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Mulching Methods and Removing Dates of Mulch Affects Growth and Post Harvest Quality of Garlic (*Allium sativum* L.) cv. Uiseong

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Abstract. This experiment was conducted to elucidate the effects of mulching materials and removing time of the transparent polyethylene (PE) film on the growth of garlic at Uiseong experimental field, Korea. The experimental mulching materials comprised of transparent polyethylene film (0.025 mm) and net polyethylene (NPE). Plant height and leaf number of garlic were highest at PE treatment when the PE removing date was March 18 and this treatment also promoted the no. of cloves. Length of leaf sheath and bolting rate were highest and bulb weight loss rate was lowest at PE + NPE treatment when the PE removing date was March 18. But clove number was the lowest in this treatment compared to conventional PE film treatment. Conventional mulching method accelerated secondary growth rate but bulb weight loss was vice versa. There were statistically no differences in bulb diameter among treatments but conventional treatment positively focused on bulb diameter. Whenever PE film remove can suppress weeds compared to no mulching treatment but the dry weight of weeds were increasing trends as the removal dates of PE film were delayed. Transparent PE or PE + NPE treatments can be recommended to grow best quality garlic when PE film removing date is March 18.

***Additional key words*:** bulb weight loss, number of clove, polyethylene film, secondary growth

Introduction

Garlic (*Allium sativum*) is one of the bulbous herbaceous spice and widely grown in tropical and temperate region. It is an important and widely cultivated crop used for food as well as medicinal purposes because of its thrombotic, lipid lowering, cardiovascular and anticancer effects (Agarwal, 1996). Garlic is known to be thermo-photo sensitive crop and its vegetative growth and bulb development are greatly influenced by growing environment (Jones and Mann, 1963; Rahim and Fordham, 1998). Manipulation of growing environment by cultural practices has the potentiality to improve yield. Mulching is one of the good cultural practices for the favorable manipulation of microclimate. The accumulated air and soil temperature and solar radiation have highly positive correlations with plant height, leaf length and leaf area of garlic (Hwang, 2000). The role of mulching of the growth and production of plants is well recognized. Mulching has been suggested to conserve soil moisture (Adetunji, 1990; Bristow and Abrecht, 1989; Gajri et al., 1994; Zaman and Mallick, 1991) increase soil temperature, decrease run off and soil erosion (Sur et al., 1992) and sometimes even substitutes the soil (Amal et al., 1990). It protects the plants from loss of soil moisture by wind and soil evaporation and reduces the irrigation requirements (Amal et al., 1990; Vanderwerken et al., 1988). Mulches help check weed growth and improve the soil structure and fertility by trapping nutrient (Geiger et al., 1992). Mulches also help in better utilization of soil nutrients meeting up the need of irrigation and thus increase crop yield. In addition, yield increase has been attributed to the ability of mulch to increase soil temperature (Adetunji, 1990) enhance nutrient availability (Patra et al., 1993) and increase root growth (Gajri et al., 1994).

The goals of this study were to improve the mulching materials and methods also reduce the labors and savings time in garlic cultivation

Materials and Methods

The experiment was conducted in the garlic experimental field at Uiseong city during the period of October 27, 2008 to June 22, 2009. Fertilizer N-P-K was applied at 22-20-20

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kg respectively and compost manure 3000 kg were applied in 10a land with 150 kg $CaCO_3$. 60% of this fertilizer was used during final land preparation and rest of 40% was applied on March 1st and March 4th as installments.

The experimental mulching materials were comprised of transparent polyethylene (PE) film (0.025 mm) and net polyethylene (NPE). There were 8 treatments like as; no mulching, conventional PE film mulching, and removing dates of PE film from PE and PE + NPE treatments at 3 different dates; Feb. 26, March 8 and 18, respectively. The experiment was laid out in randomized completely block design (RCBD).

The size of the unit plot was 1.5 m × 6 m, plant spacing 15 cm × 10 cm and the cloves were planted at 4 cm depths. Mulching with transparent polyethylene film and net polyethylene were done 13th November. Data were collected from 30 garlic plants with 3 replications in the date of March 18, May 31 and June 7. The observations were undertaken on plant height (cm), no. of leaves, neck diameter (mm), stem diameter (mm), length of leaf sheath (cm), bulb diameter (mm), no. of clove, dry weight of weeds ($g \cdot m^{-2}$), secondary growth rate (%), and bolting rate (%). Weeds were collected on April 25, for measurement the degree of infestation. Weeds were dried at 110℃ for 24 hours and then weighted after cutting weed roots. The garlic plant was harvest on June 12 and harvested garlic was dried at field condition for 10 days and cut the bulb with 1 cm neck. First measurement of bulb weight took on June 22 and second weight 2 months after harvest (August 22) to measure the storage ability of garlic bulb.

The collected data on different parameters under study were statistically analyzed by Duncan's multiple range test (DMRT) at 5% level of significance using MSTAT-C program in computer.

Results

In the early stages (Table 1), plant height was influenced by mulching methods and removing dates of mulching materials. The plant height was increased steadily and reached to its maximum at PE3 treatment and it was highest (52.8 cm) followed by conventional mulch. The shorted plant (14.8 cm) was recorded at the treatment of no mulching plot. Leaves number were significantly different among the mulching materials. Maximum leaves number (6.2) were found in PE3 treatments and then PEN3 (6.1) followed by conventional practices (5.7). PEN1 and PEN3 treatments increased the neck diameter at 11.7 mm and 11.9 mm, respectively, as well as length of leaf sheath was longer grown under PE3 and PEN3 treatments as 10.5 cm and 11.1 cm, respectively, while conventional and no mulching treatments reduced the garlic growth in this stage.

In the late stages of garlic growth (Table 2), plant height was highest (90.1 cm) at the treatments of PEN3 and then PE3 (88.2 cm) compared with conventional mulch (84.2 cm). There was statistically no difference in the point of neck diameter among all treatments. Leaves number was same in PE1, PE2 and PEN3 treatments compared to conventional mulch (7.3 cm) but the maximum length of leaf sheath was found in PEN1 and PEN2 treatments. In (Table 3), there were statistically no different among the treatments in case of bulb diameter but result shown conventional PE film treatment accelerate bulb diameter. Number of clove was lower (6.93) at PEN3 treatment followed by conventional mulch (8.09). Secondary growth rate (Fig. 1) was highest in conventional mulch but bolting rate was same among all treatments except conventional mulch. Storage ability (Fig. 2) was greatly influenced by mulching methods and removing dates of PE film. Highest weight loss (38%) rate was found in conventional PE film

Table 1. Effects of mulching and polyethylene film removing treatments on early growth of garlic (Mar. 18, 2009).

Treatments[z]	Plant height (cm)	No. of leaves	Neck diameter (mm)	Length of leaf sheath (cm)
PE1	28.1 d[y]	5.1 c	10.8 ab	5.3 bc
PE2	37.2 bc	5.2 bc	10.6 ab	6.2 b
PE3	52.8 a	6.2 a	11.3 a	10.5 a
PEN1	31.1 bcd	5.7 abc	11.7 a	5.3 bc
PEN2	38.0 b	5.2 bc	11.5 a	6.2 bc
PEN3	54.2 a	6.1 ab	11.9 a	11.1 a
Conventional PE film	30.7 cd	5.7 abc	10.3 ab	4.6 c
No mulching	14.8 e	3.7 d	8.0 b	2.0 d

[z]PE and PEN means transparent polythene film and transparent polythene + net polythene; numbers 1, 2, 3 means removing dates of PE film at Feb. 26, March 8 and 18, respectively.
[y]Mean separation within columns by DMRT at 5% level.

Table 2. Effects of mulching and polyethylene film removing treatments on late growth of garlic (May 31, 2009).

Treatments[z]	Plant height (cm)	No. of leaves	Neck diameter (mm)	Leangth of leaf sheath (cm)
PE1	87.6 ab[y]	7.3 a	14.8 a	29.1 cd
PE2	87.5 ab	7.3 a	14.1 a	31.9 abc
PE3	88.2 a	6.6 ab	13.0 a	33.0 ab
PEN1	86.4 ab	6.4 bc	14.1 a	33.4 a
PEN2	86.4 ab	6.7 ab	13.2 a	34.3 a
PEN3	90.1 a	7.3 a	14.0 a	32.1 abc
Conventional PE film	84.2 ab	7.3 a	14.4 a	29.8 bc
No mulching	80.7 b	5.7 c	13.4 a	26.4 d

[z]PE and PEN means transparent polythene film and transparent polythene + net polythene; numbers 1, 2, 3 means removing dates of PE film at Feb. 26, March 8 and 18, respectively.
[y]Mean separation within column by DMRT at 5 % level.

Table 3. Effects of mulching and polyethylene film removing treatments on bulb diameter and number of cloves of garlic.

Treatments[z]	Bulb diameter (mm)	No. of clove	Bulb weight (g) at harvesting time (June 22)	Bulb weight (g) at 2 months after harvest
PE1	47.06 a[y]	8.17 a	38.8 b	25.8 b
PE2	47.55 a	8.07 ab	40.8 a	26.9 b
PE3	48.83 a	8.20 a	40.5 a	26.6 b
PEN1	48.83 a	7.30 abc	40.2 a	27.7 b
PEN2	46.45 a	7.47 abc	40.6 a	29.6 ab
PEN3	48.07 a	8.07 ab	40.8 a	31.8 a
Conventional PE film	50.00 a	8.09 ab	39.8 b	24.6 bc
No mulching	45.72 a	6.93 c	31.0 c	23.7 c

[z]PE and PEN means transparent polythene film and transparent polythene + net polythene; numbers 1, 2, 3 means removing dates of PE film at Feb. 26, March 8 and 18, respectively.
[y]Mean separation within column by DMRT at 5 % level.

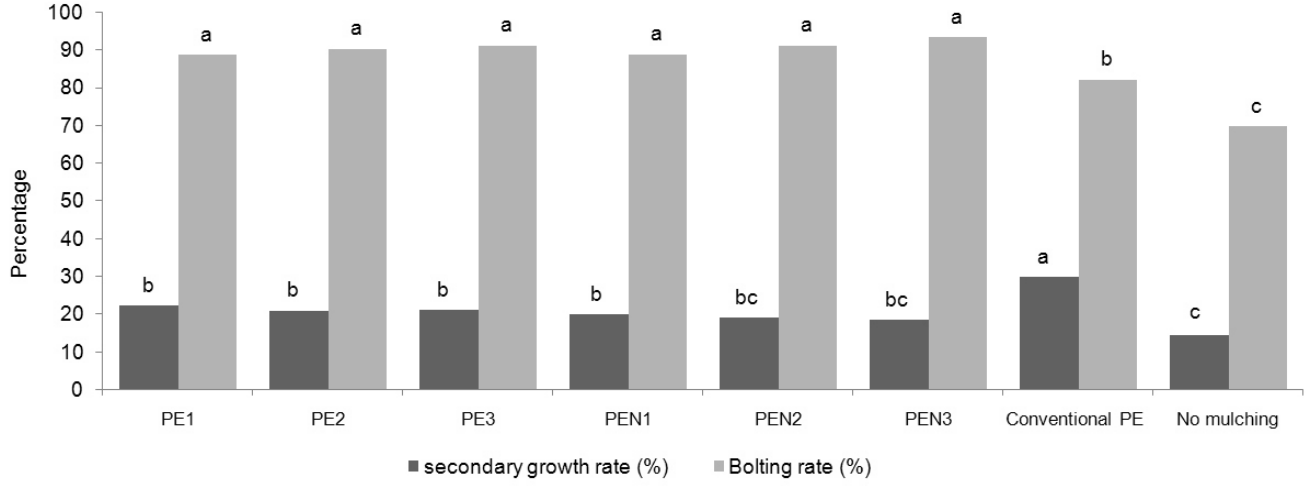

Fig. 1. Effects of mulching and polyethylene film removing treatments on secondary growth and bolting rate of garlic (June 7, 2009). PE and PEN means transparent polythene film and transparent polythene + net polythene; numbers 1, 2, 3 means removing dates of PE film at Feb. 26, March 8 and 18, respectively.

treatment; this result was found 2 months later from harvesting time while PEN3 treatment was shown the lowest weight loss rate (22%). Weed infestation (Fig. 3) was highest (693.3 g·3.3 m^{-2}) in the plot of no mulching and lowest (203.3 g·3.3 m^{-2}) was found in conventional PE film but there was no significant variation among others polythene film mulching methods.

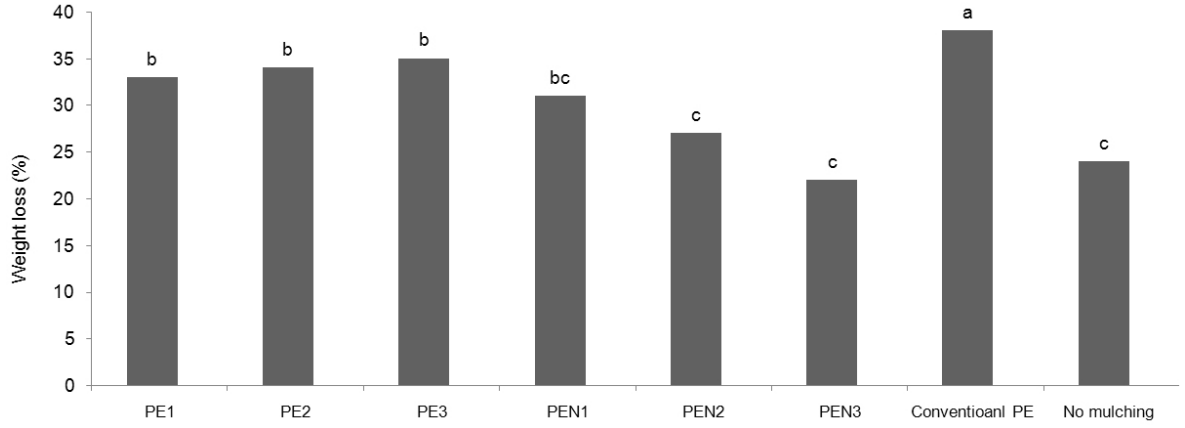

Fig. 2. Effects of different mulching and polyethylene film removing treatments on storage ability of garlic (2 months after harvest). PE and PEN means transparent polythene film and transparent polythene + net polythene; numbers 1, 2, 3 means removing dates of PE film at Feb. 26, March 8 and 18, respectively.

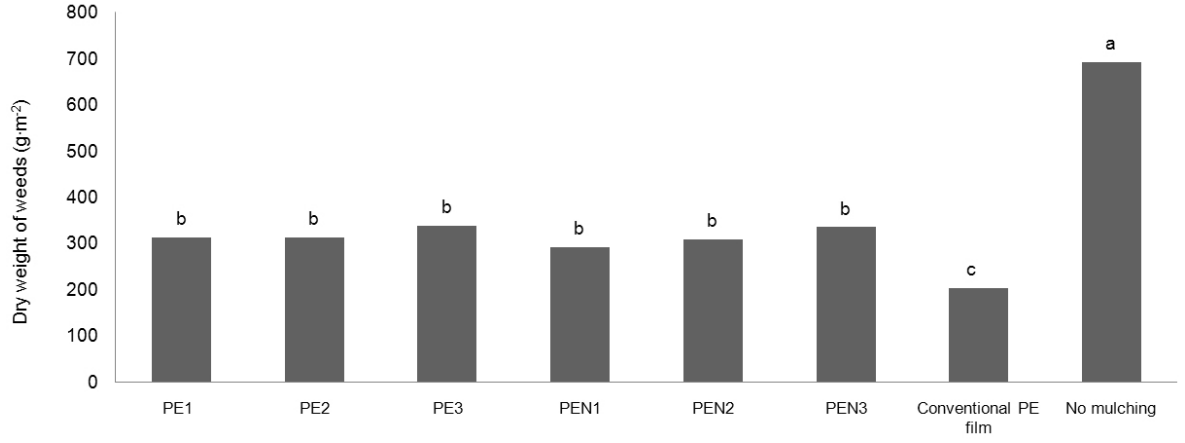

Fig. 3. Effects of mulching and polyethylene film removing treatments on dry weight of weeds in garlic field (April 25, 2009). PE and PEN means transparent polythene film and transparent polythene + net polythene; numbers 1, 2, 3 means removing dates of PE film at Feb. 26, March 8 and 18, respectively.

Discussions

Garlic is cultivated during the winter season which characterized heavy snow as well as lack of rainfall. Thus mulching could solve the problem of scanty soil moisture to some extent in winter conserving the moisture.

In all stages, plant vegetative growth was pronounced at PE3 and PEN3 treatments. Plant height, leaves number, neck diameter, length of leaf sheath were highest at the PEN3 treatment, because this treatment captured high root zone temperature and reserved high percentage of soil moisture for long period. This happens because much of the incident radiation is absorbed by films (Argall and Stewart, 1990) but does not pass through to the soil. Conventional PE film enhanced the bulb diameter although it's not statistically differing to other mulches. Polythene film mulch warm the soil and retain soil moisture by reducing evaporation, moist conditions throughout the growing season, encouraging good root development. Modification of the soil microclimate results in changes in soil temperature that may affect plant growth and yield (Diaz-Perez and Batal, 2002). Transparent polythene film mulch allowed much of the incident radiation to enter into the soil but permitted little of the outgoing radiation to go back out of the soil thus creating a favorable environment for plant vegetative growth. Garlic plants required a warm condition for its vegetative growth (Baten et al., 1995). Mia (1996) reported that plants grown with polythene mulch gave higher bulb yield than non mulch and showed better performance in most of the yield contributing characters like plant height, number of leaves per plant, stem diameter and number of clove. Hosssain (1996) stated that plant height, leaf number, stem and bulb diameter, bulb weight and bulb yield were found to be significantly higher in polythene mulched. Mulch is reported to retain soil moisture for longer duration provide additional amount of nutrition which help to enhance the vegetative growth and rate of

photosynthesis as a result the total production is increased (Pongsa-Anutin et al., 2007).

Bulb diameter was same in size among all treatments but it had increasing trend in the conventional PE mulch owing to absorb incident radiation that can be readily transmitted to the soil and the air is relatively immobile near the soil surface with a low thermal conductivity which increases soil temperature consistently (Cooper, 1973). During the bulbing stage, increasing in root zone temperature are associated with onion yield (Diaz-Perez et al., 2004). This increase in soil temperature as well as humidity consistently improves garlic bulb development (Hwang et al., 1990).

In our experiment, bulb weight loss rate was highest (38%) in the treatment of conventional polythene film compare to PE + net polythene mulch, reason might be there, during extreme winter (December to February) cumulative temperature and soil moisture were higher in conventional polythene film mulch (data not shown), for this favorable condition garlic bulb reserved more water and this reserved water lost quickly during storage period. Secondly, storage environment that is hanging orientation of garlic might affect on the storage ability.

Dry weight of weeds was highest (693 $g \cdot m^{-2}$) at no mulching plot compared to transparent polythene film mulching treatments (Fig. 2) because there was adverse environment to grow weeds due to mulch. Weed control in crops is a difficult, time consuming and expensive task. Transparent polythene mulches have the potential to alter soil temperature, crop water use, improve crop quality and in some cases reduce weed competition, thereby improving crop development and increasing yields (Lamont, 2005; Ngouaajio and Ernest, 2005). Plastic mulch is both effective at warming the soil and reducing weed competition. (Lamont, 2005).

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