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Full Length Article

Effects of Dimethylpentalin on Enzyme Activity and Microbial Diversity in Sorghum Soil

Wenbin Bai[1,2], Jianping Hao[1*], Jianhua Zhang[2], Ruifeng Guo[2], Changlin Cao[2] and Xiaoyan Jiao[3]
[1]*College of Agriculture, Shanxi Agricultural University, Taigu 030801, Shanxi Province, China*
[2]*Sorghum Institute of Shanxi Academy of Agricultural Sciences/Shanxi Key Laboratory of Sorghum Genetic and Germplasm Innovation, Jinzhong 030600, Shanxi, China*
[3]*Institute of Agricultural Environment & Resources, Shanxi Academy of Agricultural Sciences, Taiyuan 030031, Shanxi, China*
[*]For correspondence: tghjp88@sina.com
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Abstract

To explore the effects of different concentrations of dimethylpentyl on soil enzyme activity and microbial community influence, the changes of soil invertase, urease, catalase, polyphenol oxidase, alkaline phosphatase, bacterial number, fungal number, bacterial and fungal community diversity under the two treatments (indoor potted and field environment) were studied. The results showed that the activity of soil enzyme was activated by dimethylpentylene, and there was no obvious concentration effect relationship. The community of soil bacteria and fungi was sensitive to the change of concentration of dimethylpentylene forest, which changed with the change of application concentration. © 2020 Friends Science Publishers

Keywords: Dimethylpentalin; Soil enzyme activity; Soil microorganism; Sorghum

Introduction

Herbicide application is an effective way to remove weeds and other plants in the field and to reduce the overwintering base of some field pests to ensure crop production. Under the background of long-term applications, herbicides also led to a series of ecological damages. Many researches have confirmed that the long-term use of herbicides can cause damages to soil ecosystem, the decrease of soil organisms and the decrease of soil fertility (Li *et al.* 2007; Wang *et al.* 2012). The use of pesticides has a great impact on the soil microorganisms. The types of microorganisms in the soil environment are diverse and bacteria are the main part of the microbial composition (Zhang *et al.* 2019). The types and quantities of beneficial microorganisms in the soil affect the quality of the soil (Moroenyane *et al.* 2018), while pesticides have a great impact on the bacterial flora in the soil (Li *et al.* 2017).

Dimethylpentylene is a dinitroaniline herbicide, which can be applied to a variety of vegetables and crops (Swarcewicz and Gregorczyk 2012). The problem of soil quality after the application of dimethylpentylene has been widely concerned by relevant scholars (Triantafyllidis *et al.* 2009). It has been confirmed that herbicides have certain effects on soil organisms by some scholars (Swarcewicz and Gregorczyk 2012). Babich and Stotzky (1983) showed that soil microorganisms in the soil ecosystem had its specific response mechanism to pesticide application. Enzyme activity and microorganism of native soil have been regarded as an important index of soil quality by many scholars (Trasar-Cepeda *et al.* 2000; Marx *et al.* 2001). Soil microorganisms play a key role in pesticide degradation and biotransformation (Ye *et al.* 2018). The change of community structure and function can indirectly reflect the severity and sustainable development of soil pollutants (Becerra-Castro *et al.* 2015). Sorghum is one of the most important cereal crops in the world. It has a wide range of uses, and has a usable value in food, industry, environmental protection, agriculture and other aspects (Lu *et al.* 2009). Sorghum in China is mainly planted in Inner Mongolia, Shanxi, Guizhou and other places (Jing *et al.* 2014), mostly in poor soil. Up to now, the researches on dimethylpentylene at home and abroad mostly focused on pesticide residues in soil, while the researches on enzyme activity and microbial diversity in Sorghum planting soil are less (Chopra *et al.* 2015; Jia *et al.* 2015).

In order to study the effect of dimethylpentyl on soil enzyme activity and microorganism in the sorghum planting area, this paper describes the effect of dimethylpentyl on soil enzyme activity and microorganism by measuring the changes of soil enzyme activity and microorganism after application of different concentrations of dimethylpentyl. The purpose of this study was to explore the response law of dimethylpentylene and provide theoretical basis for the scientific and reasonable use of dimethylpentylene.

Materials and Methods

Test soil treatment

The soil was collected from the uncultivated farmland in the papaya mining area of Shuozhou city, Shanxi province. The soil with a depth of 0 ~ 20 cm was collected, where the soil texture was loam. It was filter with 2 mm sieve, and then put into flowerpots, each of which contained 3 kg of soil. Dimethylpentyl EC 33% was purchased from Tianjin Jingjin pesticide factory. The effective content of dimethylpentylene was 0, 200, 400, 600, 800, 1000, 1200, 1400 g a.i. ha^{-1} respectively. After treatment, it was cultured in a 25℃ incubator, and the soil water content was maintained at about 25% by adding sterile water every day. The activities of various enzymes in the soil were measured. The test was repeated three times in parallel.

Detection method of soil enzyme activity

Soil urease activity was determined by phenol sodium hypochlorite colorimetry with NH_3-N (mg g^{-1} d^{-1}); invertase activity was determined by 3, 5-Dinitrosalicylic acid colorimetric method was used to measure the activity of glucose (mg^{-1} d^{-1}); alkaline phosphatase was used to measure the activity of sodium phenylphosphate colorimetric method, and phenol (mg^{-1} d^{-1}); catalase activity was used to measure the activity of potassium permanganate titration method, and $KMnO_4$ (mL g^{-1} d^{-1}). Polyphenol oxidase activity was used to measure the activity of pyrogallol (mg^{-1} d^{-1}) (Shao 2007). The test was repeated three times in parallel.

Detection of soil microbial quantity and community diversity

The number of main groups of soil microorganisms was determined by the dilution coating plate method (Shao 2007). Bacteria were grown in beef extract peptone medium and fungi in Martins medium. Soil microbial diversity was determined by denaturing gradient gel electrophoresis (Lisa *et al*. 2001; Shao 2007). Excel 2007 and SPSS 19.0 were used to analyze the data, and Quantity 4.6.2 was used to analyze DGGE.

Results

Effect on invertase activity

The result showed that there were two peaks with different treatments. In the potted environment, the enzyme activity reached a peak value of 0.245 g g^{-1} h^{-1} at 400 g a.i. ha^{-1}, and then showed a downward trend, indicating that the inhibition effect was shown, reaching the second peak value of 0.346 g g^{-1} h^{-1} at 1400 g a.i. ha^{-1}. In the field environment, the changing trend was similar to that of the potted plant, and the peak value was 0.317 g g^{-1} h^{-1} under the treatment of 400 g a.i. ha^{-1}. Then the enzyme activity decreased to 1400 g a.i. ha^{-1} and increased again to 0.329 g g^{-1} h^{-1} (Table 1).

Effect on urease activity

The effect of dimethylpentylene on urease activity was different from that of the sucrase activity. With the increase of treatment concentration, the activity of urease gradually increased, reaching the peak value at 800 g a.i. ha^{-1}, which was 1.562 g a.i. ha^{-1}, then gradually decreased to 0.195 g a.i. ha^{-1}at 1400 g A.I./hm^2. The urease activity also showed similar changes in the field environment, and reached the highest level at 800 g a.i. ha^{-1}, which was significantly higher than other treatments (Table 2).

Effect on catalase activity

The change of catalase activity in different treatments was not significantly different from that of sucrase and urease. It can be seen from Table 3 that the catalase activity in the treatment of 600 g a.i. ha^{-1} in pot and field environment was the lowest and significantly lower than that in other treatments, and there was no significant difference among other treatments.

Effect on polyphenol oxidase

It can be seen from Table 4 that the activity of PPO is generally low under the treatment of dimethylpentylene, and the difference is not obvious under different treatments. With the increase of the concentration of dimethylpentylene, the activity of PPO in the potted environment gradually increased, reaching the peak value at 600 g a.i.·ha^{-1}, which is 0.0039 g a.i. ha^{-1}, and then gradually decreases, showing the inhibition effect, to 1400 g a.i. ha^{-1}Then it picked up to 0.0032 g a.i. ha^{-1}. The PPO activity in the field also showed the same trend.

Effect on alkaline phosphatase

The effect of dimethylpentylene on alkaline phosphatase activity showed that with the concentration of dimethylpentylene increasing, the enzyme activity first decreased and then increased, then decreased and finally increased. When the concentration of dimethylpentylene was 400 g a.i. ha^{-1} to 600 g a.i. ha^{-1}, the enzyme activity reached 0.034 g a.i. ha^{-1}, the first peak, and then decreased to 1200 g a a.i.·ha^{-1}, the enzyme activity reached 0.078 g a.i. ha^{-1}, which was the second peak. The trend of change in the field environment is similar to that in the potted environment (Table 5).

Impact on the number of bacteria and fungi

The effect of different concentrations of dimethylpentylene

Table 1: Effect of different concentrations of dimethylpentylene on soil invertase activity (g g^{-1} h^{-1})

Concentration (g a.i. ha^{-1})	Potted plant	Field
0	0.113 ± 0.001a	0.105 ± 0.009a
200	0.160 ± 0.018bc	0.141 ± 0.008a
400	0.245 ± 0.015d	0.317 ± 0.104b
600	0.195 ± 0.017c	0.176 ± 0.021a
800	0.168 ± 0.008bc	0.149 ± 0.003a
1000	0.157 ± 0.005bc	0.165 ± 0.001a
1200	0.128 ± 0.010ab	0.119 ± 0.012a
1400	0.346 ± 0.006e	0.329 ± 0.006b

Table 2: Effect of different concentrations of dimethylpentylene on soil urease activity (g g^{-1} h^{-1})

Concentration (g a.i. ha^{-1})	Potted plant	Field
0	0.076 ± 0.002a	0.072 ± 0.005a
200	0.949 ± 0.008e	0.886 ± 0.017c
400	0.132 ± 0.009c	0.132 ± 0.009b
600	0.137 ± 0.010c	0.097 ± 0.014a
800	1.562 ± 0.006f	1.404 ± 0.007d
1000	0.107 ± 0.003b	0.077 ± 0.001a
1200	0.069 ± 0.003a	0.070 ± 0.004a
1400	0.195 ± 0.009d	0.146 ± 0.003b

Table 3: Effect of different concentrations of dimethylpentylene on catalase activity in soil (g g^{-1} h^{-1})

Concentration (g a.i. ha^{-1})	Potted plant	Field
0	4.361 ± 0.074b	4.044 ± 0.037b
200	4.369 ± 0.075b	3.745 ± 0.078b
400	4.812 ± 0.232b	4.812 ± 0.232b
600	2.228 ± 0.512a	1.361 ± 0.248a
800	4.031 ± 0.037b	3.993 ± 0.076b
1000	4.685 ± 0.037b	2.967 ± 0.076b
1200	4.095 ± 0.074b	3.993 ± 0.075b
1400	3.880 ± 0.967b	2.872 ± 0.136b

Table 4: Effect of different concentrations of dimethylpentylene on the activity of soil polyphenol oxidase (g g^{-1} h^{-1})

Concentration (g a.i. ha^{-1})	Potted plant	Field
0	0.0018 ± 0.0001ab	0.0020 ± 0.0002ab
200	0.0021 ± 0.0001abc	0.0024 ± 0.0002bc
400	0.0038 ± 0.0002d	0.0038 ± 0.0002de
600	0.0039 ± 0.0009d	0.0041 ± 0.0007e
800	0.0028 ± 0.0001bcd	0.0028 ± 0.0001bcd
1000	0.0024 ± 0.0001bc	0.0024 ± 0.0002bc
1200	0.0010 ± 0.0001a	0.0012 ± 0.0001a
1400	0.0032 ± 0.0002cd	0.0033 ± 0.0001cde

on the number of soil bacteria is different. As shown in Table 6, under the treatment of 0- g a.i. ha^{-1}, dimethylpentylene has a certain activation effect on the number of bacteria in potted environment and field environment, and the activation effect is more significant. Under the treatment of 600–800 g a.i. ha^{-1}, the number of bacteria begins to decline, and then increases when it reaches 1000–1400 g a.i. ha^{-1} Trends. The number of bacteria in the field was similar to that in the potted plant, and it was activated at 0–400 g a.i. ha^{-1}. The number of bacteria in the treatment of 600–1400 g a.i. ha^{-1} was significantly lower than that in the treatment of 0–400 g a.i. ha^{-1}. It can be seen that the number of bacteria reached a

Table 5: Effect of different concentrations of dimethylpentylene on soil alkaline phosphatase activity (g g^{-1} h^{-1})

Concentration (g a.i. ha^{-1})	Pot	Field
0	0.030 ± 0.009ab	0.017 ± 0.002a
200	0.010 ± 0.002a	0.014 ± 0.006a
400	0.034 ± 0.002ab	0.034 ± 0.002abc
600	0.034 ± 0.001ab	0.038 ± 0.002bc
800	0.027 ± 0.005ab	0.025 ± 0.002ab
1000	0.046 ± 0.009b	0.040 ± 0.001bc
1200	0.078 ± 0.012c	0.082 ± 0.012d
1400	0.056 ± 0.002b	0.051 ± 0.003c

Table 6: Effect of different concentrations of dimethylpentylene on the number of soil bacteria (10^5 cfu g^{-1})

Concentration (g a.i. ha^{-1})	Potted plant	Field
0	4.75 ± 0.66a	2.08 ± 0.58a
200	16.33 ± 1.56d	11.33 ± 0.82d
400	11.37 ± 0.94c	11.37 ± 0.94d
600	5.13 ± 0.20a	3.73 ± 0.19ab
800	7.77 ± 0.12b	7.97 ± 0.15c
1000	10.03 ± 0.33bc	4.60 ± 0.40b
1200	7.90 ± 0.06b	2.60 ± 0.06a
1400	10.80 ± 0.15c	4.73 ± 0.12b

general balance at 1000–1400 g a.i. ha^{-1}.

The effect of different concentrations of dimethylpentylene on the number of soil fungi is shown in Table 7. The number of fungi in the potted environment decreased to different degrees, all of which were lower than those in the untreated environment. Except for the number of fungi in the treatment of 1000 g a.i. ha^{-1}, the number in the other treatments was significantly lower than that in the untreated environment. The number of fungi in 200 g a.i. $ha^{-1}$and 1400 g a.i. ha^{-1} treatments was significantly lower than that in other treatments, but there was no significant difference among other treatments. The trend of change and potted environment was different under the field environment. Compared with the untreated environment, different concentrations of dimethylpentylene had different degrees of activation on the number of fungi. It can be seen that under the treatment of 400 g a.i. ha^{-1}, the number of fungi reached a peak value of 16.07 10^3 CFU g^{-1}, with obvious activation effect, and then decreased to a certain extent.

Impact on soil bacterial community diversity

The diversity of the bacterial communities in different treatments of the potted environment is significantly different (Fig. 1). From Table 8, it can be seen that the diversity of bacterial community under 8 concentrations treatment is very different. The similarity of the bacterial community under 1000 g a.i. $ha^{-1}$and 1200 g a.i. ha^{-1} treatment is the highest, 67.4%. With the increase of the concentration of dimethylpentylene forest, the diversity of bacterial community and Shannon index also increased (Table 9).

It can be seen from Fig. 2 that the diversity of soil bacterial community under different concentrations of dimethylpentylene forest treatment in the field environment

Table 7: Effect of different concentrations of dimethylpentylene on the number of soil fungi (10^3 cfu g^{-1})

Concentration (g a.i. ha^{-1})	Potted plant	Field
0	19.25 ± 1.75c	4.92 ± 0.55a
200	12.33 ± 1.48a	7.58 ± 1.75b
400	16.07 ± 0.19b	16.07 ± 0.19c
600	16.40 ± 0.44b	14.12 ± 0.24c
800	15.68 ± 0.43b	14.40 ± 0.10c
1000	18.96 ± 0.48bc	15.46 ± 0.24c
1200	16.29 ± 0.24b	15.07 ± 0.25c
1400	9.90 ± 0.39a	6.62 ± 0.40ab

Table 8: The similarity of bacterial community under different concentrations of dimethylpentane forest in pot

	0	200	400	600	800	1000	1200	1400
0	100							
200	42.1	100						
400	0.0	7.3	100					
600	0.0	0.0	51.8	100				
800	0.0	0.0	14.3	37.7	100			
1000	0.0	12.9	25.7	11.7	9.6	100		
1200	0.0	24.6	28.6	9.1	9.8	67.4	100	
1400	0.0	0.0	28.0	32.5	24.8	31.7	45.9	100

Table 9: Shannon index of bacterial community under different concentrations of dimethylpentane forest

0	200	400	600	800	1000	1200	1400
0.79	0.61	0.53	1.04	0.92	1.35	1.22	1.46

Table 10: The similarity of bacterial community under different concentrations of dimethylpentane forest in the field

	0	200	400	600	800	1000	1200	1400
0	100							
200	56.1	100						
400	43.5	55.1	100					
600	34.1	36.0	68.7	100				
800	29.4	20.3	24.3	24.9	100			
1000	43.6	39.6	58.7	57.7	38.0	100		
1200	38.4	35.3	37.7	23.1	58.1	45.0	100	
1400	45.8	35.0	58.0	54.3	33.0	77.7	37.5	100

Table 11: Shannon index of bacterial community under different concentrations of dimethylpentane forest in the field

0	200	400	600	800	1000	1200	1400
1.87	1.36	0.45	0.33	0.52	0.79	1.32	1.40

is different from that under the potted environment. The similarity of bacterial community diversity under 400 g a.i. ha^{-1} and 600 g a.i. ha^{-1} treatment is the highest, which is 68.7%. Shannon index showed a trend of decreasing first and then increasing (Table 10–11).

Impact on the diversity of soil fungal community

The diversity of the fungal community was significantly different under different treatments in the potted environment (Fig. 3). From Table 12, it can be seen that the diversity of fungal community under 8 concentrations treatment was very different, and the similarity of 400 g a.i. ha^{-1} and untreated fungal community was the highest, 69.4%. With the increase of the concentration of dimethylpentylene forest, the diversity of fungal community and Shannon index also increased (Table 13).

From Fig. 4 we can see that the diversity of the soil fungal community under the treatment of different concentrations of dimethylpentylene forest in the field environment is different from that under the potted

Fig. 1: Effect of different concentrations of dimethylpentylene on the diversity of bacterial community in potted soil
From left to right: 0, 200, 400, 600, 800, 1000, 1200, 1400 g a.i. ha^{-1}

Fig. 2: Effects of different concentrations of dimethylpentylene on the diversity of soil bacterial community in the field
From left to right: 0, 200, 400, 600, 800, 1000, 1200, 1400 g a.i. ha^{-1}

Table 12: The similarity of fungal community under different concentrations of dimethylpentane forest in pot

	0	200	400	600	800	1000	1200	1400
0	100							
200	55.4	100						
400	69.4	26.2	100					
600	58.3	65.4	36.0	100				
800	0.0	17.2	0.0	0.0	100			
1000	0.0	6.8	0.0	0.0	26.6	100		
1200	56.7	42.7	45.1	33.5	10.9	15.7	100	
1400	0.0	11.3	6.6	21.9	11.6	15.5	33.9	100

Table 13: Shannon index of fungal community under different concentrations of dimethylpentylene forest in pot

0	200	400	600	800	1000	1200	1400
0.51	0.72	0.63	0.48	0.96	1.10	1.23	1.55

Table 14: The similarity of fungal community under different concentrations of dimethylpentane forest in the field

	0	200	400	600	800	1000	1200	1400
0	100							
200	50.6	100						
400	35.9	33.8	100					
600	13.1	17.7	17.0	100				
800	36.4	32.2	46.3	13.6	100			
1000	17.9	33.5	62.5	14.8	43.3	100		
1200	49.9	54.7	51.6	9.1	55.2	54.4	100	
1400	56.9	58.4	42.8	13.5	50.6	45.1	80.7	100

Table 15: Shannon index of fungal community under different concentrations of dimethylpentane forest in the field

0	200	400	600	800	1000	1200	1400
1.13	1.20	0.89	1.46	1.37	0.32	0.88	0.84

environment. The similarity of bacterial community diversity under the treatment of 400 g a.i. ha^{-1} and 1000 g a.i. ha^{-1} is the highest, which is 62.5%. Shannon index showed a trend of decreasing first, then increasing and finally decreasing (Table 14–15).

Discussion

Soil enzyme is a biologically active protein in soil, which, together with soil microorganisms, promotes the biochemical process of soil. Soil enzyme plays an important role in the initial stage of decomposition of organic residues and the transformation of some inorganic compounds, and has an important impact on the evolution of soil fertility. When the activity and quantity of soil microorganism decrease, soil enzyme keeps the soil metabolism at a relatively stable level (Frostegard *et al.* 1993), which is a biological index reflecting the soil quality (Liu *et al.* 2001; Zhang *et al.* 2009). Soil enzymes play an important role in the process of soil material cycle and energy conversion. The study of soil enzyme activity is helpful to understand the status and evolution of soil fertility.

Invertase was closely related to the degree of soil ripening. In this study, different concentrations of

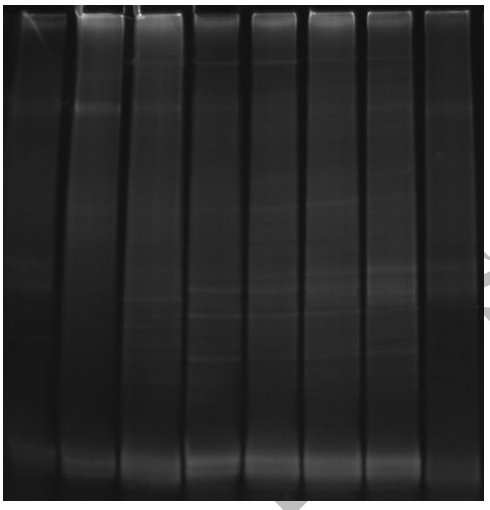

Fig. 3: Effect of different concentrations of dimethylpentylene on diversity of soil fungal community in pot
From left to right: 0, 200, 400, 600, 800, 1000, 1200, 1400 g a.i. ha^{-1}

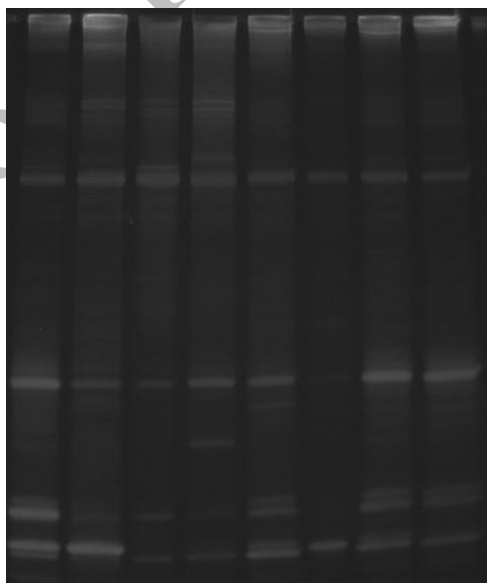

Fig. 4: Effect of different concentrations of dimethylpentylene on the diversity of soil fungal community in the field
From left to right: 0, 200, 400, 600, 800, 1000, 1200, 1400 g a.i.ha^{-1}

dimethylpentylene in pot and field environment promoted the activity of invertase to a certain extent. After 400 g a.i. ha^{-1}, the effect of high concentration on invertase activity gradually decreased, which was close to the untreated soil. Some scholars have shown that there are dimethylpentylene degrading bacteria (Das *et al.* 2012) in the soil, and the microbial community in the soil is different, so the effect of promoting sucrase activity is also different. Urease is closely related to the transformation, absorption and utilization of soil nitrogen. Pot experiment showed that dimethylpentylene could activate urease activity in the soil. (Sireesha *et al.* 2012) study showed that dimethylpentylene

had a certain effect on urease activity. Field experiments showed that dimethylpentylene can activate urease activity. The reason may be that the field soil has sufficient light and high microbial biological activity, and there are kinds of microorganisms degrading dimethylpentylene in the soil, so the enzyme activity is improved. Catalase is closely related to the activity of microorganisms, which can reduce the toxicity of the surrounding environment to microorganisms. In this study, after the application of dimethylpentylene, the overall effect is to inhibit catalase activity, but the degree of inhibition is weak. When the dose of dimethylpentylene is a certain amount, it also shows a certain promoting effect on catalase. Some scholars have shown that the effect of dimethylpentalin on catalase is not obvious (Jing *et al.* 2010), and this study is similar to this study. The activities of PPO in different concentrations of dimethylpentylene were different, but the overall performance was to promote the enzyme activity to a certain extent. With the increase of the concentration of dimethylpentylene, the activities of PPO also showed a trend of increasing. Sireesha *et al.* (2012) showed that different concentrations of dimethylpentyl had a certain activation effect on soil enzyme activity, and the results of this study were also consistent with this. Alkaline phosphatase (ALP) was closely related to the transformation and utilization of soil phosphorus, and the activity of ALP was different under different concentrations of dimethylpentyl forest. In this study, the activity of dimethylpentylene increased. Some scholars have confirmed that dimethylpentylene can promote the activity of alkaline phosphatase, which is shown by the changes of enzyme activity in potted and field environment. With the different concentrations of dimethylpentylene, the change of soil enzyme activity also has a dramatic change (Chopra *et al.* 2010). Guo Yanmei and other researchers believe that the impact of dimethylpentylene on soil enzyme indirectly reflects the degree of its harm to the ecological environment (Guo 2014). In general, the application of dimethylpentylene can affect soil enzyme activity, thus affecting soil nutrient cycle and metabolism.

Soil microorganism is an important role in the soil ecosystem, which plays an irreplaceable role in the adaptation, degradation and transformation of pesticides in soil (Horton and Bruns 2001; Zhang *et al.* 2003). Soil microorganisms are sensitive to subtle changes in the environment and can be used as sensitive indicators to observe the biological properties of soil (Artursson *et al.* 2006; Manickam *et al.* 2010). Many research results show that some herbicides can inhibit or kill soil microorganisms, and some can promote some microorganisms in the soil. It can be seen that different drugs have different effects on soil microorganisms (Jing *et al.* 2010). From the perspective of the external environment, dimethylpentylene is degraded in the soil mainly through microbial metabolism, hydrolysis, photolysis and other ways (Pinto *et al.* 2011). The community structure, soil type, soil organic matter, soil moisture content, soil pH and other factors of soil microorganisms will affect the degradation of dimethylpentylene (Kulshrestha *et al.* 2015). In this study, dimethylpentylene showed a certain activation effect on Soil Micro bacteria and fungi in potted and the field environment. The effect of dimethylpentylene on soil microbial number and community diversity varied with the concentration of dimethylpentylene. Under the influence of different concentrations of dimethylpentylene forest, bacterial and fungal communities showed different biodiversity indexes, and showed obvious differences among communities, which indicated that they were sensitive to the influence of soil microbial community structure. Shao *et al.* (2011) studied the soil microbial community of artificial larch forest after applying chlorothalonil. The effect of dimethylpentylene on soil bacteria and fungi was greater than that on actinomycetes. When there are microorganisms that can degrade dimethylpentylene in the environment, it will increase the number and proportion of these kinds of microorganisms (Haiier *et al.* 2011). Some studies have shown that the main degradation of dimethylpentylene in the environment is bacillus and Azotobacter in some fungi and bacteria, and dimethylpentylene can be the only carbon source for growth (Ni *et al.* 2016). The increase of the number and proportion of these microorganisms may be one of the reasons why dimethylpentyl can activate the soil microorganisms. The results showed that chlorothalonil had certain activation effect on soil microorganisms (Shao *et al.* 2011), and the results of this study were similar to this. Some scholars have also shown that a certain concentration of dimethylpentylene can inhibit the number of soil microorganisms, which may be related to the soil environment, application days and application concentration (Yan *et al.* 2005).

Conclusion

The residues of different pesticides in the soil after application will have a series of biological effects on the soil ecological environment. As the main participants of the soil ecological environment, soil microorganisms also improve a series of pollution caused by pesticides through their own community adaptation mechanism. From the perspective of this study, the response mechanism of soil microorganisms to chemical pesticides remains unresolved, and the role and value of soil microorganisms in pesticide residue soil need further research and development.

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Author Contributions

Wenbin Bai conceived and designed the experiments and wrote the paper; Wenbin Bai and Jianping Hao performed the soil microbial quantity and community diversity; Jianhua Zhang and Ruifeng Guo performed the soil enzyme activity; Changlin Cao and Xiaoyan Jiao analyzed the data.

Reference

Artursson V, RD Finlay, JK Jansson (2006). Interactions between arbuscular mycorrhizal fungi and bacteria and their potential for stimulating plant growth. *Environ Microbiol* 8:1–10

Babich H, G Stotzky (1983). Developing standards for environmental toxicants: the need to consider abiotic environmental factors and microbe-mediated ecologic processes. *Environ Health Persp* 49:247–260

Becerra-Castro C, AR Lopes, I Vaz-Moreira, EF Silva, CM Manaia, OC Nunes (2015). Wastewater reuse in irrigation: a microbiological perspective on implications in soil fertility and human and environmental health. *Environ Intl* 75:117–135

Chopra I, R Chauhan, B Kumari (2015). Persistence of pendimethalin in/on wheat straw, soil and water. *Bull Environ Contam Toxicol* 95:694–699

Chopra I, B Kumari, SK Sharma (2010). Evaluation of leaching behavior of pendimethalin in sandy loam soil. *Environ Monit Assess* 160:123–126

Das AC, H Nayek, SD Nongthombam (2012). Effect of pendimethalin and quizalofop on N_2-fixing bacteria in relation to availability of nitrogen in a Typic Haplustept soil of West Bengal, India. *Environ Monit Assess* 184:1985–1989

Frostegard A, A Tunlid, E Baath (1993). Phospholipid fatty acid composition，biomass and activity of microbial communities form two soil types experimentally exposed to different heavy metals. *Appl Environ Microbiol* 59:3605–3617

Guo MY (2014). Degradation dynamics of two herbicides in soil and effect on soil enzymes. *MSc Thesis*. Henan Institute of Science and Technology, Xinxiang, China

Haiier L, M Tonolla, J Zopfi, R Peduzzi, W Wildi, J Poté (2011). Composition of bacterial and archaeal communities in freshwater sediments with different contamination levels (Lake Geneva, Switzerland). *Water Res* 45:1213–1228

Horton TR, TD Bruns (2001). The molecular revolution in ectomycorrhizal ecology：peeking into the black-box. *Mol Ecol* 10:1855–1871

Jia HJ, Q Jin, Y Liang, XQ Han, DS Yang (2015). Residue and dissipation of pendimethalin by high performance liquid chromatography in cotton soil fields at different depths. *J Shihezi Univ Nat Sci* 33:689–693

Jing RY, LY Wang, JY Wang, HB Tan, GQ Mu, WD Wang (2010). Effect of acetochlor application on soil microorganism number and enzymes activities. *Chin J Eco-Agric* 18:1302–1305

Jing XL, QS Liu, JA Ping, QJ Cheng, WB Bai, FY Zhang (2014). Development trend and countermeasures for sorghum industry in Shanxi. *J Shanxi Agric Sci* 42:621–624

Kulshrestha G, SB Singh, SSP Lai, NT Yaduraju (2015). Effect of long-term field application of pendimethalin: enhanced degradation in soil. *Pest Manage Sci* 56:202–206

Li J, B Huang, Q Wang, Y Li, W Fang, D Yan, M Guo, A Cao (2017). Effect of fumigation with chloropicrin on soil bacterial communities and genes encoding key enzymes involved in nitrogen cycling. *Environ Pollut* 227:534–542

Li X, KW Pan, P Gao, JC Wang, DG Cai (2007). Effect of the pesticide on soil microbe and enzyme activity. *J Anhui Agric Sci* 35:6510–6512

Lisa AM, S Brenda, GS Michael (2001). Comparative denaturing gradient gel electrophoresis analysis of fungal communities associated with whole plant corn silage. *J Microb* 47:829–841

Liu YL, J Lv, RC Wang (2001). Research on Characteristics of soil microbe in hilly eroded red soil after reclamation. *J Soil Water Conserv* 15:64–67

Lu QS, JQ Zhou, K Zhu, ZP Zhang (2009). On the development of Sorghum Industry in China. *Rainfed Crops* 29:78–80

Manickam N, A Pathak, HS Saini, S Mayilraj, R Shanker (2010). Metabolic profiles and phylogenetic diversity of microbial communities from chlorinated pesticides contaminated sites of different geographical habitats of India. *J Appl Microbiol* 109:1458–1468

Marx MC, M Wood, SC Jarvis (2001). A microplate fluorimetric assay for the study of enzyme diversity in soils. *Soil Biol Biochem* 33:1633–1640

Moroenyane I, BM Tripathi, K Dong, C Sherman, Y Steinberger, J Adams (2018). Bulk soil bacterial community mediated by plant community in mediterranean ecosystem, Israel. *Appl Soil Ecol* 124:104–109

Ni HY, Y Li, N Li, Q Cao, D Chen, J Zhang, Q He, J He (2016). Biodegradation of pendimethalin by *Bacillus subtilis* Y3. *J Environ Sci* 41:121–127

Pinto AP, AT Caldeira, DM Teixeira, E Mestrinho, AV Dordio, MDC Romeiras (2011). Degradation of terbuthylazine, diflufenican and pendimethalin pesticides by *Lentinula edodes*, cultures. *Curr Opin Biotechnol* 22; Article S70

Shao J (2007). Soil microbial diversity under different agricultural utilizations in Shizishan, Wuhan. *MSc Thesis*. Huazhong agricultural university, Wuhan, China

Shao YY, ZY Wang, L Zhou, SP Wu (2011). Effect of chlorothalonil on soil microbial communities of *Larix* artificial shelter-forest. *Acta Ecol Sin* 31:819–829

Sireesha A, PC Rao, CS Ramalaxmi, G Swapna (2012). Effect of pendimethalin and oxyfluorfen on soil enzyme activity. *J Crop Weed* 8:124–128

Swarcewicz MK, A Gregorczyk (2012). The effects of pesticide mixtures on degradation of pendimethalin in soils. *Environ Monit Assess* 184:3077–3084

Trasar-Cepeda C, MC Leir, S Seoane, F Gil-Sotres (2000). Limitations of soil enzymes as indicators of soil pollution. *Soil Biol Biochem* 32:1867–1875

Triantafyllidis V, D Hela, G Salachas, P Dimopoulos, T Albanis (2009). Soil dissipation and runoff losses of the herbicide pendimethalin in tobacco field. *Water Air Soil Pollut* 201:253–264

Wang B, HH Jiao, BL Liu, Y Tian, JY Zheng, ZH Yue (2012). The Research Progress of Soil Enzyme to Pesticide Degradation Mechanism. *Chin Agric Sci Bull* 28:253–257

Yan CR, XQ Zhang, W Gao, XJ Liu (2005). Ecological effect of soil microorganism on chemical pesticide and its adaptive mechanism. *Jiangsu Agric Sci* 2005:82–86

Ye XL, F Fei, XY Lei (2018). Microbial resources and ecology-microbial degradation of pesticides. *Nat Resour Conserv Res* 1:22–28

Zhang C, TT Zhou, LS Zhu, ZK Du, B Li, J Wang, JH Wang, YN Sun (2019). Using enzyme activities and soil microbial diversity to understand the effects of fluoxastrobin on microorganisms in fluvo-aquic soil. *Sci Total Environ* 666:89–93

Zhang HX, XY Wang, HY Qi (2003). Development in research methods of microbial ecology. *Acta Ecol Sin* 23:988–995

Zhang P, HJ Guo, ZL Dao, BY Long (2009). Preliminary study on soil biochemical activities in Gaoligong mountains. *Acta Pedol Sin* 37:275–279