DEVELOPMENTAL VARIATION OF FOUR SELECTED VETIVER ECOTYPES

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Abstract

Studies on the developmental variation of four ecotypes of vetiver [*Vetiveria zizanioides*: Sri Lanka, Surat Thani and Ratchaburi (VT02), and *Vetiveria nemoralis*: Kamphaeng Phet 1] were undertaken at the Queen Sirikit Botanical Garden, Chiang Mai, Thailand during August 1997 to September 1998. The investigation of shoot apex development were emphasized on the rate of leaf primordial production (plastochron interval), the rate of leaf appearance (phyllochron interval), floral initiation, floral structure and anthesis. The results revealed that the four ecotypes had the similar patterns of apex development but differed substantially in the duration and rate of each development. Sri Lanka and Surat Thani ecotypes were developed to floral initiation and progressively advanced to anthesis at approximately 273-300 days after planting which were more earlier than those of Ratchaburi and Kamphaeng Phet 1 (360 and 368 days after planting). All four ecotypes had similar linear relationship in the leaf primordial production with plastochron intervals of 6.4, 6.3, 7.4 and 7.6 days/primordium), respectively. This suggested that Sri Lanka and Surat Thani had faster rate of leaf primordial production. For the number of leaves on main stem, the four ecotypes performed an exponential relationship with faster leaf production at the first 150 days, thereafter the rates would slow down. In this case, Surat Thani and Kamphaeng Phet 1 had faster rates of leaf production with the maximum leaf number of 21, whereas Sri Lanka and Ratchaburi exhibited slower rate with approximately 16-18 leaves per plant. The four ecotypes produced tillers that fitted to the quadratic relationship by which slow tillering was observed in the early stage of development, especially in Sri Lanka and Ratchaburi, which produced only 7-8 tillers/plant. Whilst, Surat Thani and Kamphaeng Phet 1 tillered at the faster rate with the highest tillers of up to 18-22.

Introduction

Among the developmental variation affected by various environmental effects, floral initiation (FI) is the most crucial phase having the greatest variation. This event remarks the switch transition from the vegetative to reproductive stage and in turn extents to the anthesis development. Of the factors influencing basic vegetative period (BVP), temperature and photoperiod are the most important climatic factors but they were differed depending on plant species and variety. The variation that would be expected are time to floral initiation, growth and development at post-floral initiation, as well as the extent to variation in rate and number of leaves produced on main stem.

During the 1997-99, the Project had launched the series of experiments to investigate for the effects of environmental factors on the growth and development of selected vetiver ecotypes. The main objective was focused on the detailed studies on the shoot apex development, the rate of leaf primordial initiation (plastochron interval) and the rate of leaf appearance on main stem (phyllochron interval) of the four ecotypes, *i.e*. *Vetiveria zizanioides* Nash: Sri Lanka, Surat Thani, and Ratchaburi (VT02), and *Vetiveria nemoralis*: Kamphaeng Phet 1. The results obtained would be used as basic information leading to more understanding in the relationship among the apex development, leaf production and tillering capacity, as well as for the anthesis of vetiver ecotypes which in turn extents to further finding of the suitable vetiver cultivation in Thailand.

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Materials and Methods

Four ecotypes of the vetiver grass obtained from the micropropagation compressing of three ecotypes of *Vetiveria zizanioides* Nash [Sri Lanka, Surat Thani and Ratchaburi (VT02)], and one ecotype of *Vetiveria nemoralis* (Kamphaeng Phet 1) were transplanted for the investigation of their shoot apex development. The experiment was carried out during August 1997 to September 1998 at the Queen Sirikit Botanic Garden, Chiang Mai, Thailand. At the time of planting, all vetiver plants were expected to develop equivalently to those that grown from seeds of approximately two months old. Five sample plants of each ecotype were randomly selected monthly after transplanting for the investigation of the shoot apex development. When shoot apex had developed to the reproductive phase, plants were then sampled weekly. The dissection technique proposed by Kirby and Appleyard (1986) was used in this study. Under the stereomicroscope, the following shoot apex development were observed: (1) the number and rate of leaf primordial initiation (plastochron interval), (2) the number and rate of leaf appearance (phyllochron interval), (3) morphological changes on the apex, and (4) the number and rate of tiller production.

Data collected were then analyzed and identified for the relationship with the age of the plants. In this case, regression analysis based on the method of Steel and Torrie (1980) was applied. In addition, detailed observation on the morphological changes in both vegetative and reproductive phase were undertaken and different phasic development of vetiver shoot apex was classified.

Results and Discussion

Morphological Changes of the Shoot Apex

The four ecotypes of selected vetivers had the similar pattern of shoot apex development which could be classified into various phases as shown in Table 1 and Fig. 1. They were, however, differed substantially in the duration of each developmental phase, *i.e.* vegetative phase, time to floral initiation and anthesis. The Sri Lanka and Surat Thani ecotype developed more faster to floral initiation (273 DAP, days after planting) and to anthesis (300 DAP) than those of the Ratchaburi and Kamphaeng Phet 1 (360 and 368 DAP, respectively). It was noticed that Kamphaeng Phet 1 performed relatively more uniform anthesis than the others. These developmental variation would be reflected due to both genetic and environmental effects. Several reports had shown that photoperiod and temperature played important roles on the floral initiation and development in a number of crop species (Vergara and Chang 1976; Major 1980; Roberts et al.1998; Kaveeta 1993; Ellis et al. 1994)

Rate of Leaf Primordia Development (Plastochron Interval)

The linear relationship between the number of leaf primordia produced on the shoot apex of the main stem and days after planting of the four vetiver ecotypes was detected. The predicted equations for the ecotypes Sri Lanka, Surat Thani, Ratchaburi, and Kamphaeng Phet 1 obtained were $y = 0.156x + 3.707$, $r^2 = 0.98$; $y = 0.160x + 3.889$, $r^2 = 0.97$; $y = 0.136x + 4.427$, $r^2 = 0.93$; and $y = 0.132x + 3.527$, $r^2 = 0.98$, respectively (Fig. 2). Subsequently, the predicted rates of leaf primordia production (plastochron interval) for the four ecotypes would be 6.4, 6.3, 7.4, and 7.6 days/primordium, respectively. This indicated that the Sri Lanka and Surat Thani ecotypes developed at faster rate of leaf primordial production than those of the Ratchaburi and Kamphaeng Phet 1 ecotypes.

Rate of Leaf Appearance (Phyllochron Interval)

The very similar patterns of the production of leaf number on main stem of the four vetiver ecotypes were detected, but they were considered as inconsistent rates. In all cases, relatively faster rate of leaf production was observed within 150 DAP, thereafter slower rates were detected up to 250 DAP. From that up to 320 DAP, the rates of faster production were again achieved. Hence, the exponential relationship between the number of leaves produced and days after planting with the equations of the four vetiver ecotypes were shown in Fig. 2. It was clearly shown that Surat Thani and Kamphaeng Phet 1 produced relatively fast rate of leaf production of up to 21 leaves/plant within 150 DAP.

Whilst, Sri Lanka and Ratchaburi produced at slow rate of only 17.4 and 16.3 leaves/plant, respectively. This pattern of leaf production of the studied vetiver was sharply contradictory to those that recorded in rice, corn, wheat, barley and sugarcane (Cao and Moss 1989; Kaveeta 1993; Apakupakul 1996). Accordingly to the suggestion of Kirby (1995) that the models in prediction of leaf phenomenon would need to consider for the environmental effects, i.e. temperature and photoperiod. In the case of vetiver, it would be possible that beyond the 150 DAP the plants were subjected to lower temperature thus causing slower rate of leaf appearance and in turn reflecting to an inconsistent rate. For more reason, Moore and Moser (1995) reported that the rate of leaf production (phyllochron interval) of perennial grasses had significant linear relationship with day degree, the accumulative daily temperature.

Tiller Development

The number of tillers produced of the four vetiver ecotypes fitted to the quadratic relationship with days after planting. It was noticed further that the rate of tiller production was relatively low during the early stage of plant development. The Surat Thani and Kamphaeng Phet 1 had faster rate of tillering with greater number of tillers/plant than those of the Sri Lanka and Surat Thani. Moreover, close relationship between number of tillers/plant and total leaf number produced was also detected for all vetiver ecotypes.

Conclusion

1. All vetiver ecotypes had similar patterns of apex development but differed in the duration and rate of each developmental phase
2. There were linear relationship in leaf primordial production with plastochron interval of 6.4, 6.3, 7.4 and 7.6 days in Sri Lanka, Surat Thani, Ratchaburi and Kamphaeng Phet 1, respectively.
3. The formation of leaves formation on main stem was at a faster rate of 150 days after planting.
4. Sri Lanka and Ratchaburi produced 7-8 tillers/plant whilst Surat Thani and Kamphaeng Phet 1 produced 18-22 tillers/plant.

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Table 1. Phasic development of vetiver shoot apex

Phase	Phasic name	Phenomenon observed
1	Vg (Vegetative phase)	Apical dome remains smooth flat cone shaped. The base of dome plays an important role for the initiation of leaf primordia by which the first initial of leaf primordial is outwards whereas the followering primordia are formed inwards (Figs. 1-A and 1-B)
2	AE (Apex elongation phase)	The portion of vegetative shoot apex above the topmost leaf primordia is a dome which grown upwards and widens before floral initiation take places (Fig. 1-C)
3	FI (Floral initiation phase)	The portion of elongated shoot apex begins to form meristematic patch which attached to the apex axis, with differentiated cells denoted (Fig. 1-D).
4	MP (Meristematic Patch)	Shoot apex continues to form meristematic tissues from the base of the apex upward. The portion of primordium of meristematic patch denotes the initiation of the panicle axis and the tip of the reproductive apical cone (Fig.1-E).
5	BP (Branch Primordia)	The appearance of branch primordium begins when the shoot apex elongates at approximately 1 cm. The development of panicle axis is clearly detected (Fig. 1-F)
6	SP (Spikelet Primordia)	Panicle axis commences to form spikelet primordia upward up to 8-10 primordia. The development of these primordia refers to the initiation of pedicelled spikelet and sessile spikelet primordia (Fig. 1-G).
7	CP (Complete Primordia)	Complete primordia production on the panicle axis is observed. The sequence of the growth and development of the spikelet components begin. At the base of the axis, pulvinus is formed (Fig. 1-H).
8	ED (Ear Development)	The panicle axis begins to elongate and form the panicle branches in the whorl shaped upward. There after, elongation of the panicle branches commence. (Fig. 1-I). This stage of development refers to the subsequent appearance of the floral parts, *e.g.* sterile lemma, lemma, palea, stamen and pistil, etc.
9	A (Anthesis)	Anthesis within the panicle is denoted.

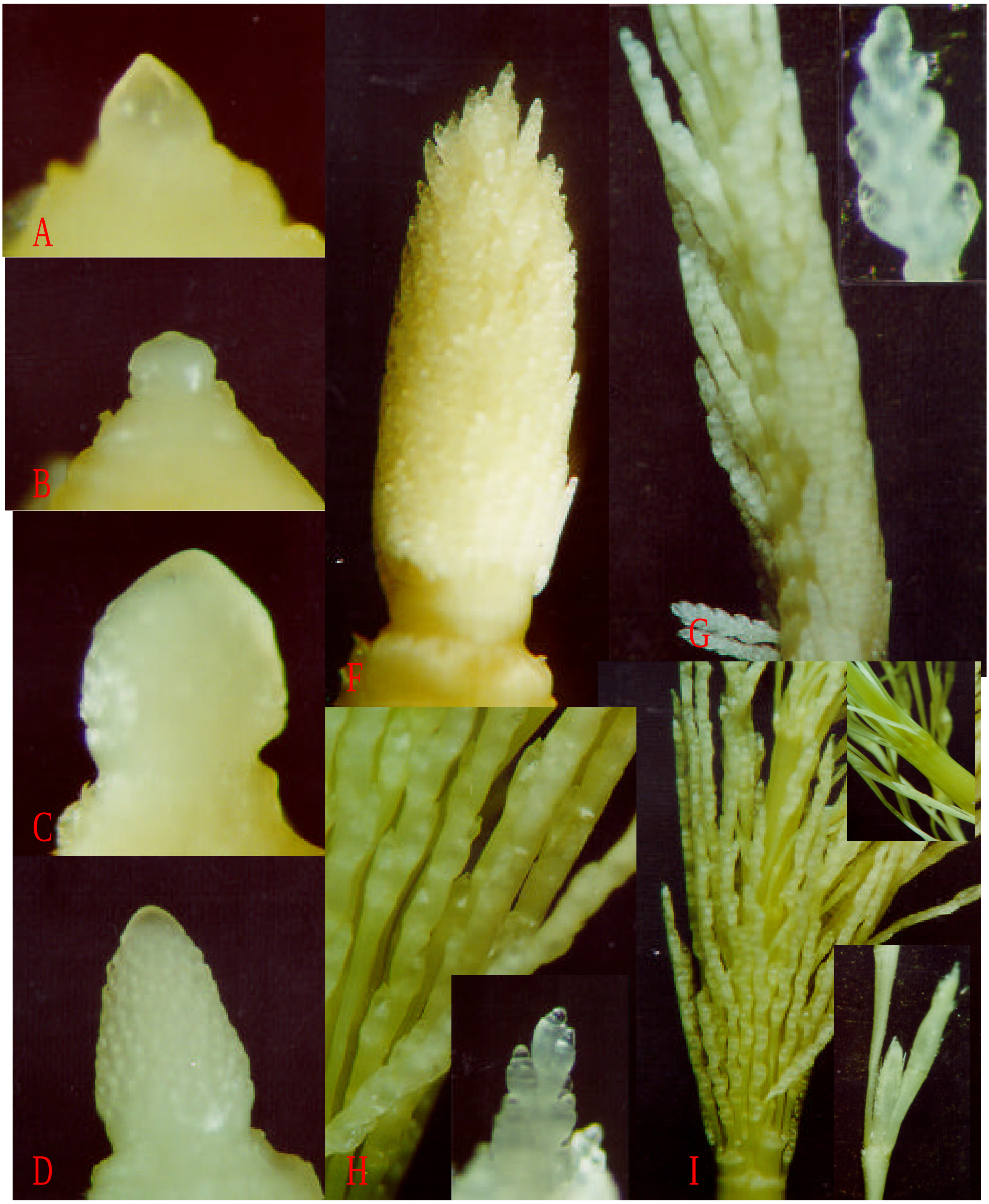

Fig. 1. Morphological changes in vetiver grass apical development:

A = Early vegetative phase
B = Late vegetative phase
C = Apex elongation phase
D = Floral initiation phase
E = Meristematic patch
F = Branch primordia
G = Spikelet primordia
H = Complete primordia

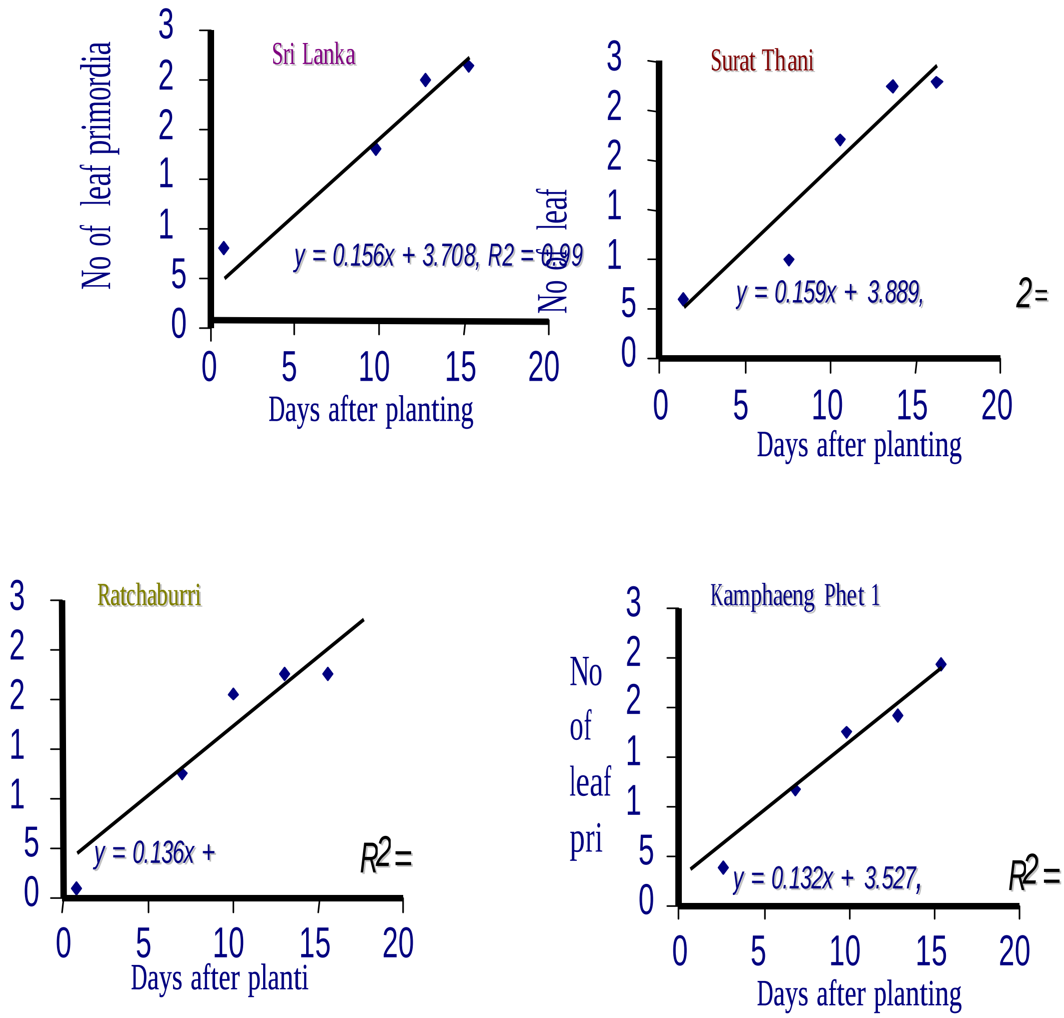

Fig. 2. The relationship between number of leaf primordia on main stem and time after planting of four ecotypes vetiver at Chiang Mai