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Effects of Mulching Materials on Growth of *Allium tuberosum* Rottler and Weed Control

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Abstract - This study was carried out to elucidate the effect of mulching materials on the growth of Chinese chive (*Allium tuberusum* Rottler) and weed control. Chinese chive was grown under five mulching materials, pine leaf, oak leaf, rice straw, rice hull and sawdust, at the Experimental Farm of Chungbuk National University from June 20, 2009 to September 30, 2009. *Amaranthus mangostunus, Digitaria sanguinalis, Portuclaca. oleracea, Echinochioa crus-galli* var. *frumetacea* and *Setaria viridis* were dominant weeds. Both pine and oak leaves were significantly effective mulching materials in terms of weed control indices in both nursery and field. Soil moisture contents were 1.2～3.7% higher in mulching, especially in oak leaf mulching. Mulching with pine leaf significantly increased plant height, sheath length, leaf length, bulb-, root- and leaf-weights and yield of Chinese chive, but there were no significant differences among the other mulching materials although better than those in non-mulching.

Key words - Chinese chive, tree leaf mulching, dominant weeds, weed control index

Introduction

Allium tuberousum Rottler is one of favored edible vegetables because of its tender leaves and unique fragrance. Recently, cultivation of Chinese chive has been increased in Korea. In 2008, total 98,703 M/T of Chinese chive were produced in 2,477 ha. Chinese chive has been produced more in the protected cultivation than in the fields.

To establish better production system of high quality Chinese chive, various cultivation methods, such as temperature and light control, fertilization, nursery material and size of plug tray, were compared. The range of optimum temperature for Chinese chive was 20～25℃ and no seed was developed although flowering was induced under short day less than 10 hours (Chung and Youn, 1996). Under hydroponics, fertilizer concentration resulted no differences in plant height, number of leaves, number of branches and dry matter weight, but the highest fresh weight was observed at EC 1.41 (Lee, 2009). Fertigation was not proper for Chinese chive cultivation, but the customary application of compost (6 tons/ha) not only remarkably improved soil composition and Chinese chive growth but also decreased nitrate nitrogen accumulation (Park, 2007). Park (2007) also reported that pellet-type oyster shell products was better than power-type in Chinese chive cultivation. Growth and root activity of Chinese chive were better in mixture of perlite and vermiculite (25:75, v/v) and mixture of perlite, vermiculite and coconut pith (28:28:4, v/v) (Oh, 2002), On the other hand, transparent, yellow and pink films promoted the growth of Chinese chive, while green and blue films inhibited its growth. Growth of Chinese chive seedlings increased as the cell size of plug plate and growing period in plug plate increased (Kim et al., 2001). Field establishment after transplanting was poorer as cell size of plug plate and growing period in plug plate decreased. Due to its shallow root system, Chinese chive is susceptible to drought, which would be easily resulted in poor quality with dried leaf tips and decreased yield.

Chinese chive is mainly used as green vegetable. Therefore, cultivation without chemicals is desired. To cultivate Chinese chive without using chemicals, soil aeration needs to enhance the soil physical structures through the compound granular soil formation, which promote deep and wide distribution of root system of plants and better soil moisture re-

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tention. Reduced labor for weed control and/or higher activities of earthworm and mole in zero tillage cultivation suggest possible exclusion of polyethylene film as mulching material. Mulching is known to be effective in improving physical characteristics of soil, such as temperature and moisture, and in preventing soil erosion and nutrient depletion (Courter, 1964; Jensen, 1988). Mulching is one way to control weeds by intercepting light. Various mulching materials, such as paper, rice straw, grass and crop residues as well as polyethylene film, have been used. Depending on the location and/or time of mulching, the effect of the same material might be greatly different. Mulching with polyethylene film or its poor aeration would decrease the activities of soil animals, and thus result bad effect on soil texture too. Especially, severe high temperature damage could be resulted by polyethylene film mulching in hot and humid season like summer.

Recently, Kim (2004) reported that growth and yield of *Adenophora triphylla* var. *japonica* Hara were increased by the leaf mulching of *Larix leptolepis* (Sieb. et Zucc.) Gordon, while those of oriental melon (Kim, 2000), lettuce (Kim, 2002), egg plant (Kim, 2003), chinese cabbage (Kim, 2005), and onion (Kim, 2008) were increased by the mulching of pine leaves. Dry weight and number of weeds were also reduced by mulching. Although the effect of various mulching materials were studied in various crops, the effect of mulching on Chinese chive were not comprehensively studied. Therefore, this experiment was performed to elucidate the effect of several mulching materials on the growth and yield of Chinese chive as well as on the weed control.

Materials and Methods

This experiment was carried out at the Experimental Farm of Chungbuk National University (CBNU) from June 20, 2009 to September 30, 2009. Chinese chive (Kyongshin Seed Co.), was used in the both experiments.

In the first experiment, Chinese chive was seeded with 30 cm between rows and 15 cm within a row on June 20, 2009 to study the effect of mulching materials on the growth of Chinese chive seedling and weed control. Used mulching materials were pine and oak leaves, rice straw, rice hull and sawdust. Six liters of pine leaf and straw, and 8 liters of oak leaf, rice hull and sawdust in seedling nursery, and 8 liters of pine leaf and straw, and 10 liters of oak leaf, rice hull and sawdust in Chinese chive production field were used after seeding and before transplanting, respectively, to cover the experimental plots. Pine and oak leaves were collected at the CBNU campus, rice straw produced at the Experimental Farm of CBNU in 2008, rice hull obtained from the Saemaeul rice mill at Sacheon-dong, Cheongju, sawdust of *Larix leptolepis* (S. et. Z.) Gordon was obtained from Kangnam sawmill at Jeosan-ri, Kangnae-myon, Cheongwon, Chungbuk.

In the second experiment, four plants per hill, which were taken from the Chinese chive field planted in June 2008, were planted on June 20, 2009 to study the effects of mulching materials on the growth of Chinese chive and weed control. The distances between rows and within row were 20 cm and 15 cm, respectively. All fertilizers were applied before the seeding in the rates of $N\text{-}P_2O_5\text{-}K_2O$=4.6-1.7-5 kg/10 a, 1,500 kg/10 a of compost and 2 kg/10 a of boron according to the standard manual on Chinese chive of Rural Development Administration.

The size of the experimental plot was 1.5 x 1.2 m, and the randomized complete block design with 3 replications was used in both experiments. Soil moistures were measured 5 times from July 15 to September 15. Soil samples were taken at the 10 cm depth and dried 5 days at 105℃ before measuring by dry soil weight method. Chinese chive was harvested on October 5 and plant height, number of branches, stem diameter, leaf length, leaf width and number of leaves were measured before drying at 75℃ to measure the dry weights of leaf, stem and roots. Weed species and number of weeds in each experimental plot were observed twice on July 30 and August 30, and dry weights were measured after drying 3 days at 75℃.

Results and Discussion

The effects of mulching material on the number of weeds and weed control index in Chinese nursery were shown in Table 1. *Amaranthus mangostunus* and *Digitaria sanguinalis* were dominant weeds in mulching, while *Portulaca oleracea* and *D. sanguinalis* were dominant in the control. Number of weeds was the least in mulching with pine leaf, mulching

with straw, rice hull or sawdust showed the similar number of weeds, and oak leaf mulching resulted rather to poor weed control. Therefore, calculated weed control indices were as high as 82% in pine leaf mulching, ranged to 75～79% in mulching with straw, rice hull or sawdust, and as low as 62% in oak leaf mulching.

Number of *A. mangostunus* was not significantly different among mulching materials except sawdust, while mulching treatment significantly reduced the numbers of *D. sanguinalis* and other weeds. On the other hand, numbers of *Echinochioa crus-galli* var. *frumentacea* and *Eleusine indica* were not shown significant differences among all treatments. It is interesting that both weeds belong to Graminaeae family. Number of *Portulaca oleracea* was the most variable, although mulching was effective in weed control. Number of *P. oleracea* was lower in mulching of pine leaf, straw, rice hull and sawdust and higher in oak leaf mulching. Weed growth depended on the field management methods, i.e. by removal weeds after harvest, their growth decreased greatly due to the prevention of seed dispersal. Planting sweet potato or beans around the field was also effective in reducing weed growth, while more weeds grew when their seeds were mixed in mulching materials.

Dry weights of weeds affected by various mulching materials were similar to the number of weeds in nursery as shown in Table 2. Dry weight of weeds in mulching decreased by 1/4～1/8 comparing to that in the control. *D. sanguinalis, A. mangostunus.* and *E. indica* were the dominant weeds in mulching, while *P. oleracea* and *D. sanguinalis* were dominant in the control. The dominance of *P. oleracea* and *D. sanguinalis* in the control was due to their vigorous growth, while *P. oleracea* was more competitive than other weeds in mulching.

Table 1. Number of weeds and weed control index as affected by mulching materials in Chinese chive nursery (plants/m^2)

Mulching material	AM*[1]	DS	EC	EI	PO	Others	Total	Weed control index*[2] (%)
Control	18.3 ± 1.2*a	40.0 ± 6.7a	4.3 ± 1.9a	6.7 ± 2.4a	48.0 ± 7.2a	121.7 ± 10.7a	239.0	0
Pine leaf	13.7 ± 1.2a	10.0 ± 2.1b	1.3 ± 0.3a	7.7 ± 0.7a	7.0 ± 2.1c	13.3 ± 1.2b	39.3	84
Oak leaf	14.0 ± 2.1a	15.3 ± 1.3b	4.0 ± 1.1a	7.3 ± 1.9a	21.3 ± 5.8b	30.3 ± 14.4b	92.2	62
Straw	18.3 ± 1.9a	10.0 ± 2.5b	4.3 ± 2.9a	7.7 ± 2.7a	4.0 ± 1.7c	9.0 ± 1.2b	53.3	77
Rice hull	18.3 ± 0.9a	7.3 ± 1.5b	3.3 ± 1.5a	3.7 ± 0.9a	5.6 ± 1.2c	16.0 ± 2.5b	54.2	79
Sawdust	7.0 ± 1.5b	18.0 ± 1.7b	8.0 ± 3.6a	2.7 ± 1.2a	11.3 ± 0.3bc	12.0 ± 3.6b	59.0	75

*[1]AM : *Amaranthus mangostunus* L., DS : *Digitaria sanguinalis* (L.) Scop., EC : *Echinochioa crus-galli* var. *frumentacea* (Roxb.) Wight, EI : *Eleusine indica* (L.) Gaertner, PO : *Portulaca oleracea* L.

*[2]Weed control index = (1-Treatment/Control) x 100.

* Values followed the same letter in a column are not significantly different at P=0.05 by DMRT.

Table 2. Dry weight of weeds as affected by mulching material in Chinese chive nursery (g/m^2)

Mulching material	AM*[1]	DS	EC	EI	PO	Others	Total	Weed control index*[2] (%)
Control	7.7 ± 0.9*b	21.6 ± 4.3a	6.9 ± 2.8a	8.7 ± 2.9a	21.4 ± 3.7a	14.0 ± 0.7a	80.3	0
Pine leaf	3.4 ± 0.3c	2.9 ± 1.0b	0.4 ± 0.1b	2.8 ± 0.3b	1.3 ± 0.3b	1.1 ± 0.4cd	11.9	86
Oak leaf	2.2 ± 0.6c	8.7 ± 0.3b	1.0 ± 0.2b	2.4 ± 0.3b	1.1 ± 0.2b	0.8 ± 0.1d	16.2	80
Straw	3.0 ± 0.5c	3.6 ± 0.8b	1.9 ± 1.2b	2.9 ± 0.7b	2.5 ± 0.6b	3.0 ± 0.3bc	16.9	79
Rice hull	9.7 ± 0.4b	2.8 ± 0.6b	4.2 ± 1.0b	1.1 ± 0.3b	5.4 ± 1.1b	4.3 ± 1.4b	27.5	66
Sawdust	13.5 ± 2.3a	2.8 ± 0.3b	1.5 ± 0.6b	0.5 ± 0.1b	1.9 ± 0.6b	0.5 ± 0.3b	20.7	74

Symbols refer to Same as Table 1.

*Values followed the same letter in a column are not significantly different at P=0.05 by DMRT.

Sawdust Mulching was not effective to control *A. mangostunus*. Moisture contents in sawdust might enhanced the growth of *A. mangostunus* than that of other weeds. Although oak leaf mulching resulted higher numbers of weeds, it resulted lower dry weights of weeds, therefore high weed control indices are similar to those of pine leaf. Weed control indices computed by dry weight rather than number of weeds are more reliable. Therefore pine and oak leaves appeared to be better mulching materials in terms of weed control in Chinese chive nursery.

The growth of Chinese chive seedlings was summarized as in Table 3. The growth of Chinese chive seedlings in mulching plots was better than those in the control. The effective weed control could be one of the factors resulting better its seedling growth. Among five mulching materials, pine leaf and rice straw resulted in better growth than other mulching materials in almost all horticultural characteristics. Pine leaf mulching resulted in higher soil moisture contents and better soil aeration, which might enhance the growths of roots and shoots of Chinese chive seedlings. Better seedling growth in straw mulching might be the effect of mulching and additional nutrient supply derived from the straw decomposition during the summer rainy season. Rather poor growth in rice hull and sawdust mulching could be due to poor soil aeration. Most of the horticultural characteristics of Chinese chive seedlings in oak leaf mulching were significantly lower than those of other mulching materials. The growth of the early stage resulted in poor seedling growth due to the lower light interception in oak leaf mulching.

Mulching increased soil moisture contents in field as shown in Table 4. Mulching with oak and pine leaves or sawdust resulted similar soil moisture contents, while those in rice hull mulching lower than in the other mulching materials. Higher soil moisture contents and its lower variation by mulching could be provided enough water condition for Chinese chive growth.

Number of weeds in the Chinese chive was shown in Table 5. *D. sanguinalis* and *A. mangostunus* were the dominant weeds followed by *P. oleracea, E. crus-galli* var. *frumentacea* and *S. viridis* in the nursery. *Euphorbia supina* Rafin was negligible by mulching and classified as the other weeds. Weed control indices were higher than 84% in mulching regardless

Table 3. Effects of different mulching materials on the growth of Chinese chive seedling (g/10plant)

Mulching material	Pant height (cm)	Sheath length (cm)	Sheath diameter (cm)	Leaf length (cm)	Leaf width (cm)	No. of branches	Wt. of root (g)	Wt. of stems (g)	Wt. of leaves (g)	Wt. of plants (g)
Control	32.02±2.29*ab	7.41±0.36ab	2.34±0.14b	24.61±0.21bc	3.25±0.03ab	4.00±0.17c	3.49±0.28c	0.98±0.06b	3.63±0.24c	8.10±0.57c
Pine leaf	36.95±2.42a	8.57±0.80a	3.06±0.66a	28.41±0.83a	3.72±0.32a	12.87±0.46a	4.81±0.29ab	1.40±0.06a	8.06±0.33a	14.27±0.65a
Oak leaf	30.52±0.85b	7.01±0.21b	2.40±0.12b	23.52±23.52c	3.08±0.08b	10.0±0.62b	4.38±0.13b	1.28±0.02a	4.16±0.11bc	9.82±0.26bc
Straw	35.89±2.34ab	7.5±0.21ab	3.05±0.11a	28.39±0.93a	3.61±0.13a	12.3±1.30a	4.83±0.47ab	1.39±0.08a	7.81±0.42a	14.05±0.94a
Rice hull	32.8±0.61ab	8.04±0.01ab	2.38±0.02b	24.8±0.12bc	3.21±0.05ab	9.8±0.06b	4.47±0.02b	1.32±0.01a	4.60±0.04a	9.79±0.66bc
Sawdust	33.6±1.27ab	7.51±0.18ab	2.53±0.09b	26.16±0.93b	3.32±0.13ab	9.6±0.17b	5.37±0.03a	1.25±0.03a	3.84±0.05bc	10.24±0.14b

*Values followed the same letter in a column are not significantly different at P=0.05 by DMRT.

Table 4. Effect of mulching materials on soil moisture content at 10 cm depth from July 15 to September 15, 2008

Treatment	Mean	Range	CV (%)
Control	12.0	6.9	16.01
Pine leaf	15.1	5.5	13.75
Oak leaf	15.7	4.2	13.69
Straw	14.9	4.6	14.10
Rice hulls	13.2	4.9	13.88
Sawdust	15.4	3.8	13.18

Table 5. Number of weeds as affected by different mulching material in Chinese chive field (plant/m^2)

Mulching material	AM*[1]	DS	EC	PO	SG	Others	Total	Weed control index*[2] (%)
Control	19.0 ± 1.7*a	50.7 ± 3.5a	3.3 ± 1.2a	29.7 ± 2.9a	56.0 ± 18.0a	101.7 ± 9.8a	260.4	0
Pine leaf	3.7 ± 0.7c	8.7 ± 0.7b	1.0 ± 0.0a	7.3 ± 2.4b	3.7 ± 0.9b	9.0 ± 1.5b	33.4	87
Oak leaf	2.7 ± 0.9c	3.3 ± 1.5c	2.0 ± 0.6a	1.0 ± 0.0c	0.7 ± 0.2b	3.3 ± 0.7b	13	95
Straw	10.3 ± 2.7b	2.0 ± 1.0c	2.7 ± 2.7a	4.0 ± 1.0bc	5.7 ± 1.7b	7.7 ± 0.9b	32.4	88
Rice hull	13.0 ± 1.5b	2.7 ± 0.3c	1.7 ± 0.7a	4.3 ± 1.7bc	4.7 ± 0.3b	15.0 ± 1.5b	41.4	84
Sawdust	3.0 ± 1.0c	10.3 ± 0.9b	1.0 ± 0.0a	3.7 ± 1.8bc	2.7 ± 0.9b	10.7 ± 2.7b	31.4	88

Symbols refer to Same as Table 1.
*Values followed the same letter in a column are not significantly different at P=0.05 by DMRT.

Table 6. Dry weight of weeds as affected by different mulching materials in Chinese chive nursery (g/m^2)

Mulching material	AM*[1]	DS	EC	PO	SG	Others	Total	Weed control index*[2] (%)
Control	7.0 ± 1.1*a	19.6 ± 1.9a	4.4 ± 0.6a	18.8 ± 1.2a	15.3 ± 2.1a	10.1 ± 0.8a	75.2	-
Pine leaf	1.0 ± 0.2c	2.4 ± 0.3b	0.5 ± 0.3b	0.9 ± 0.1c	2.6 ± 0.5b	1.0 ± 0.1c	8.4	89
Oak leaf	0.5 ± 0.2c	1.7 ± 0.5b	0.4 ± 0.1bc	0.2 ± 0.1c	1.9 ± 0.1b	0.4 ± 0.1c	5.1	93
Straw	4.4 ± 0.3b	0.8 ± 0.3b	1.1 ± 0.4b	1.8 ± 0.6bc	2.4 ± 0.1b	3.0 ± 0.2b	13.5	82
Rice hull	1.9 ± 0.c	1.3 ± 0.2b	0.2 ± 0.1b	3.7 ± 0.7b	1.1 ± 0.1b	1.3 ± 0.1c	9.5	87
Sawdust	6.5 ± 0.8a	1.6 ± 0.1b	0.3 ± 0.1b	0.9 ± 0.4c	0.6 ± 0.1b	0.7 ± 0.2c	10.6	88

Symbols refer to same as Table 1.
*Values followed the same letter in a column are not significantly different at P=0.05 by DMRT.

Table 7. Effects of different mulching materials on the growth of Chinese chive (g/stock)

Mulching material	Pant height (cm)	Sheath length (cm)	Sheath Diameter (cm)	Leaf length (cm)	Leaf width (cm)	No. of leaves	Wt. of roots (g)	Wt. of stems (g)	Wt. of leaves (g)
Control	35.7 ± 1.2*b	8.3 ± 0.3b	3.10 ± 0.07b	27.4 ± 0.6c	5.8 ± 0.2c	66.1 ± 3.3d	5.08 ± 0.07cd	2.79 ± 0.07d	4.64 ± 0.20e
Pine leaf	43.4 ± 1.0a	10.1 ± 0.5a	3.96 ± 0.04a	33.3 ± 0.3a	6.8 ± 0.2a	111.4 ± 2.9a	9.97 ± 0.09a	3.94 ± 0.04a	11.62 ± 0.20a
Oak leaf	38.9 ± 2.6b	8.8 ± 0.3b	3.18 ± 0.18b	30.1 ± 1.2abc	6.4 ± 0.3ab	93.8 ± 3.63b	6.84 ± 0.30b	3.18 ± 0.18bc	8.40 ± 0.3b
Straw	37.9 ± 1.1b	8.4 ± 0.1b	3.13 ± 0.02b	29.3 ± 0.9c	6.2 ± 0.2abc	88.3 ± 1.0bc	5.72 ± 0.07c	3.37 ± 0.03b	8.28 ± 0.05b
Rice hull	38.5 ± 0.9b	8.9 ± 0.3b	3.14 ± 0.07b	29.8 ± 1.7bc	6.3 ± 0.2abc	81.0 ± 2.0c	5.78 ± 0.60c	3.37 ± 0.09b	5.91 ± 0.13c
Sawdust	36.5 ± 1.4b	8.5 ± 0.2b	3.28 ± 0.11b	33.0 ± 0.7ab	5.7 ± 0.2c	71.2 ± 1.0d	4.49 ± 0.12d	2.97 ± 0.09cd	5.33 ± 0.12d

*Values followed the same letter in a column are not significantly different at P=0.05 by DMRT.

of materials. Although weed control was rather poor in seedling nursery, oak leaf resulted the highest weed control index of 95%. Thicker mulching was possible in transplanting than in seeding. Therefore, the mulching treatment provided better growth of Chinese chive and more effective weed control.

Dry weights of weeds in field transplanted with Chinese chive seedling were shown in Table 6. Dry weight of weeds were significantly lower by mulching on the whole. Dry weights of *A. mangostunus* and *P. oleracea* in pine or oak leaf mulching were significantly lower than in other mulching materials. On the other hand, dry weights of weeds in Gra-

mineae family, *D. sanguinalis, E. crusgalli* or *S. galuca*, were not significantly different among mulching materials. *S. viridis* was dominant in field, while *E. indica* was dominant in the seedling nursery. Number of *E. supina* was higher in the control, but its dry weight was negligible. Weed control indices ranged 82～93% with the highest of 93% in the mulching with oak leaf.

Horticultural characters of Chinese chive were shown in Table 7. All horticultural characters, such as plant height, number of branches, stem diameter, leaf length, lead width, number of leaves, leaf weight and root weight, were significantly better in mulching. Mulching with pine leaf resulted the best growth and the highest yield. There were not much significant differences in horticultural characters among other mulching materials. Such results might be due to the proper soil moisture and better soil aeration in the mulching with pine leaf. Although weed control was effective, rather poor growth of Chinese chive might be due to poor soil aeration in the mulching with rice hull or sawdust.

Soil moisture contents were higher by mulching. Although pine leaf or rice straw were better mulching materials in the seedling nursery, pine or oak leaf was better in the field. Also, soil temperature was 1～2℃ lower by mulching.

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