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## Effects of different harvesting times on growth, yield and quality of Kalmegh (*Andrographis paniculata* Wall Ex. Nees)

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Detpiratmongkol, S. and Liphan, S. (2018). Effects of different harvesting times on growth, yield and quality of Kalmegh (*Andrographis paniculata* Wall Ex. Nees). International Journal of Agricultural Technology 14(7): 1161-1170.

**Abstract** The effect of harvesting times on growth, yield and quality of kalmegh were investigated. The results were disclosed that for three local kalmegh cultivars, stem and leaf dry weight and total dry weight of Prachinburi cultivar were the the highest and followed by Nakhon Prathom and Pitsanulok 5-4 cultivars, respectively. Leaf dry weight and seed dry weight yield of Prachinburi cultivar were the highest. Harvesting times affected on growth and yield of kalmegh. The highest leaf dry weight yield (13.59 g plant<sup>-1</sup>) and andrographolide content (2.54%) were recorded at harvesting times of 135 DAP but the highest seed dry weight yield was detected 170 DAP. However, it is recommended that harvesting times at 135 DAP in Prachinburi local kalmegh cultivar should be adopted.

**Keywords:** Kalmegh, Harvesting time, Growth, Yield

### Introduction

Kalmegh, *Andrographis paniculata* Nees, is a medicinal herb from the family Acanthaceae that is a perineal herb widely cultivated in China, India, Pakistan, Srilanka and Thailand. It commonly known as a king of bitters and the whole plant of kalmegh is used extensively as an anti-inflammatory and antipyretic drug for the treatment of fever, cold, laryngitis, diarrhea and inflammation (Kumar *et al.*, 2002; Akbar, 2011).

Very few studies have been carried out in the development of agrotechniques for its commercial cultivations (Maheshwari *et al.*, 2002; Singh and Singh, 2005). Appropriate harvesting times and considered to be very important for crop quality. The active principle of plant varies with time interval, different environment at conditions (National Research Centre for Medicinal and Aromatic Plant, 2001; Kumar *et al.*, 2002) and time of harvesting had a major influence on productivity and quality of kalmegh

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(Nenade *et al.*, 2001). Ashok *et al.* (2002) reported that the best harvesting time was observed at 120 DAP to get higher biomass containing maximum andrographolide Kumar and Kumar (2013) reported that for the influence of four harvesting time (such as 120, 135, 150 DAP and seed maturity), the maximum values for dry herbage biomass yield ( $5.14 \text{ t ha}^{-1}$ ), andrographolide content (2.63%) and total yield ( $135.00 \text{ kg ha}^{-1}$ ) were detected 135 DAP. However, for harvesting at seed maturity, the dry herbage yield was decreased. As paper the earlier report, the quality of kalmegh decreases with the delay in harvesting (National Research Centre for Medicinal and Aromatic Plants, 2001). Hence, the optimum harvest time need to be standardized for this crop. The objectives of the present study were to investigate different harvesting times on growth and yield of kalmegh.

## **Materials and methods**

The experiment was conducted during June to November, 2016 at the research glasshouse of Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand. The pot experiment was laid out in a split plot design with three replications. Three local kalmegh cultivars such as Prachinburi, Nakhon Prathom and Pitsanulok 5-4 were as main-plot and four harvesting times viz; 120, 135, 150 and 170 DAP were taken as subplot.

Plastic plots 30 cm in diameter were used for cultivation that was filled with the soil, Bangkok series. Thirty days old seedlings of kalmegh were transplanted by hand to the plastic pots. The basal fertilizer with  $6.25 \text{ t ha}^{-1}$  of cattle manure and with 313 kg of 15-15-15 chemical fertilizer were applied on day 30 after transplanting. Manual weeding took place at 30 and 60 DAP and irrigation was given at every day after transplanting till harvest.

At harvest, three sample plants were randomly selected in each treatment. The height of plant was done by measuring the plant from the base up to the tip of the main stem with a measuring ruler. Data collected include number of branches per plant, number of capsule per plant and stem and leaf dry weight. Leaf and seed dry weight yield were recorded as per time of harvesting. Dry weight of plants was taken in the electric oven at  $65 \text{ }^{\circ}\text{C}$  for two days or until a constant dry weight was obtained. For Andrographolide content in leaf of kalmegh, it was estimated by using the method of Srivastava *et al.* (1959) and Kumar and Kumar (2013). Data collected were subjected to analysis of variance and where means were significantly different the Least Significant Difference was used for separation (ANOVA) using Statistix 10.

## Results

### *Plant height*

Data regarding plant height are presented in Table 1. Mean value of the data showed that different cultivars significantly affected on plant height. Maximum plant height (47.57 cm) was recorded in Prachinburi cultivar followed by Nakhon Prathom (29.95 cm) and Pitsanulok 5-4 (26.86 cm) cultivars, respectively. In case of harvesting times, it is point out that greater plant height (39.39 cm) was resulted in plants harvested at 170 DAP whereas lesser plant height (30.92 cm) was got at harvested at 120 DAP.

**Table 1.** Plant height, stem dry weight, numbers of branch per plant and leaf dry weight of three local kalmegh cultivars as affected by different harvesting times

Treatments	Plant height (cm)	Stem DW (g plant <sup>-1</sup> )	Number of branches per plant (branches)	Leaf DW (g plant <sup>-1</sup> )
Cultivars (A)				
Pitsanulok 5-4	26.86 B	2.52 C	30.00 B	1.14 B
Prachinburi	47.57 A	3.98 A	48.38 A	2.34 A
Nakhon Prathom	29.95 B	2.94 B	34.37 B	1.31 B
Harvesting times (B)				
120 DAP	30.92 c	2.63 a	35.67 b	1.66 b
135 DAP	33.45 bc	2.90 b	36.16 b	2.15 a
150 DAP	35.43 c	3.29 c	38.17 ab	1.42 bc
170 DAP	39.39 a	3.77 d	40.33 a	1.15 c
Mean	34.79	3.15	37.59	1.60
LSD (A) (0.05)	5.49	0.22	7.91	0.36
LSD (B) (0.05)	2.69	0.05	3.12	0.44
LSD (AxB) (0.05)	ns	ns	ns	ns
C.V. (%) (A)	7.34	13.14	9.79	10.50
C.V. (%) (B)	5.94	13.38	6.35	21.07

DAP = Day after planting; DW = dry weight; ns = no significant at the 0.05 probability level.

### *Stem dry weight*

Data concerning stem dry weight are presented in Table 1. The data indicated that the effect of different cultivars was significant on stem dry weight. It was evident that the maximum stem dry weight (3.98 g plant<sup>-1</sup>) was

observed in Prachinburi cultivar followed by Nakhon Prathom cultivars ( $2.94 \text{ g plant}^{-1}$ ) whereas the minimum stem dry weight ( $2.52 \text{ g plant}^{-1}$ ) was recorded by Pitsanulok 5-4 cultivar. Harvesting time effect on stem dry weight differ significantly. Maximum stem dry weight ( $3.77 \text{ g plant}^{-1}$ ) was noted in plants harvested at 170 DAP while minimum stem dry weight ( $2.63 \text{ g plant}^{-1}$ ) was in plants harvested at 120 DAP.

### ***Numbers of branch per plant***

Data regarding numbers of branch per plant are presented in Table 1. Checking of the data indicated that the different cultivars were significantly affected number of branch per plant. Mean value of data disclosed that maximum numbers of branch per plant (48.38) obtained by Prachinburi cultivar, followed by Nakhon Prathom (34.37) cultivar and minimum numbers of branch per plant (30.00) was observed by Pitsanulok 5-4 cultivar. With regard to the impact of harvesting times, the number of branch per plant (40.33) was the highest in plant harvested at 120 DAP and the lowest (35.67) was found in plants harvested at 120 DAP.

### ***Leaf dry weight***

Data concerning leaf dry weight are present in Table 1. Perusal of data indicated that the effects of different cultivars were significant on leaf dry weight. The maximum leaf dry weight ( $2.34 \text{ g plant}^{-1}$ ) was observed in cultivar Prachinburi, followed by Nakhon Prathom cultivar ( $1.31 \text{ g plant}^{-1}$ ) whereas minimum leaf dry weight ( $1.14 \text{ g plant}^{-1}$ ) was recorded by cultivar Pitsanulok 5-4. The time of harvesting had significant influence on leaf dry weight. The highest leaf dry weight ( $2.15 \text{ g plant}^{-1}$ ) was obtained the crop was harvested at 135 DAP which was statistically different to harvested at 120 and 150 DAP, respectively. The lowest leaf dry weight ( $1.15 \text{ g plant}^{-1}$ ) was obtained when the crop was harvested at 170 DAP. The highest leaf dry weight was in 135 DAP and then decreased in 170 DAP due to senescence and shading of leaves.

### ***Numbers of capsule per plant***

The influence of different cultivars was significant on numbers of capsule per plant in Table 2. The highest numbers of capsule per plant (382) were recorded in Prachinburi cultivar followed by Nakhon Prathom (302) and Pitsanulok 5-4 cultivars, respectively. Data revealed that the numbers of capsule per plant was statistically significant by time of harvesting. The highest

number of capsule per plant (377) was observed when the crop was harvested at 170 DAP which was statistically significant to crop harvested at 150 DAP and 135 DAP. The lowest numbers of capsule per plant (269) were found from 1<sup>st</sup> harvest (120 DAP).

**Table 2.** Numbers of capsule per plant, seed and leaf dry weight yield and andrographolide content of three local kalmegh cultivars as affected by different harvesting times

Treatments	Numbers of capsule per plant (capsule)	Seed DW yield (g m <sup>-2</sup> )	Leaf DW yield (g m <sup>-2</sup> )	Andrographolide content (%)
Cultivars (A)				
Pitsanulok 5-4	253 C	2.08 B	9.66 C	1.86 B
Prachinburi	382 A	3.61 A	15.21 A	2.93 A
Nakhon Prathom	302 B	2.16 B	10.61 B	2.31 B
Harvesting times (B)				
120 DAP	269 d	1.77 d	12.81 b	2.43 a
135 DAP	281 c	2.28 c	13.59 a	2.54 a
150 DAP	323 b	2.99 b	10.99 c	2.44 a
170 DAP	377 a	3.44 a	9.92 d	2.07 b
Mean	313	2.62	11.83	2.37
LSD (A) (0.05)	18.79	1.03	0.83	0.51
LSD (B) (0.05)	17.88	0.22	0.54	0.30
LSD (AxB) (0.05)	ns	ns	ns	ns
C.V. (%) (A)	12.79	18.34	13.27	10.12
C.V. (%) (B)	14.37	16.70	13.48	9.87

DAP = Day after planting; DW = dry weight; ns = no significant at the 0.05 probability level.

### *Seed dry weight yield*

Data regarding seed dry weight yield are presented in table 2. The maximum seed dry weight yield (3.61 g m<sup>-2</sup>) was obtained in Prachinburi cultivar, followed by Nakhon Prathom (2.16 g m<sup>-2</sup>) whereas the minimum seed dry weight yield (2.08 g m<sup>-2</sup>) was recorded in Pitsanulok 5-4 cultivar. Harvesting time has significant effect on seed dry weight yield. The highest seed dry weight yield (3.44 g m<sup>-2</sup>) was produced at 170 DAP and the decreased in 150 DAP and 135 DAP, respectively.

### ***Leaf dry weight yield***

Significant effect was found among three cultivars for leaf dry weight yield in The highest leaf dry weight yield ( $15.21 \text{ g m}^{-2}$ ) was obtained in Prachinburi cultivar followed by Nakhon Prathom ( $10.61 \text{ g m}^{-2}$ ) and Pitsanulok 5-4 ( $9.66 \text{ g m}^{-2}$ ) cultivars, respectively. The maximum leaf dry weight yield ( $13.59 \text{ g m}^{-2}$ ) was observed when the crop was harvested at 135 DAP and the lowest leaf dry weight yield ( $9.92 \text{ g m}^{-2}$ ) was produced when the crop was harvest at 170 DAP.

### ***Andrographolide content***

Data regarding andrographolide content (%) are presented in Table 2 indicated that effects of different cultivars were significant. Mean value of data shown that maximum andrographolide content (2.93 %) in Prachinburi cultivar, followed by Nakhon Prethom (2.31 %) whereas minimum andrographolide content (1.86 %) was recorded in Pitsanulok 5-4 cultivar. The highest content of andrographolide was recorded at a crop age of 135 DAP (2.54 %), 120 DAP (2.43 %) and 150 DAP (2.44 %) whereas the lowest content of andrographolide was observed at a crop age of 170 DAP (2.07 %).

### **Discussion**

Among three local kalmegh cultivars, Prachinburi, Nakhon Prathom and Phitsanulok 5-4 cultivars had significant differences in these eight characteristics with each others. The maximum plant height (55.18 cm), stem dry weight ( $6.76 \text{ g plant}^{-1}$ ), number of branch per plant (24.00), leaf dry weight ( $2.63 \text{ g plant}^{-1}$ ), numbers of capsule per plant (68.90), seed dry weight yield ( $37.19 \text{ g m}^{-2}$ ) and andrographolide content (2.79 %) were recorded in Prachinburi followed by Nakhon Prathom and Phitsanulok 5-4 cultivars, respectively. These results are in good agreement with the finding of Liphon and Detpiratmongkol (2017) also showed that Prachinburi was the best growth and yield. Sandeep *et al.* (2009) also reported that genotypes have significantly different effect on plant height, stem and leaf dry weight, total dry weight and dry weight yield. Almodares *et al.* (2008) concluded that kalmegh can grow well and produce high total dry weight and dry weight yield. Liphon and Detpiratmongkol (2017) stated that stem and leaf dry weight, total dry weight, leaf and seed dry weight yield and andrographolide content depended upon the type of kalmegh and cultivars (Detpiratmongkol *et al.*, 2017).

Harvesting times affected on stem growth and dry weight yield. The maximum growth and dry weight yield of kalmegh were recorded when the crop was harvested at 135 DAP. Kumar and Kumar (2013) stated that the kalmegh yield reduced with older plant with maximum realization after 135 DAP. In addition to the biomass production yield of kalmegh depends upon source-sink relationship as well as on the different components of source (leaf, shoot, numbers of branches and dry weight) and of the sink (numbers of capsule, seed yield plant<sup>-1</sup>). Harvesting kalmegh plant at 135 DAP resulted in maximum dry herbage yield was mainly due to lesser dry matter yield plant<sup>-1</sup> and senescence of leaves at later stages of crop growth (Pandey *et al.*, 2003; Maheshwari *et al.*, 2002). Seed yield at seed maturity was registered maximum due to more number of capsules plant<sup>-1</sup> Chaudhari *et al.* (2013) reported that the leaf dry weight yield of kalmegh was also found to be increased with each harvesting time and significantly maximum leaf dry weight yield of 16.25 q ha<sup>-1</sup> was recorded at 135 DAP followed by 120 DAP with 14.14 q ha<sup>-1</sup> yield and minimum leaf dry weight yield of 10.50 q ha<sup>-1</sup> was recorded at 105 DAP. These result are agreement with the findings of Wankhade *et al.* (2003) they reported the significantly highest fresh foliage yield due to harvesting at late stages (135 DAP).

In the case of early and delay harvesting time, the maximum seed dry weight yield of kalmegh was recorded when the crop was harvested at 170 DAP. The lowest seed dry weight yield (1.77 g m<sup>-2</sup>) was recorded at 120 DAP. Kumar and Kumar (2013) reported that the seed dry weight yield harvested at seed maturity (170 DAP) was resisted maximum due to more numbers of capsule per plant and capsule length. These results were in agreement with Pushp *et al.* (2013) who found that delayed harvest beyond physiological maturity : to better development of seed due to transfer of assimilates from plant parts to seed for longer period and extra time available of development of seed resulting in higher seed dry weight yield (Sallam and Ibrahim, 2014).

As the andrographolide content in leaf, the decrease in andrographolide content within plant harvested after 135 DAP might be due to the reason that andrographolide is a compound with a possibility to breakdown within aging plant (Pandey *et al.*, 2003; Shan *et al.*, 2006; National Research Centre for Medicinal and Aromatic Plant, 2001). To our study similar andrographolide content were also found by Misra *et al.* (2005) within the kalmegh variety CIM Megha-High yield. Contrary, Ashok *et al.* (2002) reported that the andrographolide content was maximum at 90 DAP and was minimum at 150 DAP. This decrease in the active principle content at 150 DAP may be attributed to increase in stem portion and loss of leaves due to aging. These results were in agreement with Kumar and Kumar (2013) reported that the

andrographolide content decreased due to the senescence of the lower leaves with minimum content at seed maturity stage (1.73 %). Furthermore, Chaudhari *et al.* (2013) who showed that andrographolide content was maximum with the harvesting time of 120 DAP (2.48 %). It is noticed that the andrographolide content was significantly lowest with the farther delay in harvesting time i.e. 135 DAP (2.21 %). However, Himbindu *et al.* (2017) also concluded that andrographolide content of kalmegh was found to contain it between 1.49 to 2.27 % at late harvest.

## Conclusion

From the results obtained, it can be concluded that among three kalmegh cultivars, Prachinburi cultivar performed better in respect of leaf dry weight yield and other parameters. For different harvesting times, maximum leaf dry weight yield was obtained from the crop harvested at 135 DAP. Thus, suggesting the use of Prachinburi cultivar and the plants harvested at 135 DAP.

## Acknowledgement

The authors are highly grateful to Dr.Charan Ditchaiwong for providing seed material. This study was financially supported by the Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand.

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(Received: 15 September 2018, accepted: 1 November 2018)