Research Journal of Applied Sciences, Engineering and Technology 7(13): 2687-2692, 2014
DOI:10.19026/rjaset.7.586
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: July 28, 2013 Accepted: August 06, 2013 Published: April 05, 2014

Research Article

Incidence of Bacterial Disease and Yield of Broccoli as Influenced by Different Rain Protectors and Varieties during the Rainy Season in Southern Thailand

Karistsapol Nooprom and Quanchit Santipracha
Department of Plant Science, Faculty of Natural Resources, Prince of Songkla University,
Hat Yai, Songkhla, 90112, Thailand

Abstract: This study is mainly focused on evaluating the effects of different rain protectors and broccoli varieties to find out whether rain protector and variety is suitable or not for broccoli production during rainy season. Broccoli was experimented at Prince of Songkla University, Hat Yai, Songkhla, southern Thailand. Study revealed that broccoli growing under plastic sheet and green shade net had lower incidence of soft rot disease (1.62 and 3.75%, respectively) than those grown in open field (13.33%) while their growing under plastic sheet (1.50%) had lower incidence of black rot disease than those grown under green shade net and open field (18.75 and 32.88%, respectively). All broccoli varieties were found to be statistically different in their response towards soft rot and black rot diseases. However, the Top Green had the highest diseases incidence (8.33 and 21.08%, respectively) while the Yok Kheo had the lowest diseases incidence (4.62 and 0.00%, respectively). The highest total yield was obtained from the Yok Kheo when those grown under plastic sheet (13.48 t/ha) while the Top Green had lowest yield when those grown in open field (3.94 t/ha). Therefore, the most suitable method for broccoli production during rainy season in southern Thailand was to grow under plastic sheet and green shade net by using the three varieties of broccoli.

Keywords: Black rot, brassicaceae, green shade net, plastic sheet, soft rot, southern Thailand

INTRODUCTION

Broccoli (*Brassica oleracea* var. *italica*) is one of the winter vegetable Cole crops. Its optimum temperature requirement is in the range of 18-24°C (Uzen and Kar, 2004). Broccoli has a very high nutritional value due to its high content of protein, carbohydrates, fibers, calcium, iron, β-carotene, thiamine, riboflavin and ascorbic acid. It also helps in digestion and assimilation of food in human body (Ahmed and Siddique, 2004). Broccoli production in Thailand has been expanding in recent years and amount of increasing broccoli production. It is generally grown in highland where the weather is cool or in lowlands during the cool season (Pornsuriya *et al*., 1997).

Bacterial disease is the serious disease in broccoli production. Soft rot disease of broccoli commonly occurs in broccoli production areas of Thailand. Soft rot disease cause by *Erwinia carotovora* ssp. *carotovora*. This bacterium enters plant tissues primarily through wounds, often created by insect feeding or bruising at harvest. Insect and water are effective modes in spreading the bacteria (Bhat *et al*., 2010). The disease affects both floret and stem tissues. It appears first as the water-socked lesion followed by maceration and soft rotting of tissue (Ludy and Powelson, 1997). Black rot disease is one of the serious diseases at seedling and planting stage and the infection resulting from infected seeds (Dutta *et al*., 2011). Disease caused by bacterial pathogen *Xanthomonas campestris* pv. *campestris* is known as the most major agricultural countries in the world, including Thailand (Schaad and Thaveechai, 1983). Bacterium colonizes the vascular system and characteristic black rot system is V-shaped lesion at leaf margins with black veins, chlorosis and necrosis (Kocks and Zadoks, 1996). Suitable environment for spreading of black rot disease, including high temperature and humidity that affects growth rate and yield content of broccoli losses (Vudhivanich, 2006). Broccoli has potential as an alternative crop in the southern Thailand where the humid tropics weather. Especially between September and December, there is continuously heavy raining (Santipracha, 2007) which is caused problems for broccoli to be destroyed by bacterial disease due to suitable environment for pathogens that caused decreasing growth and yield of broccoli.

The purpose of this study was to determine the effects of different rain protectors and varieties of broccoli on incidence of bacterial disease and the yield during the rainy season in southern Thailand.

Corresponding Author: Karistsapol Nooprom, Department of Plant Science, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand

MATERIALS AND METHODS

This study was carried out in the research field at Prince of Songkla University, Hat Yai, Songkhla, Thailand from October 28, 2012 to January 7, 2013. The experimental design was a split-plot within a randomized complete block design. The main plots were different rain protectors: plastic sheet (5% UV polyethylene film with thickness of 200 microns), green shade net (60% shade) and open field (control) with subplots being varieties: Top Green, Green Queen and Yok Kheo. Broccoli seed was sown in plastic baskets (13×16×4 inches). When the first true leaf had emerged, the seedlings were transplanted into 2-inch pots. At the fourth leaf stage, the seedlings were transferred into the field. The plot size was 1×5 m. The plant and row spacing were 0.30×0.60 m and the edge spacing was 0.20 m. Each plot had two rows of 32 plants. The broccoli was regularly watered with a sprinkler early in the morning and early in the afternoon except rainy days. After transplanting, fertilizer 21N-0P-0K was applied three times, at 2, 3 and 4 weeks and fertilizer 15N-6.5P-12.5K was applied twice, at 5 and 6 weeks, respectively. All plots were weeded with a hand hoe, twice, at 2 and 4 weeks after transplanting.

The measured data, incidence of soft rot and black rot diseases, head length, head diameter, head weight and total yield. Light intensity was measured by Light Meter (Li-250 Licor, Inc., USA). Daily minimum and maximum temperatures were measured by HOBO U23 Pro v2 Temperature/Relative Humidity Data Logger (U23-001, Inc., USA) and data of daily rainfall was obtained from the Kho-Hong Agro-meteorological Station, Hat Yai, Songkhla, Thailand. Data was analyzed using the analysis of variance and means separated by Duncan's Multiple Range Test (DMRT) at the 5% level of significance.

RESULTS AND DISCUSSION

Incidence of soft rot disease: Broccoli growing under green shade nets had higher incidence of soft rot disease (13.33%) than those grown by other methods (1.62-3.75%) as shown in Table 1. The Yok Kheo had the lowest soft rot incidence (4.62%), followed by the Green Queen (6.75%) while the Top Green had the highest disease incidence (8.33%). The interaction between different rain protectors and varieties revealed that no soft rot disease was found in the Yok Kheo when those grown under plastic sheet which was significantly different ($p \leq 0.05$) from the Top Green and Green Queen when growing under plastic sheet (1.50-1.75%). The highest disease incidence was observed in the Top Green growing under green shade net (20.00%). The highest incidence of soft rot disease was observed from broccoli grown under green shade net because among study had high temperature of 25.08-34.92°C and continuously heavy raining (Fig. 1). In addition, the environment under green shade was received low light intensity because it was shaded of 37.50%. These factors had high relative humidity under green shade net of 82.39-96.62% as shown (Fig. 2). Vodhivanich (2006) reported that high temperature and relative humidity cause increasing soft rot disease incidence in Brassicaceae family. This result was consistent with Higashio and Yamada (2004) that high temperature and relative humidity had suitability on soft rot disease cultivation and spreading. The environmental condition under plastic sheet had lower relative humidity than other methods and high light intensity of 90.00%. These factors had very suitability for spreading of soft rot disease.

Incidence of black rot disease: The lowest black rot disease incidence was observed when broccoli was grown under plastic sheet (1.50%) as shown in Table 2, followed by growing under green shade net (18.75%) while broccoli growing on open field had the highest incidence (32.88%). The Yok Kheo had the lowest incidence of disease (13.91%), followed by the Green Queen (18.14%) while the Top Green had the highest disease incidence (21.08%). The interaction between different rain protectors and varieties shown that the

Table 1: Interactions between different rain protectors and varieties on soft rot disease incidence (%) of broccoli

	Varieties (V)			
Treatments (T)	Top Green	Green Queen	Yok Kheo	Mean
Open field	3.25d	6.25c	1.75e	3.75B
Under green shade net	20.00a	12.50b	7.50c	13.33A
Under plastic sheet	1.75e	1.50e	0.00f	1.62C
Mean	8.33A	6.75 B	4.62 C	
C.V. (%)	T (16.22)	V (13.68)		

Means sharing same letters are not significantly different at $p \leq 0.05$ by DMRT

Table 2: Interactions between different rain protectors and varieties on black rot disease incidence (%) of broccoli

	Varieties (V)			
Treatments (T)	Top Green	Green Queen	Yok Kheo	Mean
Open field	38.15a	31.67b	28.83b	32.88A
Under green shade net	22.34c	31.01c	12.92d	18.75B
Under plastic sheet	2.75e	1.75e	0.00e	1.50C
Mean	21.08A	18.14B	13.91C	
C.V. (%)	T (13.72)	V (11.07)		

Means sharing same letters are not significantly different at $p \leq 0.05$ by DMRT

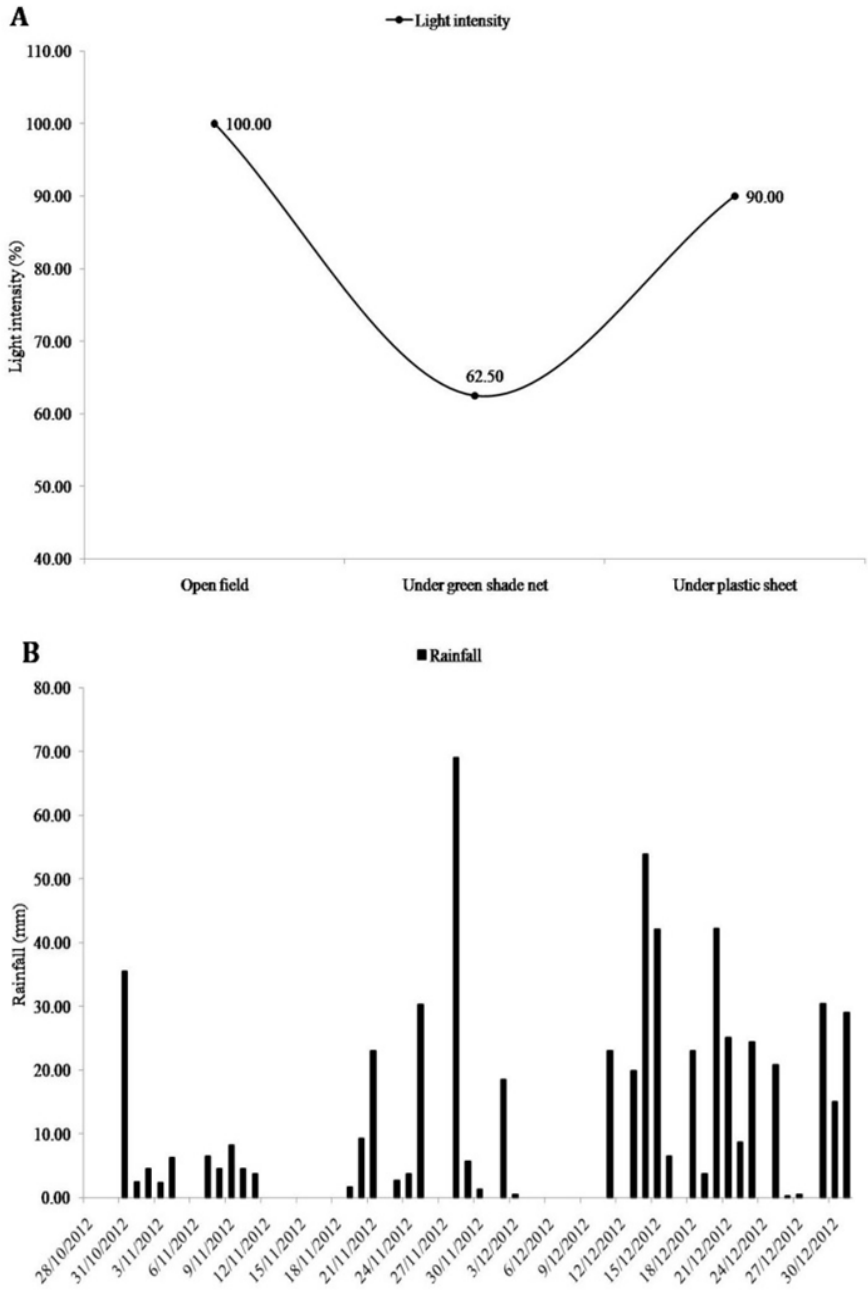

Fig. 1: Light intensity (A) and daily rainfall (B) under different rain protectors between October 28, 2012 and January 7, 2013 at Department of Plant Science, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla, Thailand

three varieties of broccoli had the lowest soft rot disease incidence (0.00-2.75%) while the highest incidence of black rot disease was obtained from the Top Green when those grown in open field (38.15%). The high incidence of black rot disease was observed from broccoli production on open field because there were high temperature of 27.16-36.99°C and continuously heavy raining (Fig. 1) that were suitable for black rot disease spreading. Pathogen well spread when it's obtained high temperature of 25.00-35.00°C (Vudhivanich, 2006). This result was also similar to Dutta *et al*. (2011) that humidity tropical climate had suitability on spreading of black rot disease.

Head length: Broccoli growing under green shade net had the highest head length (34.10 cm), followed by the growing under plastic sheet (30.52 cm) as shown in Table 3. The lowest head length was obtained from plants grown on open field (28.32 cm). The Yok Kheo was observed the highest head length (34.92 cm), followed by the Top Green (30.51 cm) while the Green Queen had the lowest head length (27.52 cm). There

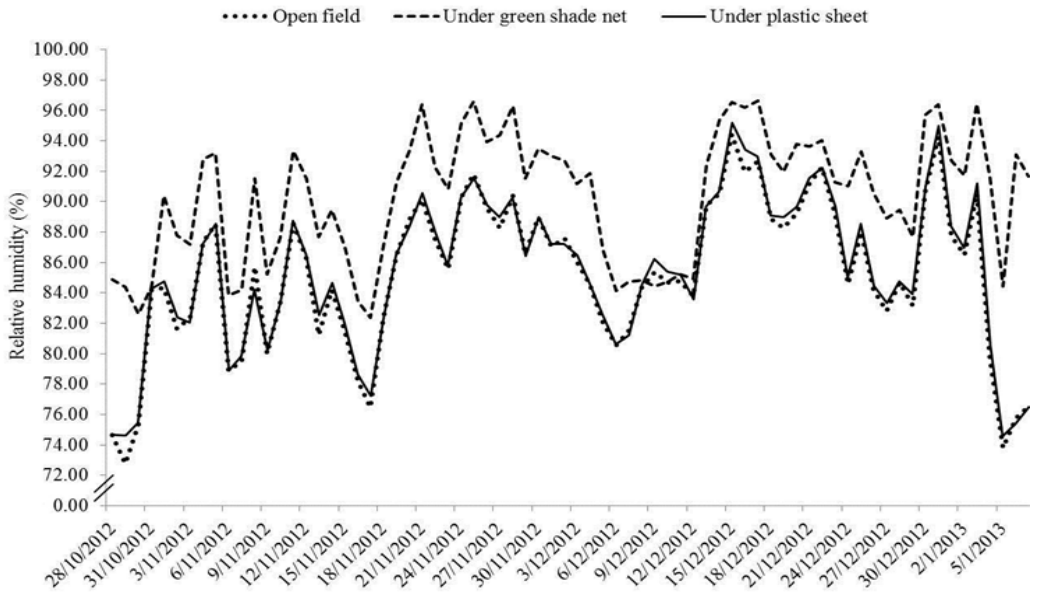

Fig. 2: Daily relative humidity under different rain protectors between October 28, 2012 and January 7, 2013 at Department of Plant Science, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla, Thailand

Table 3: Interactions between different rain protectors and varieties on head length (cm) of broccoli

	Varieties (V)			
Treatments (T)	Top Green	Green Queen	Yok Kheo	Mean
Open field	28.01e	25.93f	31.03c	28.32C
Under green shade net	34.08b	29.63d	38.59a	34.10A
Under plastic sheet	29.43d	27.00ef	35.14b	30.52B
Mean	30.51B	27.52C	34.92A	
C.V. (%)	T (3.64)	V (2.85)		

Means sharing same letters are not significantly different at p≤0.05 by DMRT

Table 4: Interactions between different rain protectors and varieties on head diameter (cm) of broccoli

	Varieties (V)			
Treatments (T)	Top Green	Green Queen	Yok Kheo	Mean
Open field	9.30g	8.73h	10.05f	9.36C
Under green shade net	10.69e	10.42e	12.71b	11.27B
Under plastic sheet	12.24c	11.72d	13.04a	12.33A
Mean	10.74B	10.29C	11.93A	
C.V. (%)	T (2.12)	V (1.64)		

Means sharing same letters are not significantly different at p≤0.05 by DMRT

Table 5: Interactions between different rain protectors and varieties on head weight (g/plant) of broccoli

	Varieties (V)			
Treatments (T)	Top Green	Green Queen	Yok Kheo	Mean
Open field	264.38e	234.81f	322.86cd	274.21C
Under green shade net	336.90c	295.56d	391.70b	341.39B
Under plastic sheet	345.46c	306.52d	434.13a	362.04A
Mean	315.58B	278.96C	382.90A	
C.V. (%)	T (5.94)	V (5.71)		

Means sharing same letters are not significantly different at p≤0.05 by DMRT

Table 6: Interactions between different rain protectors and varieties on total yield (t/ha) of broccoli

	Varieties (V)			
Treatments (T)	Top Green	Green Queen	Yok Kheo	Mean
Open field	3.94e	5.35d	7.52c	5.60C
Under green shade net	5.05d	7.88c	9.67b	7.53B
Under plastic sheet	10.38b	9.44b	13.48a	11.10A
Mean	6.46C	7.56B	10.22A	
C.V. (%)	T (7.79)	V (9.25)		

Means sharing same letters are not significantly different at p≤0.05 by DMRT

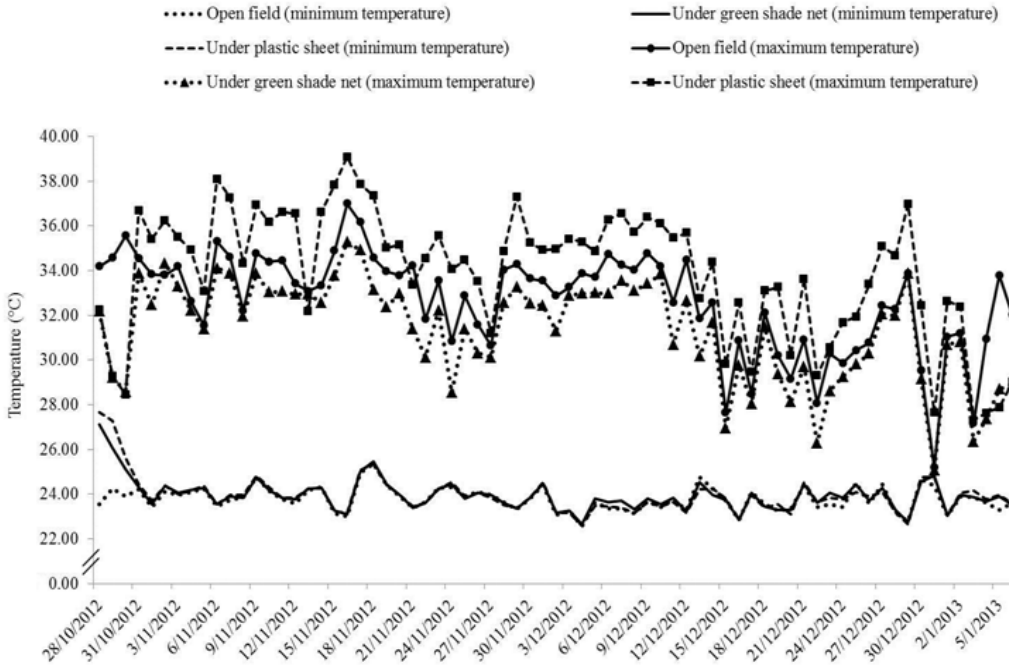

Fig. 3: Daily minimum and maximum temperatures under different rain protectors between October 28, 2012 and January 7, 2013 at Department of Plant Science, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla, Thailand

were interaction effects of different rain protectors and varieties, the highest head length was observed in the Yok Kheo when those grown under green shade net (38.59 cm) while the lowest head length was obtained from the Green Queen when growing on open field and under plastic sheet (25.93-27.00 cm) which was not significantly different ($p \leq 0.05$). Broccoli production under green shade net had higher head length than other methods because of low light intensity that cells expand more to receive light for photosynthesis (Sampet, 1993). These results are consistent with Nooprom *et al*. (2013) who found that the broccoli growing under green shade net had higher plant height that relate with head length of broccoli. Plants obtain the low light intensity that stimulated the synthesis of Gibberellin (GA). It accelerated elongation of node and internode of plants (Sampet, 1993).

Head diameter: The highest head diameter was observed under plastic sheet (12.33 cm), followed by broccoli grown under green shade net (11.27 cm) as shown in Table 4. The lowest head diameter was obtained from growing on open field (9.36 cm). The Yok Kheo had the highest diameter (11.93 cm), followed by the Top Green (10.74 cm). The Green Queen had the lowest diameter (10.29 cm). The interaction between different rain protectors and varieties revealed that the Yok Kheo growing under the plastic sheet had the highest head diameter (13.04 cm) while the Green Queen growing on open field gave the lowest head diameter (8.73 cm). Broccoli growing on open field had smallest head diameter due to had high temperature of 27.16-36.97°C in that periods (Fig. 3). Kaluzewicz *et al*. (2009) reported that broccoli heads were rapidly developed and showed a small head diameter under high temperature of 30.00-40.00°C.

Head weight: Broccoli growing under plastic sheet had the highest head weight (362.04 g/plant), followed by the growing under green shade net (341.39 g/plant) as shown in Table 5. Plants grown on open field had the lowest head weight (274.21 g/plant). The Yok Kheo had the highest head diameter (382.90 g/plant), followed by the Top Green (315.58 g/plant) while the Green Queen had the lowest head weight (278.96 g/plant). The interaction between different rain protectors and varieties revealed that the highest head diameter was obtained from the Yok Kheo when those grown under plastic sheet (434.13 g/plant). The lowest head weight was observed in the Green Queen when those grown in open field (234.81 g/plant).

Total yield: The highest total yield was observed from growing under plastic sheet (11.10 t/ha), followed by the under green shade net (7.53 t/ha) as shown in Table 6. The lowest total yield was obtained from broccoli growing on open field (5.60 t/ha). The Yok Kheo had the highest head total yield (10.22 t/ha), followed by the Green Queen (7.56 t/ha) while the Top Green had the lowest head total yield (6.46 t/ha). The interaction effect for total yield is differed from each

variety over the range of different rain protectors. The highest head total yield was observed in the Yok Kheo when those grown under plastic sheet (13.48 t/ha). The lowest total yield was obtained from the Top Green (3.94 t/ha) because broccoli plants grown on open field were obtained high temperature of 27.16-36.97°C. The incomplete development of broccoli heads and yields were decreased when those grown under high temperature of 31.00-35.00°C (Björkman and Pearson, 1998) while among experiments had continuously heavy raining (Fig. 1) that had high incidence of black rot disease. Krauthansen *et al*. (2011) reported that black rot disease caused yield losses of Brassicaceae family. Broccoli grown on open field was infected with head rot from the impact of rain drops (Santipracha, 2007) and destruction was caused by the bacterium *Erwinia carotovora* ssp. *carotovora* that cause soft rot disease in broccoli (Bhat *et al*., 2010).

CONCLUSION

The results shown that broccoli production during rainy season under plastic sheet and green shade net had lower bacterial disease incidence and higher total yield than those grown in open field. All broccoli varieties could give the highest outcome when those grown under plastic sheet of 9.44-13.48 t/ha, followed by Green Queen and Yok Kheo growing under green shade net of 7.88-9.67 t/ha. According to the present, we can recommend that the broccoli production during rainy season in southern Thailand should be selected by growing under plastic sheet and green shade net by using the Yok Kheo, Top Green and Green Queen varieties because farmers would obtain higher yield than growing in open field.

REFERENCES

Ahmed, M.J. and W. Siddique, 2004. Effect of sowing dates on growth and yield of broccoli (*Brassica oleracea* L.) under Rawalakot conditions. Plant Sci., 3: 167-169.

Bhat, K.A., D. Masood, N.A. Bhat, M.A. Bhat, S.M. Razvi, M.R. Mir, A. Sabina, N. Wani and M. Habib, 2010. Current status of post harvest soft rot in vegetables: A review. Asian J. Plant Sci., 9: 200-208.

Björkman, T. and K.J. Pearson, 1998. High temperature arrest of inflorescence development in broccoli (*Brassica oleracea* var. *italica* L). J. Exp. Bot., 49: 101-106.

Dutta, S., G. Thapa, A.R. Barman, S. Hembram and D.C. Khatua, 2011. Prediction of black rot disease progression of cabbage based on weather parameters. Rajshahi Univ., J. Environ. Sci., 1: 30-33.

Higashio, H. and M. Yamada, 2004. Control of soft rot after harvest of cabbage in Indonesia. JARQ, 38: 175-178.

Kaluzewicz, A., W. Krzesinskiw and M. Knaflewski, 2009. Effect of temperature on yield and quality of broccoli heads. Veget. Crop Res. Bull., 71: 51-56.

Kocks, C.G. and J.C. Zadoks, 1996. Cabbage refuse piles as sources of inoculums for black rot epidemics. Plant Dis., 80: 789-792.

Krauthansen, H.J., N. Laun and W. Wohanka, 2011. Methods to reduce the spread of the black rot pathogen, *Xanthomonas campestris* pv. *campestris*, in brassica transplants. J. Plant Dis. Protec., 118: 7-16.

Ludy, R.L. and M.L. Powelson, 1997. Effect of sprinkler irrigation on bacterial soft rot and yield of broccoli. Plant Dis., 81: 114-118.

Nooprom, K., Q. Santipracha and S. Te-chato, 2013. Effect of shading and variety on the growth and yield of broccoli during the dry season in southern Thailand. King Mongkut's Agri. J., 19: 54-61.

Pornsuriya, P., P. Pornsuriya and S. Teeraskulchon, 1997. Study on broccoli production in Chonbury province, Thailand. Kasetsart J. Nat. Sci., 32: 81-85.

Sampet, C., 1993. Crop Physiology. Odeon Store Press, Bangkok.

Santipracha, Q., 2007. Vegetable Crop Variety and Growing Season of Southern Thailand. Text and Journal Publication, Bangkok.

Schaad, N.W. and N. Thaveechai, 1983. Black rot of crucifers in Thailand. Plant Dis., 67: 1231-1234.

Uzen, S. and H. Kar, 2004. Quantitative effects of planting time on vegetative growth of broccoli (*Brassica oleracea* var. *italica*). Pak. J. Bot., 36: 769-777.

Vodhivanich, S., 2006. Vegetable Diseases and their Control. Kasetsart University Press, Bangkok.