Kasetsart J. (Nat. Sci.) 30 : 386-391 (1996)

Influence of Photoperiods on Dormancy and Rhizome Formation of Ginger (*Zingiber officinale* Roscoe)

Yama Raj Pandey[1], Chairerg Sagwansupyakorn[1], Oradee Sahavacharin[1], and Niphone Thaveechai[2]

ABSTRACT

The effects of photoperiods on dormancy and rhizome formation of ginger (*Zingiber officinale* Roscoe) were studied. Ginger plantlets produced from tissue culture were transplanted for better establishment and acclimatization under greenhouse and open field conditions. Well established and acclimatized plants were exposed to 8,10,12,14 hours and natural (12.01-11.19 hours) photoperiods during October,1995 to January,1996. After adjustment of photoperiods in October, new tillers were continuously produced till January under 14 and 12 hours photoperiods. New tillers were not produced and plants started yellowing and dying in November under 8 hours photoperiod and in December under 10 hours and natural photoperiods. The crop had no dormancy under 14 and 12 hours but entered dormancy under 8,10 hours and natural photoperiods. The highest fresh rhizome yield was produced under 12 hours photoperiod but rhizome yield for seed purpose was highest under 10 hours and natural photoperiods.
Key words: ginger, photoperiod, dormancy, rhizome formation.

INTRODUCTION

Ginger is a perennial herb commercially grown as an annual belongs to the family Zingiberaceae. It has been an important tropical horticultural plant valued all over the world as a spice and also for its medicinal properties (Kacker *et al.*, 1993). It is generally propagated from matured rhizome seed pieces. According to Ikeda and Tanabe (1989), the problem of having a limited supply of high quality rhizomes is compounded by fairly high levels of contamination during the initial explanting process. The main problematic disease of ginger is bacterial wilt caused by *Pseudomonas solanacearum* which can not be controlled effectively by chemical treatment (Anonymous, 1989). In addition, breeding of ginger has been severely hampered by poor flowering and seed set (Kacker,1993) and large amount of rhizomes is utilized for seed purpose which has low multiplication rate (Sharma and Singh,1995).

Micropropagation through tissue culture has been an efficient technique in ginger for the control of various pathogens. For commercial technique, transplanting and seed rhizome production from tissue cultured plantlets should be made available in all seasons of the year.

[1] Department of Horticulture, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.

[2] Department of Plant Pathology, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.

Ginger enters into dormancy in early winter and remains dormant until early spring. Though micropropagation technique in ginger can be applied all year round, seed rhizome production is limited to certain period due to induction of dormancy. Until now, there is hardly any information available on dormancy influenced by photoperiods in ginger. Growth and development in many crops are markedly influenced by the photoperiods. Wareing and Phillips (1981) mentioned that day length affects the onset of flowering behavior, certain other purely vegetative processes, formation of underground parts of plants and the growth and leaf fall of many woody plants. Ewing (1978) reported that shoot, stolon and tuber formation on potato cuttings were affected by photoperiod. The length of photoperiod influences on tuberization in a number of species. Garner and Allard (1923) found that tuberization in potato was better under short photoperiod than in long photoperiod. Similarly, underground stolons of Jerusalem artichoke were formed abundantly under shorter photoperiod than under long photoperiod (Hamner and Long, 1939).

MATERIALS AND METHODS

Plantlets of edible ginger (*Zingiber officinale* Roscoe) were originally obtained from tissue culture laboratory, Department of Horticulture and kept outside for hardening for two weeks in June, 1995. After hardening, these plants were transplanted in plastic baskets containing sand, burnt rice husk and coconut fiber in equal volume and were kept under mist spray inside the glasshouse for one month. After establishment, these plants were again transplanted into plastic baskets (45×40 cm in size) containing soil, sand, burnt rice husk and coconut fiber in equal volume during the first week of August, 1995. Spacing was 10x10 cm with 16 plants in a basket. Eighty baskets after transplanting were kept outside for acclimatization in an open field near glasshouse where the experiment was conducted at Kasetsart University, Department of Horticulture, Bangkhen, Bangkok. After well establishment and acclimatization, plants were exposed to 8,10,12,14 hours and natural photoperiods from October, 1995 to January, 1996. The experiment was arranged in a Completely Randomized Design (CRD) with 4 replications; each replication consisting four plastic baskets or 64 plants/replication. When plantlets were planted in the experimental field in August for establishment and acclimatization, natural day length was recorded 12.44 hours (sunrise to sunset). Day length was maintained by exposing plants to natural daylight plus continuation by electric light for 12 and 14 hours treatments and covering with black cotton cloth for 8 and 10 hours treatments. Electric light was adjusted with 40w bulb in each replication (0.63 sq.m. area) vertically one meter above the plants. Natural day length was recorded 12.01 hours (sunrise to sunset) on October 1, shortest day length of 11.19 hours in December and 11.31 hours at the end of January.

At the end of each month, new tillers produced and died tillers within the month were counted and statistically analyzed. Fresh rhizome field was recorded immediately after harvest in February, 1996. Before weighing, roots, aerial parts (shoots), soil and other attached materials were removed and washed. These rhizomes were air-dried in room temperature for a week. Rhizomes suitable for seed purpose (having sprouting buds) were selected and useless or shrivelled and wrinkled rhizomes were removed. Weight of these rhizomes was taken separately and statistically analyzed.

RESULTS AND DISCUSSION

The effects of day length differences between the treatments were observed. Before the crop was exposed to different day length conditions, the total

number of new tillers per clump was approximately 2 tillers/clump in all treatments which was not statistically significant (Table 1). After adjustment of light, observation was taken at the end of October. The difference in total number of tillers per clump among the treatments was found to be highly significant. The highest number of new tillers per clump (2.47) was produced and total number of tillers was counted to 4.50 under 14 hours day length and the total number of new tillers decreased gradually under shorter day length with the lowest number of tillers/clump 1.51 and total number of tillers to 3.56 under 8 hours day length.

However at the end of November, the total number of tillers per clump was increased under longer photoperiod treatments. The highest number of new tillers/clump (0.53) was produced and total number of tillers 5.03 under 14 hours day length was statistically different. The tillers under 8 hours day length started yellowing and dying which indicated that the plants might have passed their juvenile stage and entered into dormancy. The total number of tillers/clump was reduced to 3.36 from 3.56 in the previous month. In other treatments of 14,12,10 hours and natural day length, the crop did not enter into dormancy while continuous tillering was observed.

The number of tillers arising and dying was distinctly different in different treatments at the end of December. The total number of new tillers per clump was produced highest at 1.12 and total number of tillers reached to 6.15 under 14 hours day length. The total number of new tillers was increased under 14 and 12 hours day length treatments which indicated that the crop did not enter into dormancy under longer photoperiods. In other treatments of 10 hours and natural day length, the tillers started yellowing and dying, indicating induction of dormancy. Thus the crop entered into dormancy in November, 60 days after adjustment of photoperiods under 8 hours day length and in December, 90 days after adjustment of photoperiods under 10 hours and natural day length . Yellowing and dying of tillers were faster in December than in November.

The trend of increasing and decreasing of tillers was the same at the end of January. The highest number of new tillers per clump was produced 0.83 and total growing tillers were counted to 6.99/clump under 14 hours day length. The total number of tillers were still increased under 14 and 12 hours day length and did not enter into dormancy. The total number of tillers was heavily reduced under 8,10 hours and natural day length. The crop entered into dormancy and the tillers reduced to 0.08, 0.13 and 0.36/clump under 8,10 and natural day length respectively. The data given in Table 1 indicates that the crop entered into dormancy in different time with different day length conditions. The arising of new tillers was highest at the beginning in October. These may be due to the kinetic of juvenility that the plants received before placing in different photoperiods. At the end of January, the old tillers under 14 and 12 hours day length started yellowing but new tillers were still arising. Similarly, the tillers under 8, 10 hours and natural day length started yellowing and dying slowly at the beginning in November and rapidly in December and January (Figure 1 and 2).

The fresh rhizome yield difference among the treatments was found to be highly significant. The highest fresh rhizome yield of 4.65 gm/clump was produced under 12 hours day length treatment followed by 4.08 gm/clump under natural day length treatment and the lowest yield was obtained from 14 hours day length at 3.09 gm/clump. The weight of seed rhizomes for seed purpose was lower under longer photoperiod treatments than shorter photoperiods. The rhizomes under 14 and 12 hours photoperiod treatments were small, shrunk and wrinkled.

Though there is hardly any report on

Table 1 Number of tillers and rhizome yield of ginger under different photoperiods.

Photoperiods	Total number of tillers per clump at monthly intervals					Fresh rhizome yield (gm/clump)	Seed rhizome yield (gm/clump)
	Oct.1	Oct.31	Nov.30	Dec.31	Jan.31		
8 hours	2.05a	3.56 c	3.36 c	1.35 e	0.08 d	3.36 c	2.04 b
10 hours	2.10a	3.82 c	3.85 d	2.00 d	0.13 d	3.91 b	2.81 a
Natural day length (12.01-11.19 hours)	2.11a	4.16 b	4.35c	3.08c	0.36c	4.08b	2.71a
12 hours	2.07a	4.18 b	4.60b	5.39b	6.05b	4.65a	1.60c
14 hours	2.03a	4.50 a	5.03a	6.15a	6.99a	3.09c	0.48d
CV %	4.20	4.40	3.70	4.60	3.70	5.80	5.80
F test	ns	**	**	**	**	**	**

ns = non-significantly different

** = significantly different at 1 % level of probability Any two means in the same column having a common letter are not significantly different at the 5% level by Duncan's Multiple Range Test (DMRT).

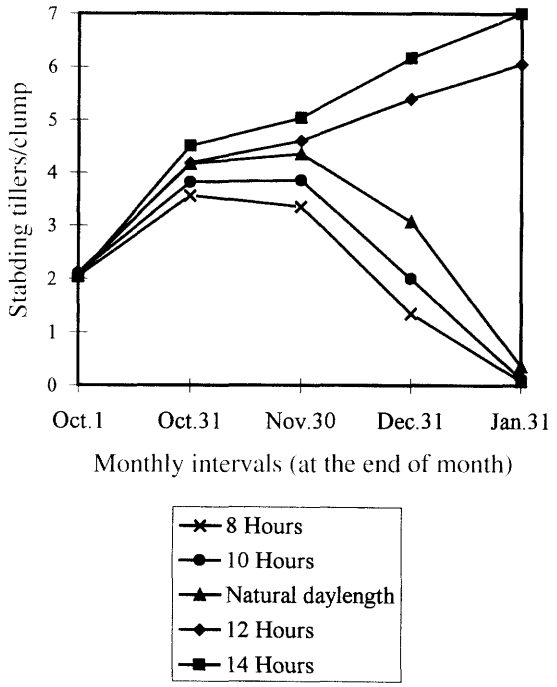

Figure 1 Monthly average of the total number of tillers of ginger standing under different photoperiods.

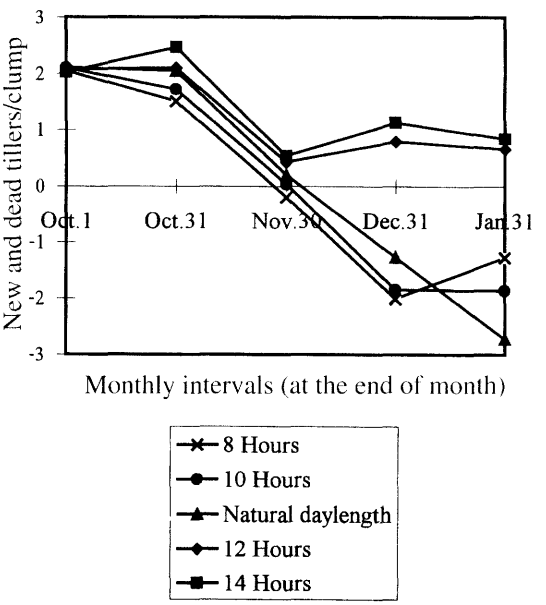

Figure 2 Monthly average number of new tiller produced under long (12hours or more) photoperiods and dead tillers under short (less than12 hours) photoperiods.

dormancy influenced by photoperiods in ginger, results of this experiment supported the findings of Karmer (1936) that *Robinia pseudacacia* plants became dormant when the photoperiod fell to 12 hours but continued to grow with additional light until the temperature fell. The dormancy was influenced by specific day lengths, temperature or both depending on the species. The lowest mean temperature in Bangkok was recorded 25.30 °C in December which is sufficient for growth and development of ginger (Bendall and Daly, 1966).Thus, tillering and dormancy induction in ginger was not influenced by temperature in this experiment. The crop had no dormancy under longer photoperiods and tillering was continuous. This result coresponded to the previous report on tillering by Salisbury and Ross (1992) that tropical grasses tiller more under long days.

Both tillering and rhizome development were influenced by photoperiods. This might be due to the action of gibberellic acid (GA) and abscisic acid (ABA) ratio. ABA concentration is higher in dormant tissue or tissues entering dormancy and translocated to the shoots where it inhibits the growth and metabolism. Bidwell (1979) reported that dormancy is commonly associated with short days and ABA concentration increases during dormancy induction whereas breaking of dormancy is associated with long days with an increase in GA concentrations. The result of this experiment revealed that longer photoperiods favored tillering and prevented rhizome development and shorter photoperiods favored rhizome development and dormancy induction. This supports the finding of Krauss (1978) that long photoperiods produce high GA levels and prevent tuber growth in potato. A relatively high GA:ABA ratio prolongs vine growth and limits and delays tuber growth. Booth and Lovell (1972) showed that application of GA to potato shoots reduced export of photosynthates to tubers, decreased starch accumulation and resulted in a cessation of tuber growth. Thus rhizome formation and development in ginger under long photoperids might have prevented due to low carbohydrates accumulation and draw on stored carbohydrates in order to produce new tillers or shoots.

From the results of this experiment, it can be concluded that ginger requires dormancy during its growth period. The crop requires long day lengths of 12 hours or more during its growth period for continuous tillering and growth without entering into dormancy and gradually reduced day length of 10 to 11 hours for seed rhizome production. Thus seed rhizome production in ginger can be done in any season by adjusting day length under controlled condition.

LITERATURE CITED

Anonymous. 1989. Methods for detection of *Pseudomonas solanacearum* in ginger. rhizomes, soil and water and some cemicals for controlling of this bacterium.Report to ACNARP, Dept. of Plant Path., Faculty of Agri., Chiang Mai University, Chiang Mai. 12p.

Bendall, R.L. and R.A. Daly. 1966. Ginger growing in the Nambour Area, Queensland, Quarterly Rev. Agric. Econ. 19: 83-96.

Bidwell, R.G.S. 1979. Plant Physiology. 2nd ed., Macmillan Pub. Co., New York. 726 p.

Booth, A. and P.H. Lovell. 1972. The effect of pre-treatment with gibberellic acid on the distribution of photosynthate in intact and disbudded plants of *Solanum tuberosum*. New Phytol. 71: 795-804.

Ewing, E.E. 1978. Shoot, stolon and tuber formation on potato (*Solanum tuberosum* L) cuttings in response to photoperiod. Plant Physiol. 61: 348-353.

Garner, W.W. and H.A. Allard. 1923. Further studies in photoperiodism, the response of the

plant to relative length of day and night. J. Agri. Res. 23: 871-920.

Hamner, K.C. and E.M. Long. 1939. Localization of photoperiodic perception in Helianthus tuberosus. Bot. Gaz. 101: 81-90.

Ikeda, L.R. and M.J. Tanabe. 1989. *In vitro* subculture applications for ginger. Hort Sci. 24:142-143.

Kacker, A., S.R. Bhat, K.P.S. Chandel, and S.M. Malik. 1993. Plant regeneration via somatic embryogenesis in ginger. Plant Cell, Tissue and Organ Culture. 32: 289-292.

Karmer, P.J. 1936. The effect of variation in length of day on the growth and dormancy of trees. Plant Physiol. 11: 127-137.

Krauss, A. 1978. Tuberization and abscisic acid content in Solanum tuberosum as affected by nitrogen nutrition. Potato Res. 21: 183-193.

Salisbury, F.B. and C.W. Ross. 1992. Plant Physiology. 4th ed., Wadsworth Pub. Co., New York. 682 p.

Sharma, T.R. and B.M. Singh. 1995. Simple and cost effective medium for propagation of ginger (*Zingiber officinale*). Indian J. of Agric. Sci. 65: 506-508.

Wareing, P.F. and I.D.J. Phillips. 1981. Growth and Differentiation in Plants. 3rd ed., Pergamon Press, Oxford. 343 p.