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Effect of Chemical Paclobutrazol on Growth, Yield and Quality of Okra (*Abelmoschus esculentus* L.) Har Lium Cultivar in Northeast Thailand

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Abstract: This investigation was carried out at Mahasarakham University Experimental Farm, Mahasarakham University, Northeast Thailand in the late rainy season of the 2003 to 2004 with the use of Roi-Et soil series (Oxic Paleustults). The experiment aims to search for more information on the effect of different rates of chemical Paclobutrazol (PBZ) application on growth, yield and quality of edible okra pods. A Randomised Complete Block Design (RCDB) with four replications was used for the experiment. The experiments consisted of five treatments, i.e., 0 (T_1), 4,000 (T_2), 8,000 (T_3), 12,000 (T_4) and 16,000 ppm ha^{-1} (T_5) of chemical PBZ. The results showed that an increase in PBZ application rate highly decreased plant height, harvesting age and significantly decreased leaf area of the fifth leaf but highly increased pod length, fresh weight/pod and fresh pod yield ha^{-1} of the okra plants. PBZ had no significant effect on stem diameter and diameter of pods of the okra plants. Total soluble solid, fibre content, titratable acid, vitamin C and pectin contents in pods were not affected by chemical PBZ application. Pod yield highly increased with an increase in rate of PBZ application. The highest edible pod yield reached a value of 4,501 kg ha^{-1} for the highest rate of PBZ application (T_5).

Key words: Chemical paclobutrazol, okra plants, fresh pod yield, growth, pod quality

INTRODUCTION

Okra crop (*Abelmoschus esculentus* L.) of Har lium cultivar is an annual vegetable crop. This crop could thrive on well in most tropical and subtropical areas where the young flower buds of pods are commonly used for human consumption as a kind of vegetable crops (FAO, 1988). It is one of many important kinds of economic vegetable crops where the fresh edible pods provide human supplementary vitamins such as C, A, B Complex, iron, calcium, proteins and many others. Fresh edible pods also provide gum and pectin where both possess medicinal properties for man such as the establishment of healthy blood vessels and the prevention of high blood pressure (Adebooye and Opunta, 1996). The pod mucilage has its medicinal properties as an emollient, laxative and expectorant (Muresan and Popescu, 1993). Okra fresh pods when taken as a vegetable crop are tender and not fibrous and it has a typical bright green colour. The fresh edible pods are commonly used for soup and stew preparations apart from salad dressing, cheese spreads and even candy making. Furthermore, edible fresh pods could be used for fat extraction for use in making brownies (Boehlje and Eidman, 1984).

Okra plant is a short day photoperiodic plant where the plants normally initiate flowers when day length becomes short, particularly during the cold season of the year (Chutuchudet, 1994). This crop could be grown in most regions of Thailand since the crop could be simply grown with a small amount of input and its life cycle is relatively short so growers could attain their income within a short period of time. This crop has its significant economic impact since more than 80% of its annual edible fresh and frozen pods being produced in Thailand have been exported to overseas. Thus the crop is popularly received more attention by growers in most regions of the country. In the 2003, Thailand exported an amount of 3,664.62 tons of both fresh and frozen pods of okra crop with an income of approximately 8-million US Dollars (Okra, 2004). However, growers in most regions of the country are now facing some problems in producing high yield and marketable quality of edible fresh pods. The problems include poor production due to poor soil fertility, poor uniformity in sizes and lengths of the pods apart from the high amount of fibre content and the light green appearance of the pods including some signs of damages caused by diseases and insect pests (Owolarafe and Shotonde, 2004). Therefore, in order to produce an acceptable export quality of okra pods, it is an urgent

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need for research workers to search for more information on such problems in order to cultivate the crop with high efficacy. The use of Chemical Paclobutrazol could possibly be one way to remedy the problems. The application of this growth regulator aimed to reduce plant height to attain bushy structure as well as the high reservation of photosynthetic assimilates in temporary sinks (stem, leaves and branches) when the crop had increased in girth of stems and a large number of branches (Evans, 1975; Suksri, 1999). The attained information could possibly assist growers of the okra plants in Thailand to achieve both high quality and yield of this vegetable crop.

MATERIALS AND METHODS

This investigation was carried at Mahasarakham University Experimental Farm with the use of Roi-Et soil series (Oxic Paleustults) in the late rainy season (September 2003 to March 2004). Initial mean values of soil organic matter (%) and soil pH (1:1 soil:water by volume) were 1.65 and 5.5, respectively. Mean values of total soil nitrogen, available phosphorus and exchangeable potassium were 0.14%, 14.62 and 73.80 ppm, respectively. The experiment consisted of five treatments, i.e., 0 (control, T_1), 4,000 (T_2), 8,000 (T_3), 12,000 (T_4) and 16,000 ppm ha^{-1} (T_5) of chemical Paclobutrazol (PBZ) with actual applied rates for T_1 up to T_5 of 0, 100, 200, 300 and 400 ppm $treatment^{-1}$, respectively. Each rate of chemical PBZ was added with distilled water to make four-litre of solutions. The land area was ploughed twice and harrowing once. The experiment was laid in a Randomised Complete Block Design (RCBD) with four replications. The plot size used was a 2×5 m with a path of 1.0 m between the plots. Thus each plot has an area of 10 m^2. 3-4 seeds $hill^{-1}$ of okra (*Abelmoschus esculentus* L.) Har lium cultivar were sown directly into the soil by hand at a distance between rows and within rows of 50×50 cm, respectively. Therefore, each plot has altogether 55 Okra plants, i.e., a hectare of land area has 40,000 plants. One week after emergence, seedlings were thinned out leaving only one seedling $hole^{-1}$ followed by the application of the different rates of chemical PBZ into the soil. One half of the four liters (2 litres) of each rate of the solutions was applied directly into the soil according to their respective treatments, i.e., each plant received approximately 9.1 mL and the other half (2 L) was applied at 14 days after emergence. Thus each plant of each treatment received a total amount of the PBZ solutions of approximately 18.2 mL of the prepared solutions. Only 20 plants of the inner rows of each replication were chosen for the various measurement parameters. The measurements on growth parameters include plant height (measured each stem from above ground level up to the uppermost tip of the leaves), diameter of stems with the use of a vernier caliper, Kanon Instrument, Japan (measured at the point of the first true leaf), leaf numbers $plant^{-1}$ and leaf area of a single leaf of each plant (measured at the fifth true leaf) with the use of a portable leaf area meter, model AM-300, ADC Bioscience, England. Fresh edible pod yields of each treatment were collected and weighed out from time to time where appropriate. The measurements on plant height, number of leaves, leaf area and stem diameter $plant^{-1}$ were carried out at two-week intervals starting from 15 days up to 60 days after emergence. The colour of pods was inspected and compared against the pod colour chart of The Royal Horticultural Society's Colour Chart of the UK. The percentage of Total Soluble Solid (TSS) of pods was examined using a hand refractometer, E type, Series 2111-W10. Model N-1E, Japan. The percentage of fiber content was carried out with the method of Gould (1977) and the determination of titratable acidity content was carried out with the use of malic acid titrated against NaOH 0.1 N and phenolphthalen 1%. The phenolphthalein 1% chemical was used as indicator (AOAC, 1984). Vitamin C content was determined with the method of AOAC (1980), whilst pectin content was carried out with the method of Wattanawanichakorn (1965). The obtained data were statistically analysed using SPSS Computer Programme, Version 6 (SPSS, 1999). The data on height, stem diameter, number of leaves and leaf area (fifth leaf) taken at 15, 30 and 45 days after emergence were omitted since they produced a similar significant effect due to chemical Paclobutrazol application as that of the sampling at 60 days after emergence, thus only the data collected at 60 days after emergence are included in this work.

RESULTS

Plant height, stem diameter, number of leaves and leaf area: With plant height, the results showed that plant height significantly decreased with an increase in the rate of chemical Paclobutrazol applied to the soil. The tallest okra plant was found with T_1 (control treatment) with a mean value of 100.96 cm followed by T_2 up to T_5 with values of 88.10, 82.71, 75.79 and 66.25 cm, respectively. T_2 and T_3 did not significantly differed from each other but T_3 was lower. The differences were large and highly significant (Table 1). Stem diameters were not statistically different from one another where it ranged from 2.67 to 2.73 cm for T_5 and T_2, respectively. Number of leaves/plant increased with an increase in rate of chemical Paclobutrazol with values ranged from 30.59 to 38.81 for

T_1 and T_5, respectively. The differences were large and highly significant. For leaf area of the fifth leaf, the results showed that all rates of chemical PBZ applied significantly decreased leaf area of the okra plants compared with the control Treatment (T_1). All rates of chemical Paclobutrazol gave a similar leaf area of the fifth leaf although leaf area decreased with an increase in PBZ application up to T_3 then there was a small increase up to T_5. The differences between control (T_1) and PBZ treatments (T_2-T_5) were relatively large and statistical significant. Leaf area of the fifth leaf of all treatments ranged from 544.93 to 587.84 cm^2 for T_3 and T_1, respectively.

Harvesting age, fresh yield ha^{-1}, diameter and length of pod: The results showed that harvesting age highly decreased with an increase in chemical Paclobutrazol application compared with the control Treatment (T_1). Harvesting ages of T_2 up to T_4 were similar but T_5 was the lowest with values ranged from 43 to 54 days after emergence for T_5 and T_1, respectively (Table 2). Fresh pod yields ha^{-1} increased with an increase in chemical Paclobutrazol application with values ranged from 3,689 to 4,501 kg ha^{-1} for T_1 and T_5, respectively. The differences were large and highly significant. There were no statistical differences found on stem diameters of the okra plants, whilst pod length highly increased with an increase in chemical Paclobutrazol except T_5 which was a slightly decreased but greater than control Treatment (T_1). The differences were large and highly significant. Fresh weight pod^{-1} significantly increased from T_3 up to T_5 where the highest rate of chemical Paclobutrazol of T_5 gave the highest fresh weight of individual pods. The differences were large and highly significant. The appearance in colour of all pods in all treatments was classified and categorized into Green Group 143/A grade.

Table 1: Mean values of height, stem diameter, number of leaves and leaf area (fifth leaf) of okra plants taken at 60 days after emergence as influenced by different rates of chemical paclobutrazol

Treatments	Height (cm)	Stem diameter (cm)	Number of Leaves/plant	Leaf area (cm^2)
T_1	100.96a	2.70	30.59c	587.84a
T_2	88.10b	2.73	32.12c	557.90b
T_3	82.71b	2.68	35.92b	544.93b
T_4	75.79c	2.73	37.36ab	551.90b
T_5	66.25d	2.67	38.81a	555.45b
F-test	**	NS	**	*
LSD	2.20		0.699	8.38
CV %	12.96	13.24	7.80	14.62

Letters within each column indicate significant differences at probability ** 0.01, * 0.05

Total soluble solid (%), fibre%, titratable acid%, vitamin C and pectin: The results showed that total soluble solid of edible okra pods did not increase with an increase in rates of chemical PBZ with values ranged from 3.20 to 3.25 for T_1 and T_4, respectively. There was no statistical difference found due to treatments. Similarly, fibre content% was not affected by the different application rates of chemical PBZ with values ranged from 0.56 to 0.58 for T_1 and T_2, respectively (Table 3). Likewise, titratable acid % did not influence by the different rates of chemical PBZ applied. This was also found with the amount of vitamin C content in pods where it ranged from 4.57 to 6.07 (mg/100 mL of okra juice) for T_1 and T_4, respectively. The percentage of pectin in form of

Table 2: Mean values of harvesting age, fresh pod yield/ha, diameter of pod, pod length, fresh weight/pod of okra plants as influenced by different rates of chemical paclobutrazol

Treatments	Harvesting age (days)	Fresh pod yield (kg ha^{-1})	Diameter of pods (cm)	Pod length (cm)	Fresh weight (gm pod^{-1})
T_1	54a	3,689cd	1.69	7.12c	7.51c
T_2	48b	3,623d	1.70	7.68b	7.88c
T_3	48b	3,835c	1.73	8.72a	8.80ab
T_4	47b	4,248b	1.78	8.63a	8.55b
T_5	43c	4,501a	1.72	8.12b	9.23a
F-test	**	**	NS	**	**
LSD	0.64	51.41		0.164	0.186
CV %	7.62	12.35	7.15	9.55	14.88

Letters within each column indicate significant differences at probability ** 0.01, NS = Non Significant

Table 3: Mean values of total soluble solid (TSS%), fibre%, titratable acid%, Vitamin C content (mg 100 mL^{-1} of okra juice) and pectin content in form of calcium- pectate salt% of okra fresh pods as influenced by different rates of chemical paclobutrazol

Treatments	TSS (%)	Fiber (%)	Titratable acid (%)	Vitamin C content	Pectin content (Calcium pectate %)
T_1	3.20	0.57	0.20	4.57	0.81
T_2	3.20	0.58	0.26	5.50	0.87
T_3	3.22	0.57	0.34	5.70	0.95
T_4	3.25	0.56	0.36	6.07	0.94
T_5	3.22	0.57	0.27	5.87	0.93
F-test	NS	NS	NS	NS	NS
CV %	8.10	6.55	12.65	13.72	12.65

NS = Non Significant

calcium-pectate was not affected by the different rates of chemical PBZ, i.e., an increase in chemical PBZ did not increase pectin content in the okra juice.

DISCUSSION

The application of different rates of chemical Paclobutrazol (PBZ) as a growth regulator aimed to reduce the synthesis of gibberellin (GA) in the plant tissues for the delaying in growth of the okra plants where GA has its significant effect in inhibiting cell division in the subapical meristem of the shoot resulted in the reduction of stem elongation (Gianfagna, 1995; Benjawan *et al*., 2006). It is well justified that PBZ inhibited GA biosynthesis particularly with respect to the pathway at the ent-kaureno oxidation stage (Rademacher, 1995). Nadia *et al.* (2006) stated that PBZ application reduces plant height, i.e., the higher the rate of PBZ added to the soil the lower the plant height. Similarly, Latimer *et al.* (2001) showed that an excessive reduction in growth of containerized herbaceous perennials was found due to high application rates of PBZ where higher amount of PBZ application gave its higher effectiveness in antigibberellin production than that of the lower ones. It was observed with this work that at the initial sampling period PBZ application failed to provide its significant effect on this respect but later in the subsequent sampling periods okra plant heights were significantly reduced. This could have been attributable to the low environmental temperature (10°C) where the okra plants were allowed to grow under this level of temperature during its early growth period, thus it could have been stunted growth of the okra plants. The results confirm the work reported by Syed and Hussain (1997). Lorenz and Maynard (1998) stated that okra crop is a warm season crop where it requires a range of temperature between 18-30°C for a rapid growth and it could be even more rapid when young edible pod has removed. These results confirm the work reported by Martin and Ruberte (1981). The inhibition effect on vegetative growth of apple trees being grown on soil-treated with chemical PBZ was relatively high, particularly with respect to shoot elongation. These results have been reported by a number of workers such as Wieland and Wample (1985) and Chacko (1986).

The effect due to chemical PBZ application on stem growth of the okra plants was not significantly found. This may be attributable to its retardant property of this growth regulator inhibited stem growth of the okra plants, i.e., PBZ inhibited stem elongation. This confirms the work reported by Fernandez *et al.* (2006) where they reported that PBZ application did not encourage stem elongation of *Phillyrea angustifolia* after its application at a rate of 40 mL L^{-1} $plant^{-1}$. However, when it comes to number of leaves/plant, the results showed that number of leaves/plant highly increased with an increase in rates of PBZ application. The retarded growth effect on subapical dominance of okra plants may have caused poor growth of stem but encouraged more branches for a greater number of leaves hence number of leaves was highly increased. Dej-udom and Sa-nguansak (1990) showed that the growth in stem of rice was significantly reduced but number of tillers and leaf area/hill of aromatic rice plants (*Oryza stiva*) significantly increased. However, with this work the results showed that leaf area of the fifth leaf of each treatment being applied with chemical PBZ was significantly decreased when compared with control treatment. Similarly, Nishizawa (1993) reported that the application of PBZ reduced petiole length and size of strawberry leaves but lateral crowns and flower clusters significantly increased. This similar result due to chemical PBZ application was reported by a number of workers e.g., Marshall *et al.* (2000) with jack pine (*Pinus banksiana*), white spruce (*Picea glauca*) and black spruce (*Picea mariana*) and Khader (1990) with mango (*Mangifera indica* L.) where he suggested that chemical PBZ had its significant effect on GA_3 synthesis in leaves of mango plants by diminishing cell elongation with low production rate of cell division.

The results on harvesting age revealed that PBZ application highly reduced number of days for the initial harvest of edible pods, particularly the highest rate being applied. The results indicated that PBZ application hastens maturity of edible pods as well as the rapid growth of fresh edible pods where the higher the rate of PBZ applied the higher the yield ha^{-1} of pods. However, a decline in yield ha^{-1} due to chemical PBZ application was not found with this work. It may be possible that edible pod yield of the okra plants could be declined with a higher rate higher than the present work. It is well advocated that chemical PBZ has its important property on the accumulation of carbohydrates thus it hastens a rapid growth of sinks or pods where it significantly increased crop yields ha^{-1} (Whiley, 1993; Katz *et al*., 2003; Benjawan *et al*., 2006). Nevertheless, chemical PBZ had no significant effect on pod diameter but highly affected both pod length and edible fresh weight/pod. This may be attributable to the rapid rate of carbohydrate production demanded a larger size of sinks for a rapid unloaded translocation of assimilates, thus the highest edible pod yield ha^{-1} of 4,501 kg of T_5 was attained. Chemical PBZ application had no significant effect on total soluble solid (%), fibre content, titratable acid, vitamin C and pectin content. The results suggested that chemical PBZ has no influential effect on chemical composition of the okra fresh pods but it encourages high production of the okra edible pods. The high pod yield ha^{-1} with a greater length of pods and the appearance of colour of Green Group 143/A grade plus a short period of harvesting age could possibly be of high advantage in producing this edible vegetable crop for domestic and overseas consumption. Nonetheless, it may be of interest to carry out more okra experiments on higher rates of chemical PBZ, higher than the present work in order to attain a decline in fresh pod yield ha^{-1} since the highest rate being used with this work did not give a decline in fresh pod yield ha.

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REFERENCES

Adebooye, C.O. and C.O. Opunta, 1996. Effects of galex on growth and fruit nutrient composition of okra (*Abelmoschus esculentus* L.). Ife J. Agric., 18: 1-9.

AOAC, 1980. Association of Official Analysis Chemists. Official Methods of Analysis. Washington, D.C. pp: 1018.

AOAC, 1984. Official Methods of Analysis. 14th Edn., Association of Official Analytical Chemists. Arlington. Virginia, USA., pp: 1200.

Benjawan, C., P. Chutichudat, K. Boontiang and T. Chanaboon, 2006. Effect of chemical paclobutrazol on fruit development, quality and fruit yield of Kaew mango (*Mangifera indica* L.) in Northeast Thailand. Pak. J. Biol. Sci., 9: 717-722.

Boehlje, M.D. and V.R. Eidman, 1984. Farm Management. John Wiley and Sons Inc., New York.

Chacko, E.K., 1986. Physiology of vegetative and reproductive growth in mango (*Mangifera indica* L.) trees. In: The First Australian Mango Research Workshop. Melbourne, Australia, pp: 54-70.

Chutuchudet, P., 1994. Plant Hormones, a lecture note for undergraduate students, Department of Agricultural Technology, Mahasarakham University, Northeast Thailand.

Dej-udom, A. and V. Sa-nguansak, 1990. Effect of application periods in spraying growth regulator chemicals on yields and yield components of jasmine rice (*Oryza sativa*). A case study report of the 1990. Kasetsart University, Bangkok, Thailand.

Evans, L.T., 1975. The Physiological of Crop Yield. In: Evans, L.T. (Ed.). Crop physiology: Some case histories. Cambridge University Press, UK.

FAO., 1988. Food and Nutrition Paper 42. Traditional Food Plants. FAO, Rome, pp: 320.

Fernandez, J.A., L. Balenzategui, S. Banon and J.A. Franco, 2006. Induction of drought tolerance by Paclobutrazol and irrigation deficit in *Philyrea angustifolia* during the nursery period. Sci. Hortic., 107: 277-283.

Gianfagna, T.J., 1995. Natural and Synthetic Growth Regulators and Their Use in Horticultural and Agronomic Crops. In: Plant Hormones: Davies, P.J. (Ed.), Physiology, Biochemistry and Molecular Biology, Kluwer Academic Publishers, Dordrecht.

Gould W.A., 1977. Food quality assurance. The AVI Publishing Company, Inc., Westport, Connecticut, pp: 314.

Katz, E., O. Ziv, R. Venkatachalam, E. Shlomo, A.H. Halvy and D. Weiss, 2003. Promotion of *Globularia sarcophylla* flowering by Uniconazol, an inhibitor of gibberellin biosynthesis,. Scientia Hotic., 98: 423-431.

Khader, S.E.S.A., 1990. Orchard application of Paclobutrazol on ripening, quality and storage of mango fruits. Sci. Hortic., 41: 329-335.

Latimer, J.G., H.L. Scoggins and T.J. Banko, 2001. Using plant growth regulators on containerized herbaceous perennials. Virginia Tech. Publication No. 430. Blacksburg. VA. USA.

Lorenz, O.A. and D.N. Maynard, 1998. Knott's Handbook for Vegetable Growers. Whiley and Sons, New York, USA.

Marshall, J.G., R.G. Rutledge, E. Blumwald and E.B. Dumbroff, 2000. Reduction in turgid water volume in jack pine, white spruce and black spruce in response to drought and Paclobutrazol. Tree Physiol., 20: 701-707.

Martin, F. and R. Ruberte, 1981. Variability in Okra seed quality. J. Agric. Univ. Puerto Rico, 65: 205-212.

Muresan, R. and H. Popescu, 1993. *Abelmoschus esculentus* (L.) Monench. Cultivat la Cluj ca sursa de poliholozide. Clujul Med., 66: 201-209.

Nadia, M., Al-Khassawneh, N.S. Karam and R. Shibli, 2006. Growth and flowering of black iris (*Iris nigricans* Dinsm.) Following treatment with plant growth regulators. Scientia Hortic., 107: 187-193.

Nishizawa, T., 1993. The effect of Paclobutrazol on growth and yield during first year greenhouse strawberry production. Sci. Hortic., 54: 267-274.

Okra, G., 2004. Central agricultural market of Thailand. http://www.talaadthai.com.

Owolarafe, O.K. and H.O. Shotonde, 2004. Some physical properties of fresh okra fruit. J. Food Eng., 63: 267-274.

Rademacher, W., 1995. Growth retardants: Biochemical features and applications in horticulture. Acta Hortic., 394: 57-73.

SPSS, 1999. Base 9.0 for Windows userGuide. SPSS Inc., USA.

Suksri, A., 1999. Some Agronomic and Physiological Aspects in Growing Crops in Northeast Thailand. 1st Edn., Khon Kaen University Press, Khon Kaen 40002, Thailand, pp: 212.

Syed, A. and S. Hussain, 1997. Effect of exogenous growth regulator on growth, flowering and yield of okra. Sarhad J. Agric., 13: 449-453.

Wattanawanichakorn, S., 1965. Relationship between time of extraction and temperature. Special Problems. Kasetsart University, Bangkok, Thailand.

Whiley, A.W., 1993. Environmental effects on phenology and physiology of mango: A review. Acta Hortic., 341: 168-176.

Wieland, W.F. and L.R. Wample, 1985. Effects of Paclobutrazol on growth, photosynthesis and carbohydrate content of ‘dDlicious’ apples. Sci. Hortic., 26: 97-104.