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Inherent Variability in Growth and Development of Two Ecotypes of Sesame Plant (*Sesamum* sp.) in Malaysia

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ABSTRACT

Differences in the growth and development of sesame ecotypes growing sporadically as uncultivated plant in dissimilar agro-ecological and habitat conditions of Serdang and Port Dickson of Malaysia have not been studied. The purpose of the study was to compare the inherent variations in growth parameters and degree of relationships between the two ecotypes over time. The quantitative growth parameters of the plants' height, leaf number per plant, total leaf area, fresh and dry weight of leaves, fresh and dry weight of roots were measured at 2, 4, 8 and 12 weeks after planting under the same growing conditions. Results indicated that the two ecotypes manifested almost similar growth patterns and the variations on growth parameters between the ecotypes were statistically insignificant. Regression analysis showed that all the growth parameters increased exponentially over time, and the growth parameters were positively correlated between the ecotypes. Thus, this study suggested that a high homology in the growth patterns between the two sesame ecotype could exist when grown under the same growing conditions, although both have adapted to different habitat conditions.

Keywords: Ecotypes, growth parameters, morphological characters, sesame, Malaysia

INTRODUCTION

Sesame (*Sesamum* sp.) is an ancient annual oilseed crop that belongs to the *Pedaliaceae* family (Kobayashi, 1991). It is a short duration crop grown widely in tropical and subtropical areas as a source of high quality edible oil and dietary supplement (Koca *et al.*, 2007). There are approximately 38 species of the genus *Sesamum* worldwide,

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and most of them are wild (Bisht *et al.*, 1998). However, most of the wild species are located in Africa, which subsequently spread to India and China in very early times (Ashri, 1989; Bisht *et al.*, 1998). Similar to other crops that have been domesticated for a long time, different varieties of *Sesamum indicum* were found to have considerable variability in plant size, shape, growth habit, corolla colour, seed size, colour, and composition (Weiss, 2000). In fact, different cultivars (landraces) can develop very differently under the same conditions, and the same cultivars can develop very differently under different conditions (Langham, 2007). According to IPGRI (2004), there are both intra- and inter-specific diversities in a sizeable number of morphological traits of sesame as revealed in germplasm characterization and evaluation studies. However, the variations in the growth and development of sesame plants have major effects on how plants respond to yield potential and on yield quality (Langham, 2008). On the other hand, plant's growth and development affect its characteristics and processes, as well as the magnitude of their responses to environmental influence and/or production inputs (Groot *et al.*, 1986).

Although Malaysia is endowed with favourable ecologies for sesame cultivation, planting of commercial sesame is still lacking in Malaysia due to the insufficient information of the local species/cultivars. Over the past few years, uses of sesame as cooking oil and industrial solvent, as well as in food and drug manufacture, have remarkably increased in Malaysia. This was substantiated by the trend of sesame seed import from 2003-2007 in Malaysia during which the imported quantity was of 7,584 tons, with an increase of 9,131 tons in 2007 (FAO, 2003-2007). Due to the rise of consumption volume, sesame has received increasing interest in Malaysian agriculture, with an aim to cultivate commercially to meet the domestic demands of this excellent source of oil with antioxidant constituents (Weiss, 1983). It was reported that two sesame species *Sesamum radiatum* (with black seeds) and *Sesamum indicum* (with pale white seeds) have been sporadically growing as uncultivated (wild) plant in some agro-ecological areas of Malaysia such as Malacca, Port Dickson, Serdang and Langkawi (Yao, 2010). In the previous study by Khairi (2011), two ecotypes identified as *Sesamum radiatum* were seen growing widely in dissimilar habitats of Serdang and Port Dickson. It has been recognized that some of the morphological (quantitative) traits between the two ecotypes significantly varied with leaf length, stem circumference and branching, even though they produced seeds of basically similar physical characteristics (length, width and thickness). However, information regarding these two ecotypes with respect to their growth and development is still limited. The evaluation of growth and the development of the ecotypes are important since it directly translates into seed production in sesame cultivation. This study was, therefore, carried out to obtain information necessary to draw comparisons of growth and development of the two sesame ecotypes collected from Port Dickson and Serdang in Malaysia.

MATERIAL AND METHODS

Source of Seed and Plant's Habitat Conditions

Sesame seeds of two ecotypes (*Sesamum radiatum*) were collected from Peninsular Malaysia: Serdang, Selangor (2.9992°N, 101.7078°E) and Port Dickson, Negeri Sembilan (2.5167°N, 101.8008°E). Although sesame plants of both populations were found to grow in open areas with other plants, some different habitat and soil conditions were observed in relation to their growth and development.

The Serdang population (Fig.1) grows in several spotted clumps (about 10 m^2 each) on less attended cattle grazing paddock, while the Port Dickson population (Fig.2) grows individually and distributed within a certain distance along the river and road. On the other hand, the soil where the serdang population grows is dark in colour having pH4.79 with nutrient contents of 2.6%N, 0.004% P, 0.01% K, 0.01% Ca, and 0.002% Mg, whereas the soil in the Port Dickson is reddish with pH3.97, and nutrient contents of 10% N, 0.003% P, 0.006% K, 0.02% Ca, and 0.001% Mg (Khairi, 2011).

Fig.1: Serdang population

Fig.2: Port Dickson population

Morphological Characteristics of the Serdang and Port Dickson Ecotypes

The range of variations among morphological (quantitative and qualitative) characteristics from the Serdang and Port Dickson populations showed the following descriptions and scores (see Table 1) (Khairi, 2011).

Seeds Processing

The collected seeds were sieved to remove extraneous plant or floral materials. The sieved seeds were divided into light and heavy fractions by using the seed blower (Model AMPS 1). The heavy fraction, which represents the fully developed seeds, was used in raising seedlings (Clewis *et al*., 2007). The seeds were then surface sterilized with 0.01% $HgCl_2$ solution for one minute and subsequently rinsed several times with distilled water. This was followed by blotting the seeds with filter paper and drying them at room temperature (25-30^{0}C).

Raising of Seedling

Seeds of each ecotype were broadcast in a separate plastic tray of 5 L size filled with 4 kg sandy loam soil. The plastic tray was kept at the nursery shed at Field 2 of Universiti Putra Malysia. Immediately after sowing, light watering was given to ensure good germination. Further watering was carried out regularly until the seedlings were fully established.

Experimental Design and Set Up

The experiment was conducted as a completely randomized design (CRD) with five replications. Forty sesame seedlings of each ecotype at 4 weeks old were hand transplanted in 3:2:1 (top soil: peat: sand) ratio of soil mixture in polybags (14 x 16 inches). Meanwhile 0.5 g (25 kg/ha) fertilizer each of N, P_20_5 and K_20 per polybag was made as basal applications. Polybags containing one plant in each were placed in the field with a spacing of 30 cm between the rows and 15 cm between the plants. During the study period, the weather parameters at the experimental location were favourable for sesame growth. Temperature was in a range of 25.6 to 32.2^{0}C, and average relative humidity was 70%. The plants were irrigated during the growth period and pesticides were applied whenever necessary.

Measurement of Growth Parameters

Growth parameters of both the sesame ecotypes were measured on three randomly selected plants, out of the eight plants under each replication. The quantitative growth parameters measured were plant height, leaf number, total leaf area, fresh and dry weight of leaves, as well as fresh and dry weight of roots. Plant height and leaf number were recorded twice in a month (every 2 weeks). In addition, two plants from each replicate were harvested at 4, 8, and 12 weeks after planting so as to measure fresh and dry weight of roots and leaves as well as total leaf area. The leaf area was measured using a leaf area meter (LI-3100, USA). For dry

TABLE 1
The morphological characteristics of Serdang and Port Dickson ecotypes

No	Quantitative characteristics	Descriptors and scores	
		Serdang	Port Dickson
1	Plant height	Tallest = 102 cm; Shortest = 45 cm	Tallest = 126 cm; Shortest = 57 cm
2	Circumference of stem *	Largest = 6.5cm; Smallest = 3 cm	Largest = 11.5 cm; Smallest = 2 cm
3	No. of branches *	Highest = 6; Lowest = 1	Highest = 10; Lowest = 3
4	No. of leaves on main stem	Highest = more than 300; Lowest = less than 100	Highest = more than 300; Lowest =less than 100
5	No of leaves with serrate margin on main stem	Highest = more than 50; Lowest = less than 50	Highest = more than 50; Lowest = less than 50
6	Leaf length*	Highest = 5.39 cm; Lowest = 1.86 cm	Highest = 9.47 cm; Lowest = 5.27 cm
7	Leaf width	Highest = 8.42 cm; Lowest = 2.49 cm	Highest = 2.9 cm; Lowest = 1.43 cm
8	Petiole length	Highest = 2.13 cm; Lowest = 0.49 cm	Highest = 2.12 cm; Lowest = 0.64 cm
	Qualitative characteristics		
9	Pubescences on stem	(1) Present	(1) Present
10	Stem colour	(1) Green	(1) Green to (3) brown
11	Degree of branches	Range from (1) more than 450, (2) lower than 450 or (3) equal 450	Range from (1) more than 450, (2) lower than 450 or (3) equal 450
12	Leaf colour	(1) Green	(1) Green
13	Leaf arrangement	(2) Alternate	(2) Alternate
14	Leaf apex shape	(2) Acute	(2) Acute
15	Leaf base shape	(2) Cuneate	(2) Cuneate
16	Leaf margin	(1) Entire to (2) Serrate	(1) Entire to (2) Serrate
17	Leaf texture	(2) Thick	(2) Thick
18	Type of primary vein	(1) Pinnate	(1) Pinnate
19	Type of secondary vein	(1) Brochidodromous	(1) Brochidodromous
20	Type of tertiary vein	(1) Reticulate	(1) Reticulate

* mean significant differences of the characters at $P<0.05$

weight measurements, the roots and leaves were oven dried for three to five days at 70-80°C.

Statistical Analysis

The data were analyzed by using analysis of variance (ANOVA). Mean separations were conducted by least significant difference (LSD) test at $P < 0.05$ level using Statistical Analysis System (SAS, 1998). Regression analysis was carried out to describe the nature and degree of relationship on various growth parameters between two ecotypes over time.

RESULTS

Data on the growth parameters of plants' height, leaf number per plant, root fresh weight, root dry weight, leaf fresh weight, leaf dry weight and total leaf area showed no significant difference between the Port Dickson and Serdang sesame ecotypes (Table 2).

Plant Height

Record on plant height indicated that it increased exponentially over time (Fig.3). There was significant correlation between plant height and time. Regression analysis showed that the plant height of Port Dickson (R^2 = 0.8488) and Serdang (R^2 = 0.9273) ecotypes was positively correlated with time. However, there was no significant difference between the plant's height of the two ecotypes over the time until 12 weeks after planting. The plant height of Port Dickson (67.3 cm) showed a higher value compared to Serdang ecotype (61.05 cm) at 12 weeks after planting when the plants started flowering (Table 2).

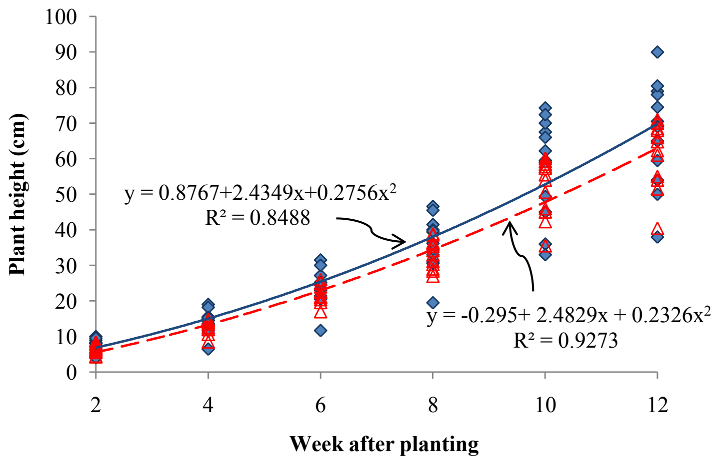

Fig.3: Plant height of Port Dickson (◆) and Serdang (△) sesame ecotypes from transplanting to 12 week after planting

TABLE 2
Growth parameters of Port Dickson and Serdang sesame ecotypes at week 12 after planting

Ecotype	Plant height (cm)	Leaf number per plant -	Root fresh weight (g)	Root dry weight (g)	Leaf fresh weight (g)	Leaf Dry weight (g)	Total leaf area (cm^2)
Port Dickson	67.33	109.92	14.14	3.52	22.95	5.51	770.6
Serdang	61.05	89.00	11.99	2.72	23.14	5.26	794.7
LSD	10.375	27.21	3.0276	0.7687	6.0698	1.5899	224

LSD at ($P < 0.05$)

Leaf Number per Plant

Leaf number per plant also increased exponentially over time and the relationship between the leaf number of Port Dickson ($R^2 = 0.7247$) and Serdang ($R^2 = 0.8541$) and time was significantly correlated. The results showed that leaf number increased with age of both the genotypes but leaf production ability of Port Dickson was insignificantly greater than that of Serdang at all growth stages (Fig.4). At 2 weeks after planting, the leaf number per plant of Port Dickson and Serdang ecotypes was 16 and 10, respectively, whereas at 12 weeks after planting, the Port Dickson and Serdang ecotype was 110.92, and 89, respectively (Table 2).

Root Fresh Weight

Data subjected to regression analysis showed that root fresh weight of Port Dickson ($R^2 = 0.7001$) and Serdang ecotype ($R^2 = 0.8227$) was significantly correlated with times, and it increased positively over time (Fig.5). However, the root fresh weight for Port Dickson ecotype exhibited higher root fresh weight in comparison to Serdang ecotype at weeks 4 to 12 after planting, which was statistically insignificant (Table 2). The root fresh weight was 1.92 g and 1.61 g at week 4, which subsequently increased to 14.14 g and 11.99 g at week 12, after planting for the Port Dickson and Serdang ecotypes, respectively.

Root Dry Weight

Root dry weight of both ecotypes increased exponentially from week 4 to week 12 (Fig.6). The root dry weight of Port Dickson ($R^2 = 0.7022$) and Serdang ($R^2 = 0.8319$) ecotypes were significantly correlated with times. At week 4 after planting, the initial weight of Port Dickson and Serdang ecotype was 0.17 g and 0.13 g respectively. It increased to 1.49 g and 1.23 g at week 8, and continued to increase to 3.52 g and

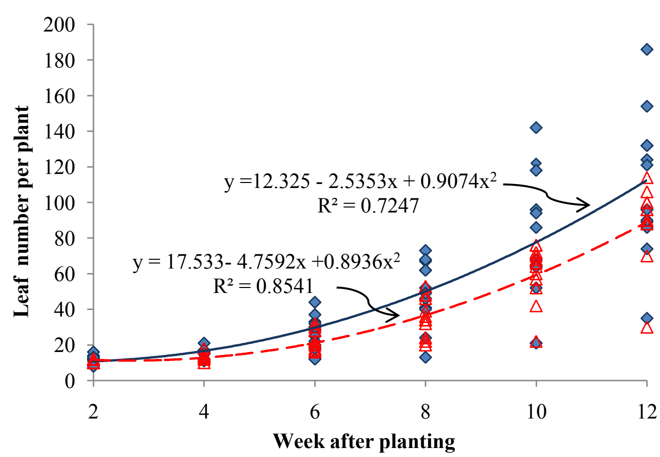

Fig.4: Leaf number per plant of Port Dickson (◆) and Serdang (△) sesame ecotypes from transplanting to 12 week after planting

2.72 g at week 12 after planting, for the Port Dickson and Serdang ecotypes, respectively (Table 2). However, there was no significant difference between the two ecotypes.

Leaf Fresh Weight

Leaf fresh weight of the sesame plants increased exponentially over time (Fig.7). Nonetheless, no significant differences were observed on the leaf fresh weight between the Port Dickson and Serdang ecotypes.

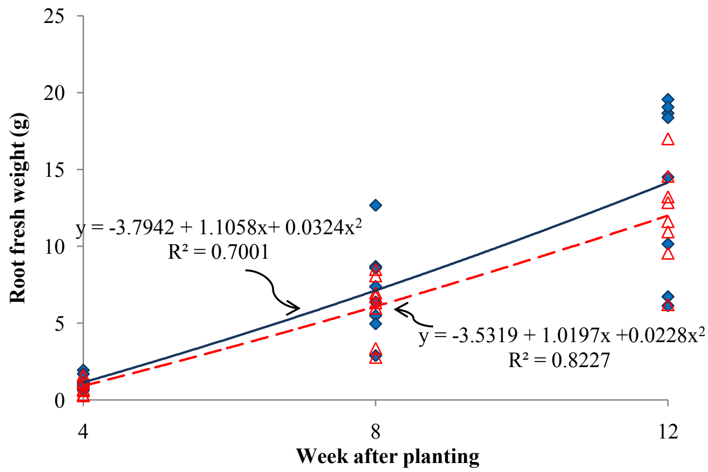

Fig.5: Root fresh weight of Port Dickson (◆) and Serdang (△) sesame ecotypes from transplanting to 12 weeks after planting

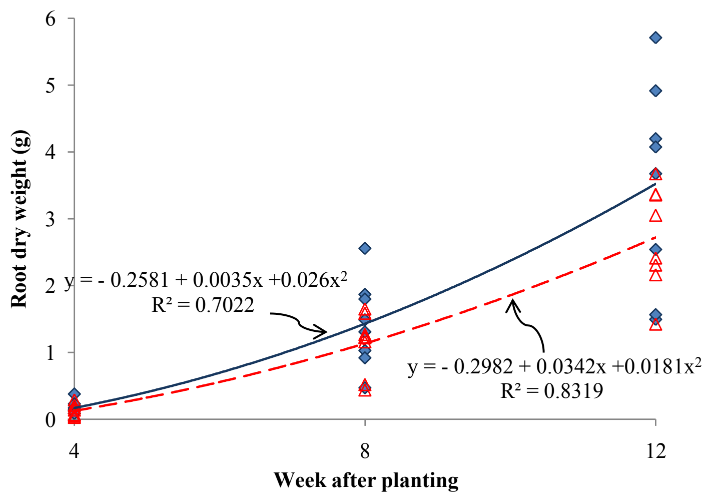

Fig. 6: Root dry weight of Port Dickson (◆) and Serdang(△)sesame ecotypes from transplanting to 12 week after planting.

The regression analysis showed that the leaf fresh weight of the two sesame ecotypes had strong relationship with time, which showed $R^2 = 0.7402$ for Port Dickson ecotype and $R^2 = 0.8169$ for Serdang ecotype, respectively. The leaf fresh weight of both ecotypes was almost the same from week 8 to week 12 after planting. It reached 22.95 g for Port Dickson and 23.14 g for Serdang ecotype at week 12 after planting (Table 2).

Leaf Dry Weight

The leaf dry weight of sesame plant also increased exponentially from week 4 to week 12 after planting (Fig.8). The increment was from 0.87 g to 5.51 g for Port Dickson ecotype and 0.78 g to 5.26 g for Serdang ecotype. The regression analysis showed that the leaf dry weight of Port Dickson ($R^2 = 0.7208$) and Serdang ecotype ($R^2 = 0.8191$) was correlated with time. However, no significant difference was observed for the leaf dry weight between the two ecotypes (Table 2). At week 12 after planting, the leaf dry weight for Port Dickson and Serdang ecotype was 5.51 g and 5.26 g, respectively.

Total Leaf Area

Total leaf surface area increased exponentially from week 4 to week 12 after planting (Fig.9). The regression analysis showed that the leaf surface area of Port Dickson ecotype ($R^2 = 0.7377$) and Serdang ecotype ($R^2 = 0.8012$) was generally correlated with time. There was also no significant difference in the total leaf area between Port Dickson and Serdang ecotypes over time. At the initial stage, the total leaf area of Port Dickson ecotype (147.59 cm^2) was higher than that of Serdang ecotype (96.80 cm^2). However, the total leaf area of Serdang ecotype increased more steadily after week 8, and it

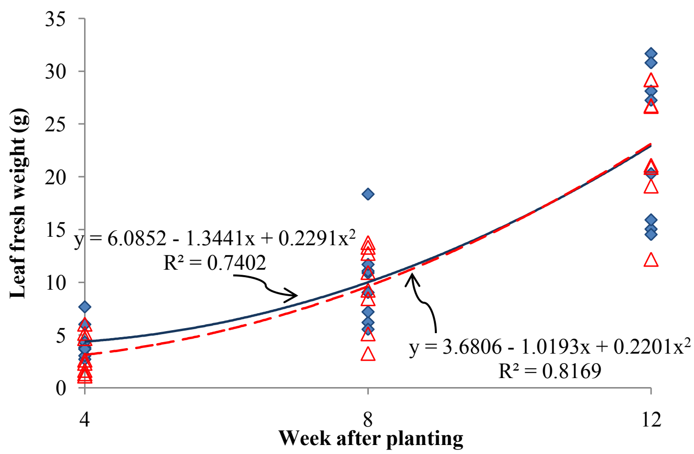

Fig.7: Leaf fresh weight of Port Dickson (◆) and Serdang (△) sesame ecotypes from transplanting to 12 week after planting

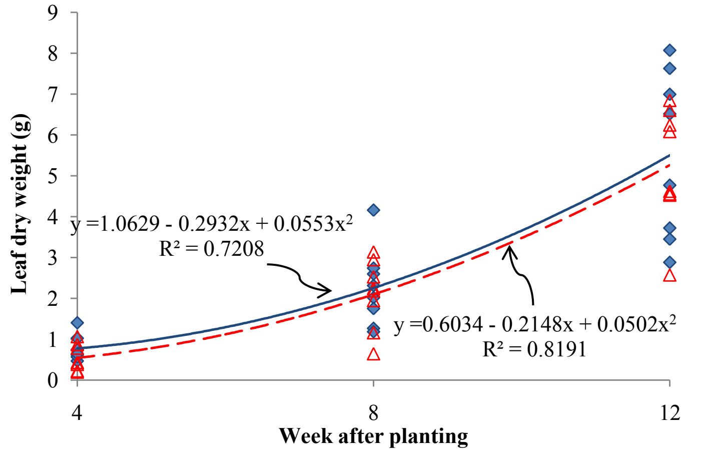

Fig.8: Leaf dry weight of of Port Dickson (◆) and Serdang (△) sesame ecotypes from transplanting to 12 weeks after planting

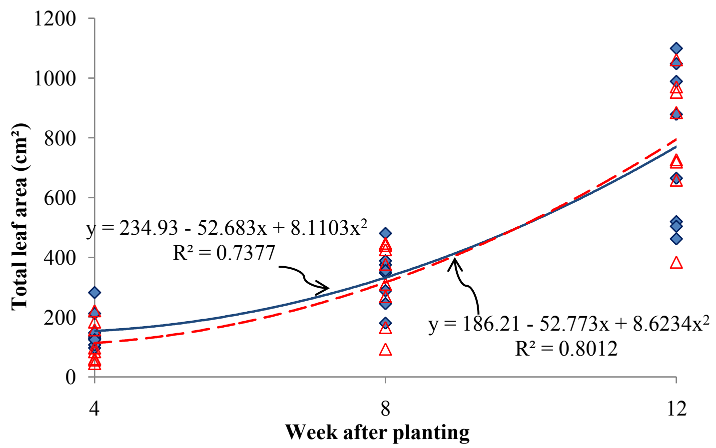

Fig.9: Total leaf area of Port Dickson (◆) and Serdang (△) sesame ecotypes from transplanting to 12 weeks after planting

was slightly higher (794.7 cm^2) than that of Port Dickson ecotype (770.6 cm^2) at week 12 after planting (Table 2).

DISCUSSION

The results obtained from the study showed that there were no statistically significant differences on the growth parameters between the two sesame ecotypes although both had adapted to different agro-ecological and habitat conditions. It was generally agreed that the phenotypic or morphological traits of a plant are the reflection of the interaction between the crop's genotype and the existing climatic and ecological factors (Akinyele & Osekita, 2006). Since the study had eliminated the environmentally induced variations by bringing the two ecotypes into cultivation under the same environmental factors, the growth parameters that showed insignificant variations between the two ecotypes were most likely due to the genotypic similarity as both belonged to the same species of *Sesamum radiatum*. This could be confirmed through morphological characterization and identification of both populations with different molecular tools. During the whole growth period, the Port Dickson plants recorded lower height, leaf number per plant and dry matter accumulation in shoot and root compared to Port Dickson ecotype. In Port Dickson ecotype, higher plant height, coupled with higher leaf number per plant, led to a higher photosynthetic activity that ultimately increased the partitioning of dry matter in the shoot and root at both early and late growth phase. Earlier observations on growth performances among the Indian sesame cultivars revealed by Basavaraj *et al*. (2000) confirmed the results of the present study.

In the regression analysis, all the growth factors of sesame such as plant height, leaf number, root fresh weight, leaf fresh weight, leaf dry weight, and total leaf area increased exponentially with time (note that this is expected, growth having a sigmoidal curve). Port Dickson and Serdang ecotypes had similar growth pattern when grown in the soil medium under the same environmental field. The exponential growth pattern with time of the growth factors showed conformity with the growth stages as described by Langham *et al*. (2008). The flattened graph for all the growth factors during the early growth period of 4 to 8 weeks after planting indicated slow growth, while the growth was faster as indicated by the steeper graph during the second phase (8 to 12 weeks after planting). These observations confirmed the results reported by Langham *et al*. (2008) on sesame as characterized by a slower growth rate in the first 30 days, when the roots grow faster than the leaves and stems. In the early growth period, sesame grows slowly because it uses its resources for the development of the root system to get proper moisture.

CONCLUSION

Since sesame plants have shown tremendous amounts of variability in the vegetative phases that ultimately affect its yield and quality, growth and development of sesame are therefore of great importance. In this study, two cultivated sesame ecotypes showed no significant differences in the growth parameters studied. On the basis of the present findings, it is found that even though the two ecotypes naturally habituated in different environmental conditions, similar growth patterns over various growth parameters of sesame plants were observed when they were grown under the same growing conditions.

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