308.5
FSC	167.9	316.2	306.3
FBC	152.7	308.0	307.2
BSC	144.7	335.8	304.1

Data in Table 2 shows that in the first year, the rapid available phosphorus content of group FSC and FBC has been increased obviously. Till May in the next year, the rapid available phosphorus content of the six groups have all been increased evidently, among which FSC is the highest. In September of the second year, the soil rapid available phosphorus content has decreased slightly, from all of that, we can see rational utilization of organic waste compost can increase rapid available phosphorus content in soil apparently.

(4) The effect on the calcium content of the soil in mulching area in peach orchard

The calcium element in the soil is one of the most elements to ensure the soil fertility. The loss of calcium will worsen the soil tilth, influence the soil quality and then have a bad effect on crop yield.

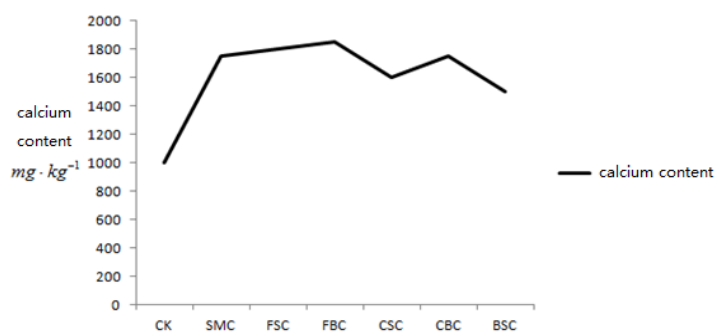


Figure 3: The effect of different organic compost mulching on the calcium content of soil in mulching area in peach orchard

It is known from figure 3 that calcium content of CK group is higher than that of other groups' because calcium fertilizer was used. When compost substrate of organic waste was added to the soil, calcium content of the soil was increased. And the calcium content of different groups was insignificant because calcium content in chicken manure and cow dung is high. The sequence of calcium content in soil of different groups is FBC>SMC>FSC >CBC>CSC>BSC>CK.

3.2 The effect of different organic compost mulching on peach tree roots

(1)The effect on the different diameter dry root weight and root density of peach trees(see Table 3)

Table 3: The effect of different organic compost on the different diameter dry root weight and root density of peach trees

Number	Different diameter dry root weight($g \cdot m^{-3}$)			Root density ($g \cdot m^{-3}$)
	<1mm	1-2mm	2-5mm	
FBC	21.7	19.0	15.7	51.2
CBC	19.4	14.1	13.6	41.3
FSC	20.2	17.7	14.5	49.4
CSC	17.7	15.4	12.4	44.5
SMC	12.7	11.8	10.0	32.5
BSC	11.5	10.7	9.5	30.7
CK	7.1	8.8	8.1	23.3

From Table 3, we can see that the plant roots that having been processed by various compost substrate has increased in number and root density. It shows that after mulching by organic waste compost substrate, the peach roots number has been increased, and the density has been enlarged. The surviving ability has been strengthened.

(2) The effect on the root activity of the peach tree

Root activity is an important index to value the root function (Zhang et al., 2015). After mulching different organic waste compost substrate, sampling the plants roots processed in different ways to evaluate the root activity. The results showed that the methods of fowl manure and bark compost(FBC) and fowl manure and saw dust compost (FSC) had the most effective influence on the root activity. The sequence of influence strength of other groups is FBC>FSC>CBC>CSC>BSC>SMC>CK, which reflects that different waste compost substrate mulched in the soil can boost the root activity of the peach tree and promote the absorption of water and nutrition.

3.3 The effect of different years of organic compost mulching on the soil in apple orchard

(1) The effect on the moisture content of the soil of the apple orchard

Figure 4 shows that different years of organic compost mulching on the soil can decrease the evaporation of water in soil and thus to increase the moisture content of it. On one hand, along with the ever-increasing of the years of mulching, the soil moisture content kept increasing. The main reason is that with the increasing of mulching years of the organic waste compost substrate, the granular structure of the soil has been changed and the moisture conservation ability of the soil has been enhanced.

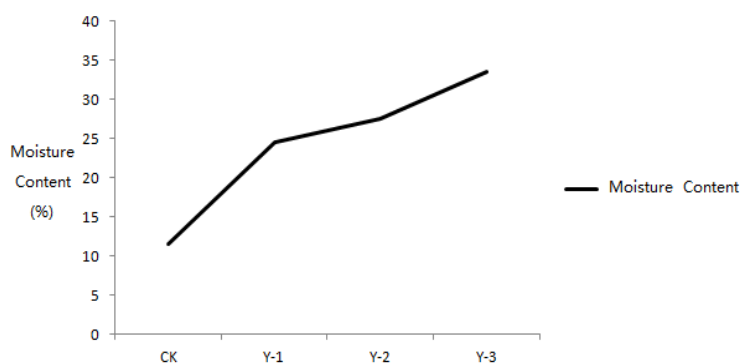


Figure 4: The effect of different years of organic compost mulching on the moisture content of soil in apple orchard

(2) The effect on the soil bulk density of the apple orchard

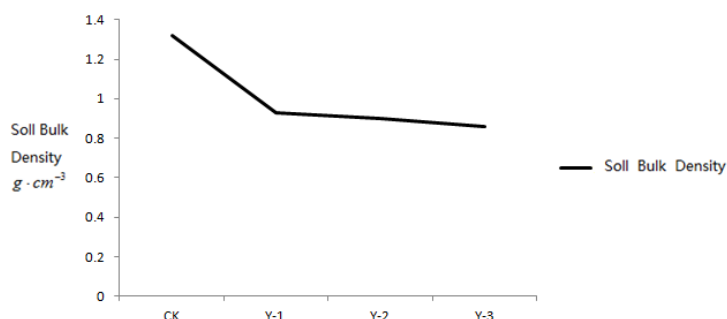


Figure 5: The effect of different years of organic compost mulching on soil bulk density in the apple orchard

From Figure 5, it can be seen that organic waste compost can improve soil pore space, decrease soil bulk density and promote the formation of granular structure, as well as enlarge the soil porosity, playing an effective way in improving the soil property. (Zhang and Wang, 2014)

(3) The effect on the soil organic material in apple orchard (see Table 4)

Table 4: The effect of different years of organic compost mulching on soil organic material in the apple orchard

Number	Organic material content($g \cdot kg^{-1}$)	
	0-20cm	20-40cm
CK	22.5	15.1
Y-1	42.3	26.2
Y-2	51.9	25.3
Y-3	64.7	33.7

From the figure in the Table above, it can be seen that, comparing with the contrast group, the organic material content of the other three groups has been increased obviously, and along with the increasing of years, the organic content kept increasing. The reason refers to the organic waste compost substrate are just mulched on the soil surface, the remain soil cannot be decomposed apart from the surface that contacting with the substrate.

3.4 The effect of different years of organic compost mulching on apple quality

From the data showed in the above Table, we can know that along with the increasing of years of organic compost mulching, the weight of single fruit of the experimental groups has increased. Meanwhile the fruit firmness is another important index of the fruit quality and rank. From the fact mentioned above, along with the increasing of mulching years of the organic waste compost substrate, the fruit quality can be increased.

Table 5: The effect of different years of organic compost mulching on apple quality

Number	Weight of single fruit g	Fruit firmness($kg \cdot cm^{-2}$)
CK	97.4	11.7
Y-1	132.4	11.1
Y-2	140.3	11.4
Y-3	180.2	10.1

4. Conclusion

The experimental result shows that, the mulching of organic compost do play a significant role in improving the soil quality, increasing the physical, chemical and biological properties of the soil evidently(Bennett and Holman 2013). Mulching organic compost on crops can effectively increase the water content in the soil and strengthen the power of locking water, thus ensure the nutrient content in the soil. in various organic compost, there are different micro-elements like nitrogen, phosphorus and potassium, when mulching them on crops, they can permeate in the soil through rainfall. In this way, the nutrient elements in the soil are increased, and thus the crop can have enough nutrient and well living environment (Mao et al, 2012). The effect and influence of various organic compost mulching on orchard soil property are discussed here, to improve soil ecological structure, utilize and circulate wastes resource rationally and increase the reservoir storage of orchard. The results showed that different organic waste compost substrate all play significant roles in boosting the growth of fruit trees (Eickenscheidt et al, 2015). Through the mulching of organic waste compost substrate, the nutrients in them were subtracted by the plants roots, which is good for the accumulation of carbohydrate in the plants, and also for increasing the number and activity of the roots. It does good to maintain the normal metabolism of the cells.

In all, mulching organic waste compost substrate in orchard can improve the soil property and structure, increase the soil fertility and keep the water content of the soil, as well as boost the nutrients absorption and utilization of the fruit trees and strengthen the tree nutrients, thus to improve the fruit quality and output, accelerate the sustainable development of Chinese agriculture.

Reference

- Bennett J., Holman J., 2013, Techno-economic analysis of solid oxide fuel cell-based combined heat and power systems for biogas utilization at wastewater treatment facilities, *Journal of Power Sources*, 233, 380-393.
- Bindraban P.S., Velde M.V.D., Ye L., 2012, Assessing the impact of soil degradation on food production, *Current Opinion in Environmental Sustainability*, 4, 478-488.
- Eickenscheidt T., Heinichen J., Drösler M., 2015, The greenhouse gas balance of a drained fen peatland is mainly controlled by land-use rather than soil organic carbon content, *Biogeosciences*, 12, 5161-5184.
- Jayathilakan K., Sultana K., Radhakrishna K., 2012, Utilization of byproducts and waste materials from meat, poultry and fish processing industries: a review, *Journal of Food Science and Technology*, 49, 278-293.
- Mao S.S., Shen S., Guo L., 2012, Nanomaterials for renewable hydrogen production, storage and utilization. *Progress in Natural Science Materials International*, 22, 522-534.
- Swanepoel P.A., Botha P.R., Preez C.C.D., 2015, Managing cultivated pastures for improving soil quality in South Africa: challenges and opportunities, *African Journal of Range & Forage Science*, 32, 1-6.
- Zhang X., Deng S., Wang X., 2015, Impact of decay promoting agent on maturity changes during composting of livestock and poultry manure, *Chinese Journal of Environmental Engineering*, 9, 888-894.
- Zhang X.C., Wang X.D., 2014, Nitrogen Transformation and Loss in Livestock and Poultry Manure Mixture During Rapid Composting Process, *Journal of Agro-Environment Science*, 33, 458-464.