Microclimatic Change and Growth Status by Soil-covering Material in Organic Garlic Cultivation

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Abstract

This study was carried out to investigate the effect of soil covering materials such as rice bran, rice hull and saw dust on garlic growth through a field experiment in wintertime. Rice bran was the smallest in term of particle size, but it recorded the highest level of bulk density. The missing plant rate after winter season was relatively high, 59.3%, and that of soil covering materials stood at the low level of 10%. Other growth factors recorded the highest level during application of rice bran. In terms of chemical properties of soil-covering materials, rice bran recorded the highest level of 1.84, 2.34 and 0.16% in the content of N, P, and K, respectively. The subsoil temperature was higher by application of rice bran as compared to that of other materials which stood at the lowest temperature (-9°C).

Introduction

In double-cropping areas in Gyeongsangbuk-do, organic cultivation of garlic as a major source of winter crop is threatened by backward technological methods for quality output due to the restricted use of input materials such as chemical fertilizer and livestock manure. In particular, winter crops including garlic are vulnerable to climate disasters such as cold snap, thus more stable production technology remains quite a pressing challenge for winter crops. Against this backdrop, we applied easily available organic materials (rice bran, saw dust, and rice hull) to the soil-covering during the planting of garlic. Under the same soil conditions, we investigated changes in the microclimate and growth of garlic to verify the optimal effect of soil-covering materials.

Materials and methods

We experimented with the 2005 Euisung garlic variety, which was planted on November 2, 2005, in a cultivation plot inside the Gyeongsangbuk-do Agricultural Research & Extension Services. According to conventional cultivation methods, we used a transparent polyethylene film (0.03mm thickness) as a mulching material for garlic cultivation. The entire cultivation plot was classified into four sections: Rice bran, rice hull, and saw dust treatment plots plus a non-treatment plot, for examination of garlic growth and microclimatic changes. We applied 700 kg/10a of rice bran, 700 kg/10a of rice hull, and 1,150 kg/10a of saw dust to three treatment plots, and these plots was arranged in a randomized block design with three replications with the area of each individual plot of 6m^2 (planting 190 stocks). We applied soil-covering materials after furrowing and sowing. Then, a PE film was used for soil mulching to entice the budding for next spring.

From December 15, 2005 through March 7, 2006, we measured daily soil temperature around the area 10cm underground via a thermometer (Hobo, Onset). We looked into garlic growth on March 9 after the re-growth period, and then we harvested crops on June 14. We analyzed both soil and plant pursuant to the Rural Development Administration's method for analysis of soil and plant (1988) and physicochemical properties of organic soil-covering materials pursuant to the Rural Development Administration's method for examination of fertilizer quality (1998).

Results

According to analysis of physical properties of organic soil-covering materials, rice bran recorded the highest density of 0.28g/cm^3, whereas rice hull pointed to the lowest density of 0.10g/cm^3 (Tab. 1). Such results are clearly due to particle size. Rice bran generated the highest level of residue after passage of particle with the size of 1mm, being followed by saw dust and rice hull respectively. Thus, both size and density of particle seem to influence the level of dissolution when it is put into the soil.

Tab. 1: Physical properties of organic soil-covering materials

Classification	Density (g/cm^3)	Passage into mesh (g/10g)			
		5ʃ	10	16	Residue
Rice Bran	0.28	0.00	0.06	2.29	7.65
Saw Dust	0.23	0.42	1.95	3.41	4.22
Rice Hull	0.10	0.00	3.92	4.73	1.35

ʃ:mm = 16/mesh

Tab. 2 compares the chemical properties of organic soil-covering materials. Application of rice bran showed higher content of N, P, and K than saw dust and rice hull, and its lower carbon-nitrogen ratio confirmed that rice bran excelled in nitrogen supply more than saw dust and rice hull. Rice hull had higher nitrogen content of 0.56% than saw dust, but it recorded lower content of other minerals.

Tab. 2: Chemical properties of organic soil-covering materials

Classification	T-N	T-C	C/N	P_2O_5	K_2O	CaO	MgO	Fe	Mn	Cu	Zn
	-------- (%) --------							----- (mg/kg) ----			
Rice Bran	1.84	45.4	24.7	2.34	0.16	0.01	0.44	32.0	131.3	4.1	46.9
Saw Dust	0.24	50.2	209.3	0.05	0.02	0.12	0.03	14.2	162.5	3.1	3.0
Rice Hull	0.56	45.5	81.2	0.06	0.05	0.02	0.02	17.9	127.6	2.7	15.8

According to analysis of garlic growth during the re-growth period (Tab. 3), the non-treatment plot generated lower occurrence rate of nearly 50% after the winter season, and it also displayed slightly poor growth patterns in terms of leaf number, stem diameter, and plant height. There was no outstanding disparity in garlic growth by organic soil-covering material, but their application resulted in excellent occurrence rate of around 90% and favorable growth patterns compared with the non-treatment control. As shown in Fig. 1, such results are also mirrored in the analysis of daily changes of soil temperature by soil-covering material during the winter season. According to examination of daily changes in soil temperature for February 3-4, the coldest time in wintertime, soil temperature in the non-treatment plot dropped to -5℃ around 7 a.m. on February 4. However, soil temperature stood at 0℃ or higher in other three plots for application of organic soil-covering materials. Consequently, the lowest soil temperature displayed a gap of around 4-5℃ by organic material, and it exerted the biggest influence over the occurrence rate and growth patterns during the re-growth period. Therefore, we should give top priority to the rise in soil temperature for stable production of quality winter crops.

Tab. 3: Growth patterns by organic soil-covering material during the re-growth period (as of March 9, 2006)

Classification	Plant Height (cm)	Stem Diameter (mm)	Number of Leaf (leaf/stock)	Occurrence Rate (%)
Non-treatment	11.6	4.8	4.0	49.7b
Rice Bran	13.1	5.7	4.4	89.3a
Saw Dust	13.5	4.8	4.0	87.4a
Rice Hull	13.1	5.2	4.1	85.8a

DMRT (Duncan's Multiple Range test) 0.05

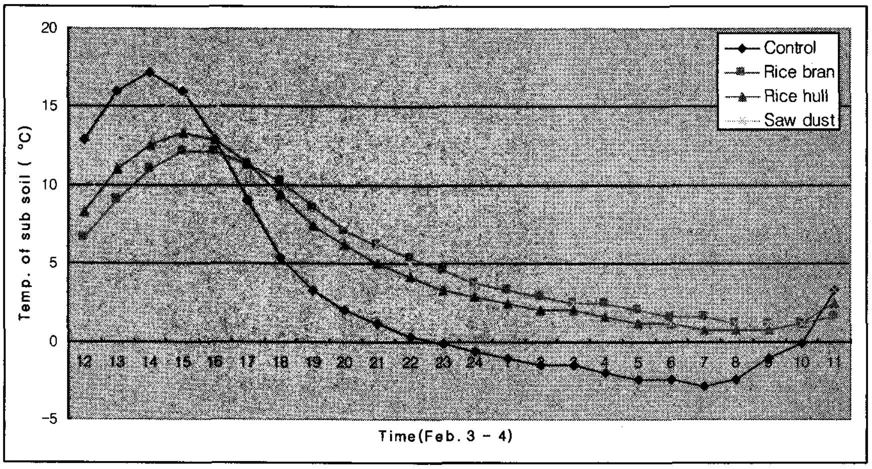

Figure 1: Change in daily soil temperature in wintertime by organic soil-covering material

We examined the growth patterns of garlic during the harvesting season to analyze the effect of organic soil-covering materials (Tab. 4). Application of rice bran recorded the largest bulb weight of 44g, being followed by saw dust and rice hull, and the non-treatment case generated a bulb weight of 37g which was similar to that of rice hull.

Tab. 4: Growth status in the harvesting season by organic soil-covering material

Classification	Bulb Weight (g)	Plant Height (cm)	Stem Diameter (mm)	Bulb Diameter (mm)	Weight of Upper Ground Part (g)
Non-treatment	36.9 b	67.5a	11.1a	47.7b	34.1a
Rice Bran	43.8 a	71.4a	10.8a	51.3a	41.7a
Saw Dust	38.9ab	70.5a	10.1a	48.9b	36.0a
Rice Hull	37.2 b	70.5a	9.1a	48.1b	33.3a

DMRT (Duncan's Multiple Range Test) 0.05

Discussion

With the aim of utilizing easily available organic materials for safe, high quality farm products, we looked at the impact of soil-covering materials such as rice bran, saw dust, and rice hull on garlic growth. Accordingly, we examined how these mulching materials influenced soil temperature for February 3-4, the coldest time in wintertime. During the application of rice bran and saw dust with smaller particle size and higher nitrogen content, soil temperature remained at 0℃ or higher unlike the non-treatment control plot. It seemed effective for a stable occurrence rate and heavier bulb weight during garlic cultivation after wintertime, thereby being recommended as an efficient tool to garlic cultivators.

Conclusions

In organic garlic cultivation, the use of rice bran and saw dust for soil-covering can boost stable production of quality garlic crop through prevention of frost damage and expansion of bulb weight amid an overall rise in soil temperature.

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