Establishment of Sesame Cultivation Practices as Succeeding Cropping System of Watermelon in the Greenhouse Condition

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ABSTRACT This experiment was conducted to develop optimum sesame cultivation practices as succeeding cropping system of watermelon in the greenhouse condition. We also compared major components in sesame seed cultivated in the greenhouse and open field condition. The adaptable varieties under the greenhouse condition were white sesame 'Pyoungan' and black sesame 'Jinki' which showed higher yield and disease resistance. We also conducted several experiments to determine optimum sowing date, planting density and pinching time. Grain yields were statistically different according to the several sowing dates. In general, sesame sowing on June 30th showed higher grain yields than July 10th, July 20th and July 30th in the greenhouse. We also found out sesame cultivation practice with the row spacing of 40 cm and interplant spacing of 30 cm (a few branch type) or 40 cm (many branch type) showed higher yield than other treatments. Optimum pinching time was 25 days after first flowering in main stem when thousand seed weight and grain yield were highest. In the comparison of major components of sesame at the different cultivation conditions, sesame seeds cultivated in the greenhouse contained 4% much more oil content than open field condition. The lignan compounds, sesamin and sesamolin were also higher by 6% in the greenhouse than open field condition. It was concluded that sesame cultivation practices as succeeding cropping system of watermelon in the greenhouse condition guaranteed higher grain yield with less labor input which is now emerging alternative farming practice system in present aging rural society and will also give sesame cultivation farmers to increase net income in Korea.

Keywords : sesame, greenhouse, sowing date, planting density, pinching time, lignan

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Sesame is originated from Africa and well adaptable to dry land condition such as high temperature and intense solar radiation environment. Sesame has been very important seasoning source in Korea for long time. As the magnitude of imported sesame has been increased, market sharing of domestic sesame has decreased and reduced self-sufficiency up to 18% in 2008. Meanwhile, the sesame cultivation areas in the greenhouse have rapidly increased from 10ha in 2007 to 116ha in 2009. Sesame is one of the major summer crops in Korea where it usually starts to cultivate from May to September as a single cropping system in the open field condition. In recent, farmers are trying to cultivate sesame in the greenhouse, however, the standard sesame cultivation system in the greenhouse has not been developed yet. In 2009, Andong, main watermelon production area in Korea, recorded to increase sesame cultivation areas as the succeeding cropping system of watermelon in the greenhouse condition up to 15% among total 1,900 ha of greenhouse areas and earned about 2.2 billion won income. This system has become as common practice in other regions. Sesame yield in the greenhouse was reported to increase due to the higher soil temperature during the sowing and late maturity period rather than open field (Park & Lee, 1982). A few basic experiments were conducted to know the appropriate planting density, sowing date and fertilizer for the sesame cultivation in the greenhouse (RDA, 1999 & 2001). It was also reported that sesame seed showed different quality composition according to the environmental factors, such as temperature, day length, cultivation areas and cultivars, capsule positions (Kang *et al*., 2000a; Kang *et al*., 2000b; Lee *et al*., 1981; Lee *et al*., 1993; Ryu *et al*., 1993a; Ryu *et al*., 1993b; Ryu *et al*., 1996; Tashiro *et al*., 1990). Until now, there were no detailed studies on the establishment of general sesame cultivation practices as succeeding cropping system of

Table 1. General agronomic characteristics of eleven sesame varieties used as raw materials.

Entry	Variety	DTF	DTM	PH (cm)	HFC (cm)	NCP	TSW (g)
1	Yangbaek	July 25	Sept. 26	163	31	120	3.2
2	Ansan	July 24	Sept. 27	150	29	109	3.0
3	Suwon	July 23	Sept. 25	155	31	114	3.1
4	Sunbaek	July 26	Sept. 27	156	30	126	3.0
5	Sungbun	July 22	Sept. 24	178	38	122	3.2
6	Kopoom	July 25	Sept. 27	176	34	118	3.0
7	Seodoon	July 21	Sept. 23	154	32	117	3.1
8	Pyoungan	July 24	Sept. 25	170	22	124	3.3
9	Yanghuck	July 22	Sept. 23	144	45	121	2.9
10	Mihuck	July 25	Sept. 27	166	24	98	2.8
11	Jinki	July 24	Sept. 25	154	27	113	2.9

† DTF : Days to flowering, DTM : Days to maturity, PH : Plant height, HFC : Height to first capsule, NCP : Number of capsule per plant, TSW : Thousand seed weight
‡ Sowing date : June 30th, pinching date : 25 days after first flowering

watermelon in the greenhouse condition. Therefore, we developed several sesame cultivation practices in the greenhouse condition. The experiment results will be helpful for farmers to get more income by reducing labor input and increasing yield potential of sesame cultivated in the greenhouse.

MATERIALS AND METHODS

Total ten sesame varieties, ‘Yangbaek’, ‘Suwon’, ‘Sunbaek’. ‘Sungbun’, ‘Kopoom’, ‘Seodoon’, ‘Pyoungan’, ‘Yanghuck’, ‘Mihuck’, ‘Jinki’ were used for the experiment to select optimum cultivar (Table 1). We used two varieties, ‘Kopoom’ with less than two branches and ‘Ansan’ with more than three branches. This experiment was conducted in the greenhouse of Department of Functional Crops, NICS, RDA during 2007~2009. To establish the general sesame cultivation system in the greenhouse, several treatments of variety selection, optimum sowing and pinching date, planting density were applied to this experiment. Four different sowing dates, June 30th, July 10th, July 20th, July 30th, and three planting densities, 40 cm × 20 cm, 40 cm × 30 cm, 40 cm × 40 cm were applied. To establish the optimum pinching date, three treatments, pinching at the 25 and 30 days after first flowering including control were applied.

Soxhlet method using Buchi B-811 extracted system was used to analyze oil content in the sesame seed. To quantify lignan compounds, we used HPLC analysis system as flow of diagram in Fig. 1 (Yasumoto *et al.,* 2003).

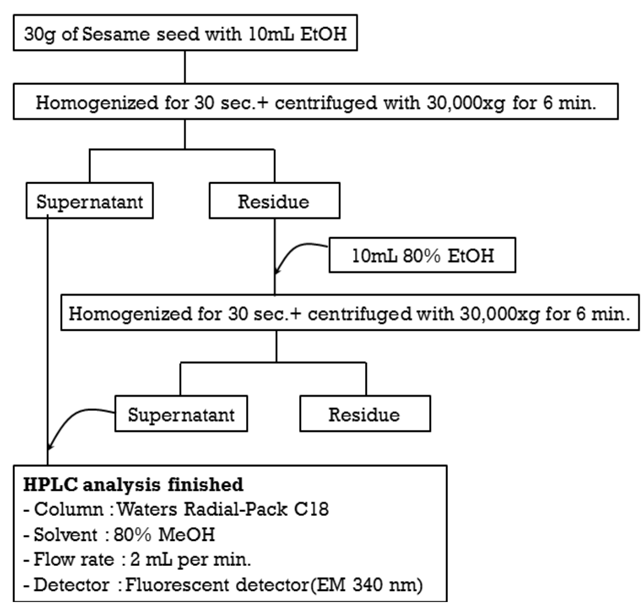

Fig. 1. Protocol of lignan compound quantification in sesame seed

Data were analyzed using ANOVA procedure of SAS statistical software (SAS System for Windows, rel. 8.02, SAS Institute, Cary, NC, USA).

RESULTS AND DISCUSSION

Effect of four treatments on the average yield of sesame seed

Table 2. Analysis of variance with mean squares of variety, sowing date, planting density and pinching date as affected by average sesame grain yield.

Source	Variety	Sowing date	Planting density	Pinching date
Yield	138.9*‡	1216.1**	1357.7**‡	1760.2**

$^{\ddagger *}$, ** means significantly different at 0.05, 0.01 probability levels respectively.

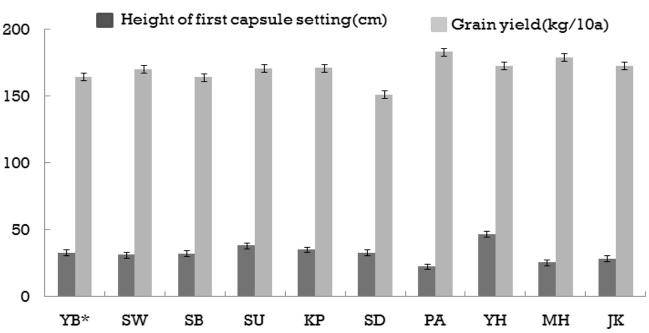

Fig. 2. Comparison of grain yield potential among total ten sesame varieties as succeeding cropping system of watermelon in the greenhouse condition

* YB : Yangbaek, SW : Suwon, SB : Sunbaek, SU : Sungbun, KP : Kopoom, SD : Seodoon, PA : Pyoungan, YH : Yanghuck, MH : Mihuck, JK : Jinki

Analysis of variance indicated that four treatments, such as variety, sowing date, planting density and pinching date significantly affected sesame grain yield (Table 2). Sowing date, planting density and pinching date showed highly significant to the sesame grain yield.

Usually, meteorological conditions in the greenhouse are different from the open field. Temperature is high, but CO_2 concentration is low. Light transmittance in the greenhouse is reduced up to about 30% compared to the open field. Nevertheless, sesame is semi-arid origin crop and required about 2,700℃ of accumulated temperature from sowing to harvest period. The light saturation point of sesame is about 50,000 lux. Therefore, general environmental conditions in the greenhouse was much more proper to sesame growth and give a possibility to increase sesame yield potential. One of the important criteria to select optimum sesame variety in the greenhouse is height of first capsule setting by which total number of capsules and yield potential per plant was determined. According to the result, ‘Pyoungan’ showed lower height of first capsule setting and much more total number of capsules per plant, and it gives higher average grain yield (1820 kg per hectare) than other varieties (Fig. 2).

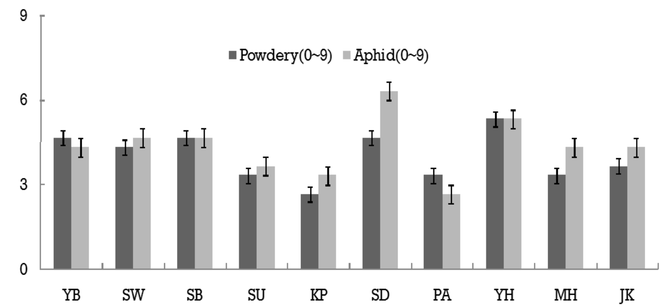

Fig. 3. Comparison of disease resistance among total ten sesame varieties as succeeding cropping system of watermelon in the greenhouse condition.

In the greenhouse, the most serious pest are aphid insect and powdery mildew which usually occur in the high temperature and dry soil condition (Fig. 3).

Pest occurrence data (Fig. 3) explains ‘Pyoungan’ showed disease resistance against the aphid insect with two degree and powdery mildew with three degree indicating that the variety is very resistant to the general pest in the greenhouse condition.

Optimum sowing date, planting density and pinching date for the sesame cultivation in the greenhouse

In the experiment to determine optimum sowing date of sesame as succeeding crop of watermelon in the greenhouse condition, sowing on the June 30th results in shorter height of first capsule setting and more number of capsule per plant which in turn recorded higher average grain yield. As the sowing date was delayed, the height of first capsule setting and the number of capsule per plant were decreased due to the shortage of reproductive growth period which, in turn, causes to insufficient ripening period at the normal reproductive growth pattern of sesame (Fig. 4).

The optimal planting density in the greenhouse cultivation was higher than in open field because it shows larger growth increment due to the high accumulated temperature. Sesame growth data (Fig. 5) indicated sesame cultivar, ‘Ansan’ with

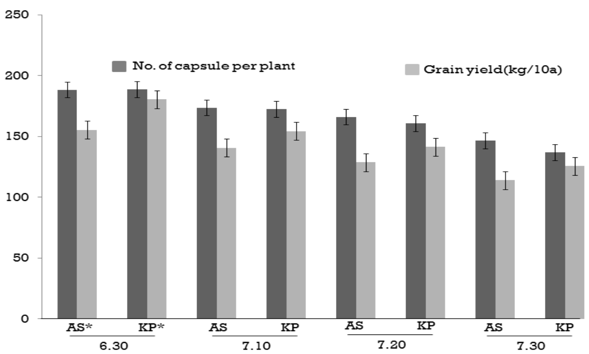

Fig. 4. Optimum sowing date of sesame as succeeding cropping system of watermelon in the greenhouse condition.
* AS : Ansan, KP : Kopoom

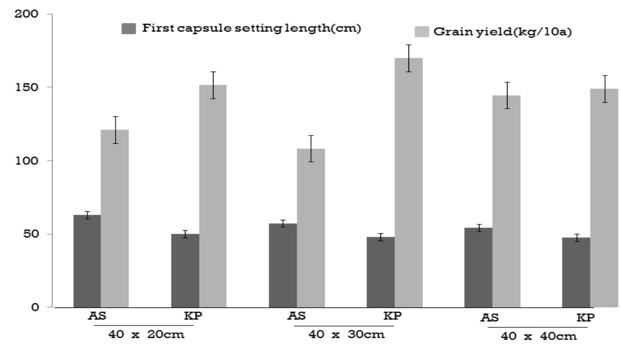

Fig. 5. Optimum planting density of sesame as succeeding cropping system of watermelon in the greenhouse condition.

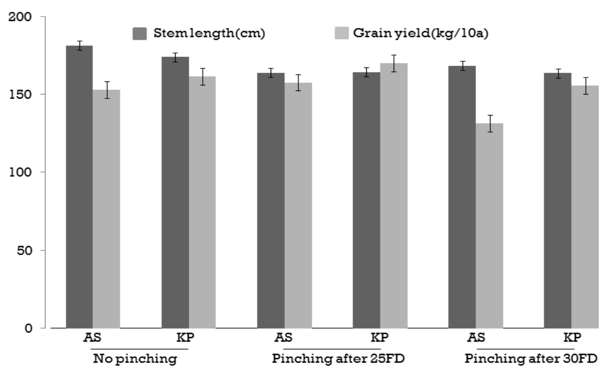

Fig. 6. Optimum pinching date of sesame as succeeding cropping system of watermelon in the greenhouse condition.

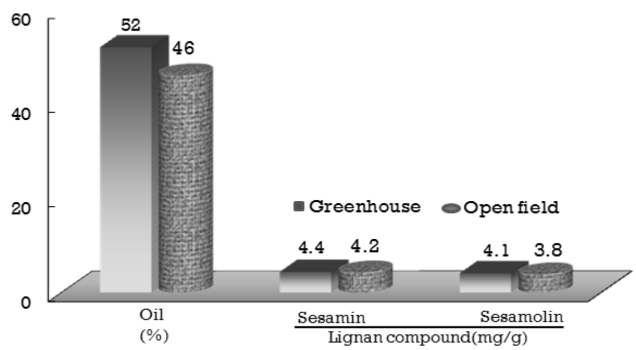

Fig. 7. Comparison of sesame oil and lignan compounds in the greenhouse and open field cultivation condition.

one or two branches shows much more number of capsule per plant and average grain yield when it practiced row spacing of 40 cm and interplant spacing of 30 cm respectively. Otherwise, sesame cultivar, ‘Ansan’ with more than branches is usually required wide planting space to produce more numbers of capsule per plant and average grain yield, which is suitable for row spacing of 40 cm and interplant spacing of 40cm respectively.

Sesame is indefinite inflorescence type in which apical growth of stem continues even though the lowest stem capsule is fully matured. In addition, sesame in the greenhouse usually shows twice as much stem length as in open field which will give farmers to pinch the upper main stem of sesame at the special growth stage. The purpose of pinching treatment to the sesame is to cut the immature upper stem to increase complete ripening rate and thousand seed weight. In case of sesame with black seed coat, the process of black coloring of seed coat is started from lower to upper part of stem during the maturity stage. That is why pinching treatment is needed to get uniformal black colored seed. Another important reason for pinching is to reduce harvest labor input during the harvest stage. Usually, sesame stem in the greenhouse grows to reach the ceiling of greenhouse which is very inconvenient to harvest by hand. According to the result from the experiment, pinching treatment, 25 days after flowering, showed shorter stem length and higher average grain yield under the greenhouse condition (Fig. 6). Pinching treatment according to the sesame variety, ‘Ansan’ with many branches and ‘Kopoom’ with a few branches, there was no statistically different regardless of the numbers of branches.

Comparison of oil content and lignan compounds in the greenhouse and open field

Oil content and lignan compounds are very important factor to determine the sesame seed quality. The kinds of sesame lignans are sesamin and sesamolin which accumulated to 1% in the seed. Both of functional compounds show anti-oxidant and anti-aging effect in the humane body (Fukuda Y *et al.*, 1986 ; Katsuzaki H *et al.,* 1994). We just compared sesame oil and lignan compounds in the greenhouse and open field condition. It statistically showed different. The average sesame oil content in the greenhouse was about 52% which was 4% higher than open field. In case of lignan compounds, sesame seed in the greenhouse contained 4.4 mg/g of sesamin and 4.1 mg/g of sesamolin respectively which was 2～3% higher than open field cultivation.

On the basis of general results of the experiment, we compared income account according to the different sesame cultivation systems. Gross income per hectare in the greenhouse condition was about 27,000,000 Korean Won and total working expenses was expected to be about 4,350,000 Korean Won. Thus, the net income was estimated about 22,650,000 Korean Won which was about 77% higher than open field. It was concluded that sesame cultivation in the greenhouse guaranteed more grain yield as well as higher seed quality with less labor input requirement which is emerging alternative farming in aging rural society in Korea.

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