

Research Article

Effect of Planting Time on Incidence of Bacterial Disease and Yield of Broccoli during Dry Season in Southern Thailand

Karistsapol Nooprom, Quanchit Santipracha and Sompong Te-chato

Department of Plant Science, Faculty of Natural Resources, Prince of Songkla University,
Hat Yai, Songkhla, 90112, Thailand

Abstract: The trial was aimed to select suitable planting times when broccoli varieties could resist well to soft rot and black rot diseases during dry season was studied at Prince of Songkla University, Songkhla, Thailand, from January to June, 2011. Split-plot in randomized complete block design was used in this experiment with four replications. The results showed that the lowest incidence of soft rot disease was observed in all broccoli varieties when they were planted in January (4.19-7.18%). After that, it would increase (22.59-45.58%) but the incidence of black rot disease was not increased when planting was done in January, February, March and June. The incidence of black rot disease was highest in April (84.24-92.64%). The Yok Kheo was produced the highest total yield when the planting took place in January and March (12.31 and 10.65 t/ha, respectively). The Yok Kheo is an interesting new hybrid variety. Its higher yield was than Top Green which is popular variety grown in southern Thailand. The yield of Green Queen was not significantly different from Top Green. It can be harvested at 11.67 and 9.38 days earlier than Top Green and Yok Kheo, respectively.

Keywords: Black rot disease, humid tropic, planting time, soft rot disease, yield of broccoli

INTRODUCTION

Broccoli (*Brassica oleracea* var. *italica* Plenck) is the most important herbaceous biennial "Cole" crop of the Brassicaceae family, which is one of the leading vegetables in the world (Ahmed and Siddique, 2004; Khatun *et al.*, 2012). Other members of the family include cauliflower (*Brassica oleracea* L. var. *botrytis* L.), cabbage (*Brassica oleracea* L. var. *capitata* L.) and kale (*Brassica oleracea* L. var. *acephala* DC.). Its optimum growing temperature is in the range between 10 and 20°C (Dhillon *et al.*, 2005). Broccoli has high nutritive value and many health benefits. The American Cancer Society (ACS) indicated that it has several anti-cancerogen effects (Diputado, 1989; Sermenli *et al.*, 2011).

Soft rot and black rot are the serious diseases in broccoli (Cui and Harling, 2006; Dutta *et al.*, 2011). Soft rot disease caused 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 tissue. It appears first as a water-soaked lesion followed by maceration and soft rotting of tissue (Ludy and Powelson, 1997). Black rot disease in broccoli caused by *Xanthomonas campestris* pv. *campestris*. Bacterium

colonizes in the vascular system and the characteristic black rot system is V-shaped lesion at leaf margins with black veins, chlorosis and necrosis (Kocks and Zadoks, 1996). The suitable environments for bacterium spreading consist of high temperature about 30-36°C for soft rot disease and 25-35°C for black rot disease and high humidity (Vodhivanich, 2006).

The weather of southern Thailand is quite humid tropics and suitable for the heat of tolerant hybrid varieties which are better adapted to the high temperature of humid tropics allowing growth and produce high yields during the dry season (Nooprom and Santipracha, 2011). However, due to suitable environment for pathogens, the spreading of soft rot and black rot diseases can be found in broccoli planting that caused yield losses of broccoli growth. The objective of the current study was to investigate the difference of planting times of broccoli varieties on incidence of soft rot and black rot diseases and varieties of broccoli which can be resisted these pathogens for commercial production during dry season in Songkhla, southern Thailand.

MATERIALS AND METHODS

This study was conducted at Prince of Songkla University, Hat Yai, Songkhla, Thailand from January to June, 2011. The design was a split-plot in a

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

This work is licensed under a Creative Commons Attribution 4.0 International License (URL: <http://creativecommons.org/licenses/by/4.0/>).

randomized complete block. The main plots were planting times: January, February, March, April, May and June with sub-plots being early varieties of broccoli: Top Green, Green Queen, Yok Kheo and Special. These varieties show good performance such as, early growth and yield when growing in Songkhla of southern Thailand (Nooprom and Santipracha, 2011). 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 transplanted 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 0.2 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 for rainy days. Fertilizer 21N-0P-0K was applied three times, at 2, 3 and 4 weeks after transplanting was done. Moreover, fertilizer 15N-6.5P-12.5K was applied twice, at 5 and 6 weeks after transplanting. All plots were weeded with a hand hoe, twice, at 2 and 4 weeks after transplanting.

The incidence rates (%) of soft rot and black rot diseases were calculated from infected plants in the plot. The yield data was measured from head diameter (cm), head weight (g/plant) and total yield (t/ha). Data of average daily rainfall, minimum and maximum temperatures from January to June, 2011 was obtained from the Kho Hong Agro meteorological Station, Hat Yai, Songkhla, Thailand. Comparison among means was done with the analysis of variance and means separated by Duncan's Multiple Range Test (DMRT) at the 5% level of significance.

RESULTS AND DISCUSSION

Soft rot incidence: The lowest incidence of soft rot disease was observed when planting was done in January (4.97%). In February, soft rot incidence was increased (45.58%). After that, it declined (22.59-39.57%) during March and June. The highest incidence (34.66%) was observed in the Green Queen followed by Top Green and Special while the Yok kheo had the lowest incidence (16.73%). The interactions between planting times and varieties were significantly influenced on the soft rot incidence. The four varieties planting in January were all observed with the lowest incidence (4.19-7.18%) as shown in Table 1. The highest disease incidence was obtained from the Green Queen and Top Green when planting occurred in February (84.72 and 60.05%, respectively). High incidence observed between February and June might be due to high temperature (31.99-33.80°C) in that period, as well as continuous raining during March and June (mean rainfall of 111.60-325.80 mm) as shown in Fig. 1. These factors affected increasing relative humidity. Kucharek and Bartz (2000) and Higashio and Yamada (2004) reported that high temperature and relative humidity had suitability on soft rot cultivation and spreading. This result was consistent with Vodhivanich (2006) that high temperature about 30-36°C and high relative humidity cause increasing soft rot incidence in Brassicaceae family.

Black rot incidence: Broccoli planted in April was observed the highest black rot incidence (88.86%) as

Table 1: Interactions between planting times and varieties on soft rot incidence (%) in broccoli

Planting times (P)	Varieties (V)				Mean
	Top green	Green queen	Yok Kheo	Special	
January	7.18 l	4.19 l	4.25 l	4.25 l	4.97E
February	60.05b	84.72a	20.49hi	17.08ij	45.58A
March	28.36fg	26.21gh	11.65jk	25.83hg	23.01D
April	43.58d	39.12de	23.77ghi	51.79c	39.57B
May	34.00ef	26.05gh	18.77i	38.45de	29.31C
June	17.90ij	27.68g	21.47ghi	23.31ghi	22.59D
Mean	31.84B	34.66A	16.73D	26.78C	
C.V. (%)	P (14.15)		V (15.73)		

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

Table 2: Interactions between planting times and varieties on black rot incidence (%) in broccoli

Planting times (P)	Varieties (V)				Mean
	Top green	Green queen	Yok kheo	Special	
January	-	-	-	-	-
February	-	-	-	-	-
March	-	-	-	-	-
April	92.43a	86.15a	84.24a	92.64a	88.86A
May	42.51c	62.82b	29.47d	72.14b	51.73B
June	-	-	-	-	-
Mean	67.47B	74.48B	56.85C	82.39A	
C.V. (%)	P (2.46)		V (10.38)		

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

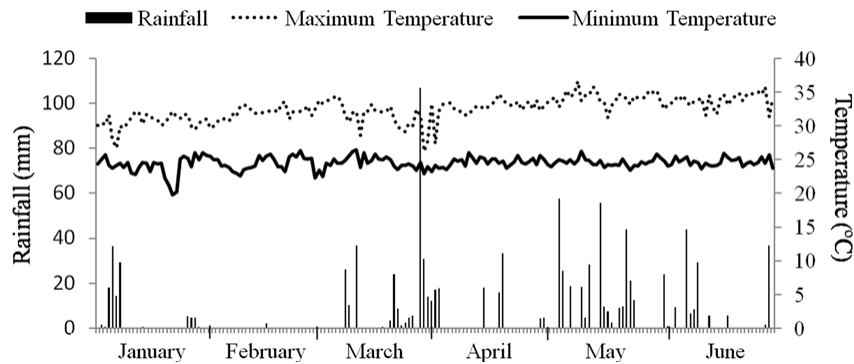


Fig.1: Daily rainfall, minimum and maximum temperatures during January to June, 2011 (Kho Hong Agrometeorological Station at Hat Yai, Songkhla, Thailand)

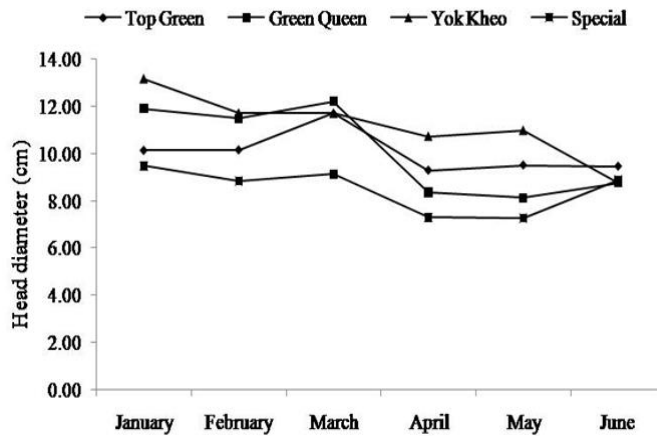


Fig. 2: Interactions between planting times and varieties on head diameter of broccoli

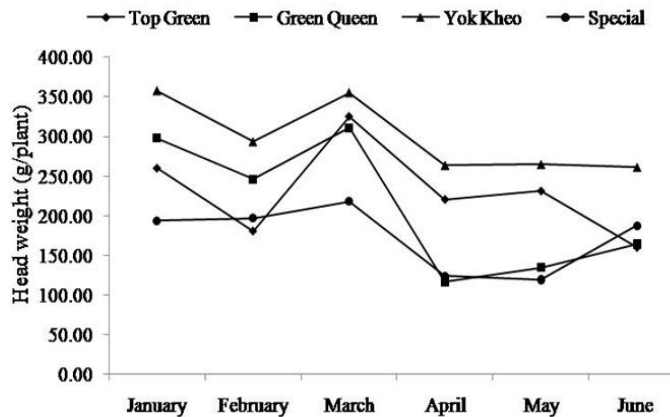


Fig. 3: Interactions between planting times and varieties on head weight of broccoli

shown in Table 2. After that, disease incidence was decreased when planted in May (51.73%). No black rot disease was found in January, February, March and not significantly different ($p \leq 0.05$). The Yok Kheo had the lowest black rot incidence (56.85%). The interactions of planting times and varieties of broccoli revealed that all varieties planted in January,

June. The highest incidence rate (82.39%) was observed in the Special, followed by Green Queen and Top Green (74.48 and 67.47%, respectively) which was February, March and June had not been affected by black rot. In contrast, their incidences increased when planted in April (84.24-93.64%). After that, disease incidence declined in May. The highest incidence was

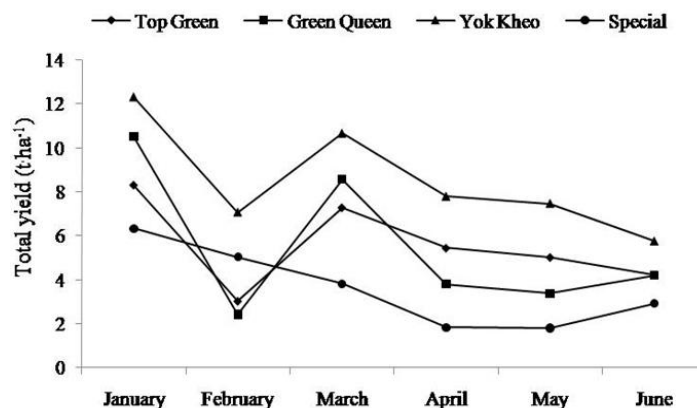


Fig. 4: Interactions between planting times and varieties on total yield of broccoli

observed in April because there was high temperature (32.75-34.20°C) and continuous raining (Fig. 1) that were suitable for black rot spreading. Black rot well spreaded when it obtained high temperature about 25-35°C (Vodhivanich, 2006). This result was also similar to Schaad and Thaveechai (1983) and Dutta *et al.* (2011) that humid tropical climate had suitability on black rot spreading.

Yield responses: Broccoli planting in January and March was obtained the high head diameter and weight (11.17-11.18 cm and 277.18-302.37 g/plant, respectively) as shown in Fig. 2 and 3 which were not significantly different ($p \leq 0.05$). In February, broccolis were obtained decreasing head diameter and weight (10.55 cm and 229.12 g/plant, respectively). The lowest head diameter and weight were obtained with planting between April and June. The highest head diameter (11.58 cm) and weight (299.18 g/plant) was obtained in Yok Kheo, followed by the Top Green and Green Queen which were not significantly different ($p \leq 0.05$) while the lowest head diameter and weight were found in the Special. The interactions of planting times and varieties of broccoli showed that the Yok Kheo planted in January got the highest head diameter and weight (13.18 cm and 357.55 g/plant, respectively). The lowest head diameter and weight were observed in the Special when planted between April and May. Broccoli planting in January and March produced high total yield (7.57-9.36 t/ha) as shown in Fig. 4 while the total yield was low when grew in other months (4.28-4.71 t/h). The Yok Kheo gave the highest total yield when planted in January (12.31 t/ha). The lowest total yield was obtained with the Special when grew between April and June (1.82-2.92 t/ha). Between April and June, broccoli had decreasing head diameter and weight due to high temperature (32.75-34.20°C) as shown in Fig. 1. The high temperature (30-40°C) caused decreasing broccoli vegetative growth that affected yield attribute losses (Kaluzewicz *et al.*, 2009). This result confirmed (Bjorkman and Pearson, 1998) that

over high temperature affected broccoli growth and yield losses. In addition, high temperature and relative humidity caused the high soft rot and black rot diseases and eventually decreasing growth and yield. Bhat *et al.* (2010) reported that soft rot caused greater total loss of vegetable crops than any other bacterial diseases while Krauthansen *et al.* (2011) reported that black rot caused yield losses of Brassicaceae family.

CONCLUSION

Our study showed that January, February, March and June had suitability for broccoli planting due to no black rot incidence in these months. While, broccoli soft rot was observed with moderate incidence except in January when the lowest soft rot incidence (4.97%) was observed. High total yield (7.57-9.36 t/ha) in broccoli planting was produced. The Yok Kheo, Green Queen and Top Green are the suitable varieties for commercial production in Songkhla during the dry season. Especially, the Yok Kheo can resist well to soft rot and black rot.

ACKNOWLEDGMENT

This study was funded by the grant from The Office of the Higher Education Commission Thailand. Mr. Karistsapol Nooprom was supported by CHE Ph.D. Scholarship. The authors would like to thank The Graduate School and Department of Plant Science, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla, Thailand for supporting the scholarship, experimental equipment and the field that the broccoli was planted in.

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.
- Bjorkman, 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.
- Cui, X. and R. Harling, 2006. Evaluation of bacterial antagonists for biological control of broccoli head rot caused by *Pseudomonas fluorescens*. *Plant Dis.*, 96: 408-416.
- Dhillon, B.S., R.K. Tyagi, S. Saxena and G.J. Randhawa, 2005. *Plant Genetic Resources: Horticultural Crops*. Narosa Publishing House Pvt. Ltd., New Delhi.
- Diputado, M.T., 1989. Growth and development studies with broccoli (*Brassica oleracea* var. *italica*). Ph.D. Thesis, Massey University Auckland, PN.
- 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. Krzesinski and M. Knaflewski, 2009. Effect of temperature on yield and quality of broccoli heads. *Veget. Crop Res. Bull.*, 71: 51-56.
- Khatun, K. F. Hossain and S.R. Saha, 2012. Effect of different transplanting dates on the growth and yield of broccoli. *J. Exp. Biosci.*, 3: 13-18.
- 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. Protect.*, 118: 7-16.
- Kucharek, T. and J. Bartz, 2000. *Bacterial Soft Rots of Vegetables and Agronomic Crops*. Univ., of Fla. Coop. Ext. Serv. Fact Sheet (Plant Pathology) No. pp: 12.
- 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, A. and Q. Santipracha, 2011. Growth and yield of 7 early varieties of broccoli in Songkhla province. *King Mongkut's Agr. J.*, 19: 54-61.
- Schaad, N.W. and N. Thaveechai, 1983. Black rot of crucifers in Thailand. *Plant Dis.*, 67: 1231-1234.
- Sermenli, T. K. Mavi and S. Yilmaz, 2011. Determination of transplanting dates of broccoli (*Brassica oleracea* L. var. *italica* Plenck) under Antakya condition. *J. Anim. Plant Sci.*, 21: 638-641.
- Vodhivanich, S., 2006. *Vegetable Diseases and Their Control*. Kasetsart University Press, Bangkok.