Effect of Wood Vinegar on Seed Germination and Water Implantation of Corn

ZHOU Ling[1,2], JIANG Enchen[2*], and LI Bosong[2]

[1] College of Agricultural Engineering, Tarim University, Alar 843300, Xinjiang, China

[2] Institute of Biomass Energy Research, South China Agricultural University, Guangzhou 510642, China

Abstract: To analyze the effect of wood vinegar on seed germination and seedling growth, the seeds of corn are dipped in wood vinegar of different densities. The results showed that significant effects were found through all the treatments on the seed germination rate, the seed germinating energy and the germinating index. The regress CUBICS curves were developed to describe the relation. The reasonable parameters range was obtained. At the same time, the corn was cultivated by wood vinegar of different densities, aiming to study the effect of wood vinegar on biomass. It showed that all treatments had obvious effects on the seedling length and dry weight aboveground, the chlorophyll and dry weight underground were not included. The research results could be used to direct the wood vinegar deeply refining process and product development.

Key words: wood vinegar, density, corn, germination, seeding growth

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Introduction

Also named plant acid, wood vinegar is a kind of liquid condensate from pyrolysis gas of agricultural and forestry waste. Its composition is complex, which contains lots of organic compounds, such as organic acid (it is basis), aldehyde, ketone, alcohol, phenol and ramifications, a small quantity of alkaline substance such as amine pyridine and some trace elements such as Ca, Mg, Na and Fe[1]. As inartificial non-contaminative agricultural material, wood vinegars were used for plant growth, disinfestations, bacterium restrainer, health and food fields in Japan, Korea, and China[2]. Researchers in China apply it as crop growth accelerant, disinfestations, bacterium restrainer and soil additive[3-8]. At present, there are a few researches take wood vinegar for hastening sprouts. Yang *et al.* uses the wood vinegars of different concentrations to deal with vegetable seeds of Chinese cabbage, little cabbage, radish, water radish and cucumber[9]. It shows that different kinds of wood vinegars bring different effects. Wood vinegar from wood chippings has obvious effects on germination and seedlings growth of Chinese cabbage and radish, but inhibit little cabbage growth. Wood vinegar from palm shells has no effects on germination of water radish, but has accelerative effects on germination and rootstalk growth of other 4 kinds of seeds. Shen *et al.* uses the wood vinegar which is 50×10^{-6} concentrations, eliminated ketone and aldhyde on rice[10]. It shows that there are obviously accelerative effects on germination and seedlings growth of rice. Ma *et al.* uses the wood vinegars with different concentrations to soak the seeds of the North

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ZHOU Ling (1972-), female, Ph. D, Primarily engaging in the use of renewable biomass. E-mail: zhoul-007@163.com

* To whom correspondence should be addressed. E-mail: ejiang@scau.edu.cn

China larch and found the accelerative effects on seeds germination[11]. The above researches show that the effects of wood vinegars are diversified and represent that one kind of wood vinegars has selectivity to different crops. There are different effects on different organs of one crop. Wood vinegars from different raw materials show different effects. In this study, the wood vinegar is produced from sawdust. The seeds of corn are soaked in wood vinegar with different concentrations to study the effect of wood vinegar on seed germination and seedling growth. In addition, hydroponics is used on the corn by the different concentrations of wood vinegar to study the effect of wood vinegar on biomass.

Materials and Methods

Materials

Corn variety: Nongda108 was collected from Agronomy School of South China Agricultural University. Wood vinegar: Sawdust from the wood factory in Huadu and Guangzhou. The equipment of pyrolysis was carbonization reaction kettle. Technical conditions:

Raw material mass: 500 g;

Ending temperature: 500℃;

Time: 2 h.

After the liquid was collected, the tar deposited and filtrated, and then the filtrate was injected in a brown bottle, deposited for 6 months. Table 1 shows the proximate analysis data of wood vinegar.

Methods

Seed germination

There were 6 kinds of dipping liquid. Water was used as the check group. The experiment groups were wood vinegars with different dilution multiples that were 500, 400, 300, 200 and 100. Each group used 30 mL dipping liquid and 50 grains of corn seeds. The dipped seeds were stored under the temperature 25-26℃ for 6 h, and then treated in artificial climate box. The germination number was checked every day in 6 days. The average value was worked out.

Table 1 Proximate analysis data of wood vinegar

pH	Density ($kg \cdot m^{-3}$)	Refractive index (%)	Color	Moisture (%)
3.45	1.0036	13	Brown	78

pH: HNNA meter; Dioptricpower: WTY-4 sugar degree; Density: Weight and volume ratio, repeated three times for the average whose error was less than 0.001 grams per time; Moisture detection[12]: METTLER TOLEDO DL31.

Hydroponics

On Oct. 9th, the corn seeds were dipped for 5 h in water, followed sand culture process. Hydroponics process began on Oct. 10th, under the condition that the corn seedlings whose roots were cultivated well and were displaced in a 1 L vessel with different concentrations of wood vinegars. There were 6 kinds of treatments. The check group was water (CK) and the experiment groups were wood vinegars with different dilution multiples that were 2 000, 1 500, 1 000 and 500. Every treatment was repeated 3 times, and every vessel was considered as one repeat. At a time, 6 to 8 seedlings were chosen and fixed at dividing points of ground stem and underground stem with sponge in foam boards' vessels, then put in a climate box. The climate box was set at the temperature of 25℃, both daytime and nighttime were 12 h. The seedlings' height was measured every day. The experiment was over and chlorophyll content was measured on the third day.

Data processing

SPSS 11.0 statistical software was used to analyze the collecting data for the relativity and analysis of variance and LSD multiple comparisons.

$$\text{Germination rate} = \frac{n}{N} \times 100\%$$

Germination index(Gi),

Gi=$\sum$Gt/Dt, Gt: Germination number on the t day after dipping seeds, Dt: Relevant days number of germination;

Germination trend (Gv)=$\frac{n}{N}$×100% (n=the number of seeds germinated in certain days, N=the total number of seeds);

Relative germination rate (%)= (for germination rate -control germination rate)/control germination rate× 100%;

$\bar{x}=\frac{\sum x_i}{N}$ ($\bar{x}$: average seedlings' length; x_i: every seedlings' length; N: the total number) chlorophyll: SPAD-502 chlorophyll meter;

Dry weight of seedling: 5-6 samples were put into drying, Oven whose temperature was 80℃, dried to constant weight.

Results and Analysis

The effect of different concentrations on corn germination rate

Corn germination rate

Germination rate was an important index to describe the seed prosperities. A high germination rate standing for the number of seeds with vitality was larger and the number of outcome seedlings was larger. It showed that after being dipped in wood vinegar of different concentrations, the germination rate of seeds was influenced by concentrations, and with the increased diluted multiples, and the germination rate increased more obviously than the check group's. When the diluted multiple was 300, the germination rate reached the top value 87% and comparative germination rate was 35.9%. However, when diluted multiple was 100, the germination rate reached 35% and comparative germination rate was -45.3% (control germination rate was 64.4%), which was considered that the inhibition appeared.

It showed that the higher the diluted multiples were, the more obvious the stimulative effect was, but the lower of the diluted multiples led to sprout being inhibited. The reason might be that the wood vinegar of mezzo concentration was acidic, which eroded the seed coats a little, and increased ventilate and water permeability of seed coats, and broken seed dormancy and advanced germination. Based on the experimental observations, the seeds became black at dilution multiple 100, which showed that the seeds had been burned and extravasations of seeds nutrient was increased with the increase of cell membrane permeability which indicated that seed structure of the cell membrane had been unstable so that cellular response could not be guaranteed normally[13-14].

Therefore, density was the key of breaking barriers of seed coat and improving seed germination rate.

Relative curves between germination rate and concentrations were gained through SPSS software(Fig. 1).

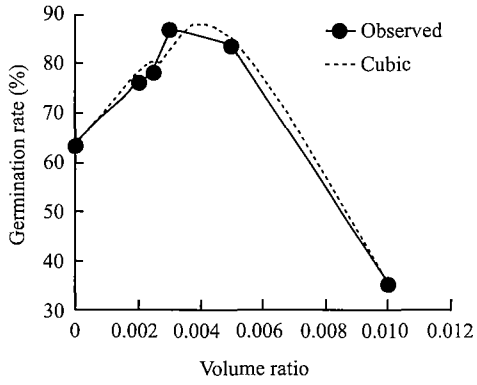

Fig. 1 Effect of concentration on rate of germination

The equation was that:

Y=-2878.8X^3-305.01X^2+255.062X+63.6031

R^2=0.989

This equation offered the theory of the best concentration's scheme.

Germination vigor and germination index affected by different concentrations

Germination vigor was a good index of the seed vitality, germination vigor generate and stronger seed vitality. Regular and concurrent germination showed that it was potential in increasing production, which showed that, the vigor of seeds with dilution multiples

400-200 remained strong on the 4th day, but the vigor of seeds with diluted concentration of 100 was sharply lower to inhibit seed germination. Fig. 2 showed that there was a cubic relationship between the germination vigor and concentrations on the 40th day.

Y=-7425.5X^3+1598.47X^2+18.6929X+62.8915

R^2=0.967

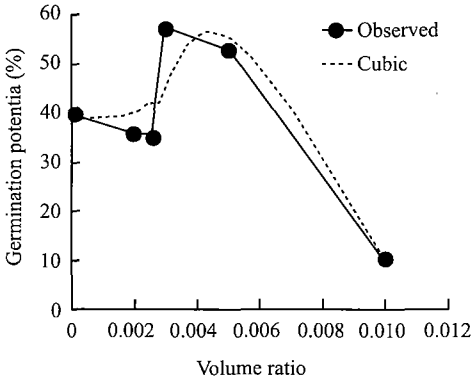

Fig. 2 Effect of concentration on corn germination potential

The range of germination peak value was between dilution multiples 400-200. Germination indexes not only contained the number of germination, but also emphasized germination velocity especially. Seeds at different time played different roles in germination index, so germination index was a good indicator of seed vigor. Experiment result showed that there was no significant difference between the dealing and the control groups on germination time. Only the germination time of the diluted density 400 advanced one day, the other test groups began to germinate after being sowed two days. Because of the complex constituents of wood vinegar, according to analysis, there were certain elements to inhibit the activity of phosphatase and converting enzyme so that cell metabolism was inhibited, thereby the germination rate was inhibited[15]. Fig. 3 showed that there was a cubic relationship between the germination index and concentrations.

Y=-73.8214X^3-509.84X^2+114.16X+17.1761

R^2=0.960.

The dilution multiples 300-200 were the peak value of germination index, and there were the same trends with germination rate and germination vigor. Therefore, dilution multiples 400-200 were the best for germination, but dilution multiples less than 100 were the scope of the germination inhibition.

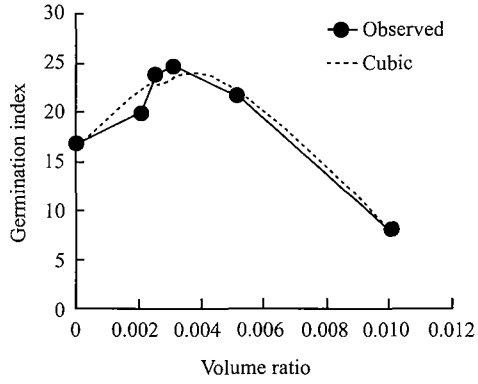

Fig. 3 Effect of concentration on corn germination index

The effect of different concentrations on the corn seedlings

The effect of different concentrations on the increase of seedling

Hydroponics was used for the corn with the different concentrations of wood vinegar. The analysis of variance was used in the increase of seedling. Table 2 showed F=5.147*, $F>F_{0.05}$. The difference between the group of 2 000 diluted multiple and other groups was obvious. In the group of 2 000 diluted multiple, the cultivated corn up-ground grew quickest. Growth stimulative rate showed that the growth was increased in this concentration, but it was minus in other treatments and CK groups. It showed that, there was the obvious stimulative effects on the up-ground of corn in the group of 2 000 diluted multiple. But other treatment groups appeared inhibition. In this experiment, dilution multiple of 2 000 was conducive to increase the corn starch, to improve the activity of seed germination to decompose storage material for growth and to enhance the vitality of seeds to promote seedling growth and seedling quality[16].

Effect of different concentrations on dry weight up-ground and underground

There were quite marked relations between different

concentrations and dry weight up-ground, according to Table 3 F=109.756**, $F>F_{0.05}$, $F>F_{0.01}$. It showed that the accumulation of up-ground mass was relative with concentrations. There was not marked difference between 2000 diluted multiples group and check group, but obvious different from other groups. The dry weight of up-ground reduced along with the diluted multiples reducing.

Table 2 The increase of seedling length in different treatment

Dealing		CK	2 000	1 500	1 000	500
Repeat	Ⅰ	192.17	210	189.00	172.42	173.83
	Ⅱ	182.50	229	162.75	193.50	161.67
	Ⅲ	187.83	192	163.33	184.33	175.50
Average 5% Significant level		191.86bc	210.50a	171.69c	182.42c	170.33c
Promote growth rate (%)			9.70	-10.50	-4.90	-11.20

α=0.05 LSD=17.3638; α=0.01 LSD=24.6974; $F_{0.05}(4, 10)$=3.48; $F_{0.01}(4, 10)$=5.99.

Table 3 The increase of dry upper weight in different treatment

Dealing		CK	2 000	1 500	1 000	500
Repeat	Ⅰ	0.0946	0.0926	0.0901	0.0789	0.0629
	Ⅱ	0.0921	0.0945	0.0862	0.0804	0.0653
	Ⅲ	0.0933	0.0931	0.0853	0.0810	0.0686
Average 5% Significant level		0.09a	0.09a	0.09a	0.08b	0.07c
Promote growth rate (%)			0.1	-6.5	-14.1	-29.7

It showed that it helped with the accumulation of up-ground mass in 2 000 diluted multiples group, and high concentration restrained the growth of up-ground. According to the literature[17], because the wood vinegar owned unique chemical properties, it was used as a medium of regulating to adjust the pH and provide free state ions so as to meet root respiration, thereby to promote the seedlings strong[1].

The result indicated there was no significant difference in dry weight of underground, F=2.079, $F>F_{0.05}$. The concentration range of wood vinegar used in experiment had little simulative effects or inhibition on dry weight of roots. It needed further research to determine whether wood vinegar was propitious to root growth of corn seedlings. Wood vinegar components were so complicated which caused difference on the root and the phenome-non needed further study.

The effect of concentrations on the chlorophyll of corn seedlings

Chlorophyll was an important index of reflecting the intension of photosynthesis, and the dry weight of the underground reflects the mass accumulation of roots. ANOVA results showed that there was no significant difference on chlorophyll value among groups. It seemed the color of leaves had little difference. It showed the concentration of wood vinegar used in experiment had no simulative effect and inhibition on chlorophyll value, which was different from the result of Northeast Forest University. The reason might be that the crop variety was different or using form of wood vinegar in different parts of the crop[7].

Conclusions

(1) It showed that different concentrations of sawdust wood vinegar had obvious effects on germination rate, germination index and germination vigor. When the diluted multiple was 300, the germination rate reached the top and the comparative germination rate was 35.9%. If diluted multiples were lower, and then the inhibition appeared.

(2) Cubic curves were drawn up by the correlativity of concentrations and germination rate, germination

index, germination vigor and length of seedlings. The correlative coefficients of R^2 are 0.989, 0.901 and 0.952, respectively. The curve showed the best dilution multiples that were 400-200 and the inhibition dilution multiples should be less than 100 for germination. The curves offered the basis of efficient utilization of wood vinegar.

(3) It showed that different concentrations of wood vinegar had obvious effects on up-ground length and up-ground dry weight of hydroponics corn seedlings. ANOVA showed that F=5.147, $F>F_{0.05}$, F=108.090, $F>F_{0.05}$. It appeared inhibition to the corn seedlings when diluted multiples were lower and it had negative effects on the group of 2 000 diluted multiples. There was not marked difference in chlorophyll value and dry weight underground.

(4) The research of wood vinegar promoted seed and seedling germination were aid of the wood vinegar deep refining process and product development.

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