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Evaluation of Physio-Agronomic and Chemical Traits in Relation to the Productivity of Eggplant (*Solanum melongena* L.)

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ABSTRACT. *Six varieties of eggplant (Solanum melongena L.) namely, SM 164 and BW 11 (recommended varieties), EGH 184 and EGH 314 (hybrids), SA7MTE2 and 07145 were evaluated to determine the relationship of physio-agronomic and chemical characteristics with yield. The research was conducted at the Horticultural Crops Research and Development Institute, Gannoruwa in the Maha and Yala seasons 2002/03. The characters evaluated were days to 50% flowering, plant dry weight, leaf area index, number of fruits, fruit yield, leaf nitrogen and petiole potassium contents. A wide variability was observed for all characters evaluated among the varieties. Days to 50% flowering had a significant seasonal variability. The highest fruit numbers and yields were recorded in EGH 184, EGH 314 and SA7MTE2 in both seasons. Days to 50% flowering and fruit number were correlated with yield (-0.55 and 0.86 respectively) and can be used as indicators to predict the yield. Among the six varieties evaluated, SA7MTE2 and EGH 184 showed desirable performances for many economically important traits and identified as the most promising varieties. The recommended varieties, SM 164 and BW 11 had low performances indicating urgent need to release improved varieties for cultivation. Cluster analysis revealed two distinct groups, which suggests that crossing of varieties from divergent groups, will have a heterotic effect.*

INTRODUCTION

Eggplant (*Solanum melongena* L.) is one of the most common and popular vegetables widely grown in almost all agro ecological zones in Sri Lanka. The national average yield is 7.2 mt/ha (fresh weight) which is almost half of the potential yield (15-20 mt/ha) recorded by the recommended cultivars under experimental conditions. However, in other countries such as China, yields of 35 mt/ha has been reported (FAO, 1990). The recommended varieties for cultivation in Sri Lanka are SM 164, Thinnavely Purple and BW 11. They were released in 1940, 1968 and 1996, respectively. Since SM 164 and Thinnavely Purple were released long ago there is an urgent necessity to introduce new improved varieties to enhance the national average production of eggplant. For many years, variety selection of eggplant and other vegetable crops were based on harvest index and phenotypic traits. These parameters however have some limitations. It has been identified that genetic variations exist in many physio-agronomic and chemical traits related to the yield among genotypes. For instance, Chongo and McVetty (2001) reported that high yielding oilseed rape varieties had higher plant dry

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weights. Kanwar *et al.* (1983) reported that leaf nitrogen had a significant correlation with the yield of groundnut even though it can fix soil nitrogen. However, in eggplant, the contribution of these characters to the variation of the yield still remains unclear. Therefore, an increased understanding of these traits of the plant could enhance their utilization for the selection of promising varieties as well as for incorporating them in future crop improvement programs. The present study was conducted to identify the relationship between physio-agronomic and chemical traits with yield and yield contributing characters of eggplant. The variability among varieties, promising varieties for recommendation and the grouping pattern according to their similarities were also investigated.

MATERIALS AND METHODS

Location and climatic conditions of the experimental site

The experiment was conducted at the Horticultural Crop Research and Development Institute (HORDI), Gannoruwa (WM2b) in the *Maha* and *Yala* seasons in 2002/03. The site is situated 480 m amsl ($80^0 3'$ E, $7^0 18'$ N) and the soil type is red yellow podzolic. The rainfall distribution, the number of rainy days and average monthly temperature of the experimental site during the period are given in Fig. 1. Accordingly, there was a slight fluctuation of temperature during the whole growing season. However, the average temperatures recorded during the first two months of field establishment in the *Maha* and *Yala* seasons were 29.3^0 and 31^0C, respectively. Also, the plants grown in the *Maha* season experienced a high amount of rainfall compared to the plants established in the *Yala* season during the first two months (749 and 347 mm, respectively).

Crop establishment and Management

Field planting was done on 12th November, 2002 and 20th April, 2003 for the *Maha* and *Yala* seasons, respectively. Six varieties of eggplant, namely SM 164 and BW11 (recommended varieties), EGH 184 and EGH 314 (hybrids), SA7MTE2 and 07145 were grown. The experiment was laid out in a Randomized Complete Block Design with four replicates. The plants were established on a ridge and furrow system at spacing of 0.9 x 0.6 m (plot size was 0.54 m^2) and a single plot consisted of 30 plants. Farmyard manure was applied one week before the planting at a rate of 10t/ha and was mixed well with the soil. Basal mixture was applied a day before planting and the top dressing was given in three doses at four, ten and fifteen weeks according to recommendations of the Department of Agriculture, Sri Lanka (Anon., 1990). Sprinkler irrigation was supplied twice a day at the initial stages of plant establishment and thereafter only once in two days upto two months when the rainfall was inadequate. The planting holes were treated with Carbofuran to control termites and root knot nematodes before planting while stem and shoot borer was controlled by spraying Atabron twice after planting. Weeding was done manually at three to six weeks after transplanting.

Measurements

Plant dry weight, leaf area index, leaf nitrogen and petiole potassium contents were measured at five successive stages after field planting, *i.e,* early vegetative stage - 4th week (S_1), 50% flowering stage -7th week (S_2), first harvest –10th week (S_3), fourth harvest -13th week (S_4), and the eighth harvest –17th week (S_5). A representative plant (healthy and vigorous) from each plot was selected to collect the data and a marked area consisting of six plants was kept for the yield measurements. The days to first flowering on 50% of the plants of each variety were taken as the days to 50% flowering. Single plant from each plot was uprooted and washed thoroughly to remove all the adhering soil particles. The leaves, petioles, stems, roots and fruits were separated. They were oven dried at 82^0 C for three days and the dry weights were recorded. The dry weight of a known leaf area (25 cm^2) from a random sample of leaves and the total dry weight of leaves were used to calculate the total leaf area of the plant. The fruits were picked at weekly intervals and the total number of matured fruits and their fresh weights were recorded separately from each plant of the marked area. Leaf nitrogen and petiole potassium were analyzed by the Kjeldahl and Flame Photometry method respectively (Anon., 1994).

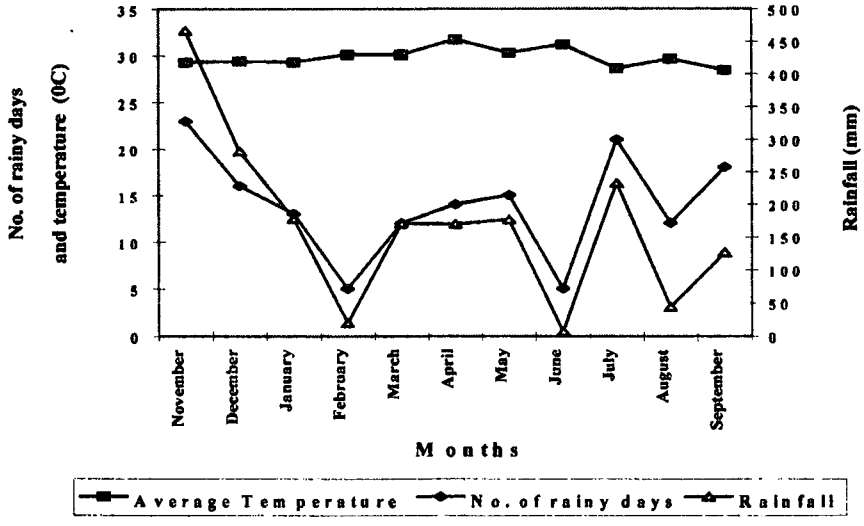

Fig. 1. Monthly variation in rainfall, rainy days and temperature at the experimental site during the *Maha* and *Yala* seasons in 2002/03.

Data analysis

The SAS computer package was used for data analysis. ANOVA and Duncans New Multiple Range Test (DNMRT) were performed to estimate the variability and for mean separation, respectively. The means of each variable were used to set up the correlation matrix. Mid Rank Method of Scoring was used to estimate the overall performance of a particular variety with regard to the characters evaluated (Gomes *et al.*, 1984). Average Linkage Cluster Analysis was performed using the means of all variables to categorize the varieties into groups or clusters according to their similarities and dissimilarities (Dunn and Everritt, 1982).

RESULTS AND DISCUSSION

Days to 50% flowering

Days to 50% flowering is an indication for early fruit setting and the yield potential of a crop. It varied among the varieties ranging from 45 to 55 days in the *Maha* season and 33 to 39 days in the *Yala* season (Table 1). Accordingly, variety SA7MTE2 followed by hybrids, EGH 314 and EGH 184 achieved 50% flowering early in both seasons while it was significantly late in recommended varieties ($P<0.05$). It also varied significantly in the two seasons. Early flowering in the *Yala* season may be attributed to low amount of rainfall received at the initial stages after field establishment because plants reach the productive stage early under slight water deficient conditions and at relatively high temperatures (Fig. 1).

Table 1. Variation in days to 50% flowering in *Maha* and *Yala* seasons.

Season	SM 164	BW11	EGH 184	EGH 314	SA7M TE2	07145	Mean
Maha	54±5.8a	55±4.1a	49±4.8b	48±3.2b	45±3.7b	5±4.9b	50.3±4.9A
Yala	39±4.2a	38±3.8a	34±4.2b	33±3.1b	33±4.4b	36±4.8ab	35.5±4.7B

Mean values in the two rows with different letters are significantly different ($P<0.05$).
Sample size n = 24

Plant dry weight and leaf area index

Significant ($P<0.05$) varietal differences were observed in dry weight and leaf area index at all sampling stages except S_1 (Fig. 2 and Fig. 3). The dry weights in all varieties were increased rapidly after 4 weeks of planting upto the 50% flowering stage (S_1-S_2). The maximum dry weight was observed in SA7MTE2 (223 g/plant) followed by 07145, EGH 184 and EGH 314 at the eighth harvest whereas the minimum was observed in SM 164 and BW 11 at the same stage (126 g and 104 g/plant respectively). It was observed that varieties SA7MTE2, EGH 184 and EGH 314 had many branches while varieties SM 164 and BW 11 showed symptoms of senescence. At four months after field establishment, varieties SA7MTE2, EGH 184 and EGH 314 did not show a drastic reduction in their dry weights. This means that under proper management conditions, the eggplant has potential to continue its productive stage for longer period of time. The leaf area index also followed the same pattern as the dry weight (Fig. 3) and the maximum was observed for EGH 184 (2.66) at the final harvesting stage. The recommended variety SM 164 recorded the lowest leaf area index (1.58) at the same stage. Leaf area index is a partial indication of the ability of the canopy to intercept light to carry out photosynthesis. It also serves as a storage organ for reduced nitrogen during the reproductive growth, thus a higher leaf area index is an advantage to the plant (Dale and Milthorpe, 1983).

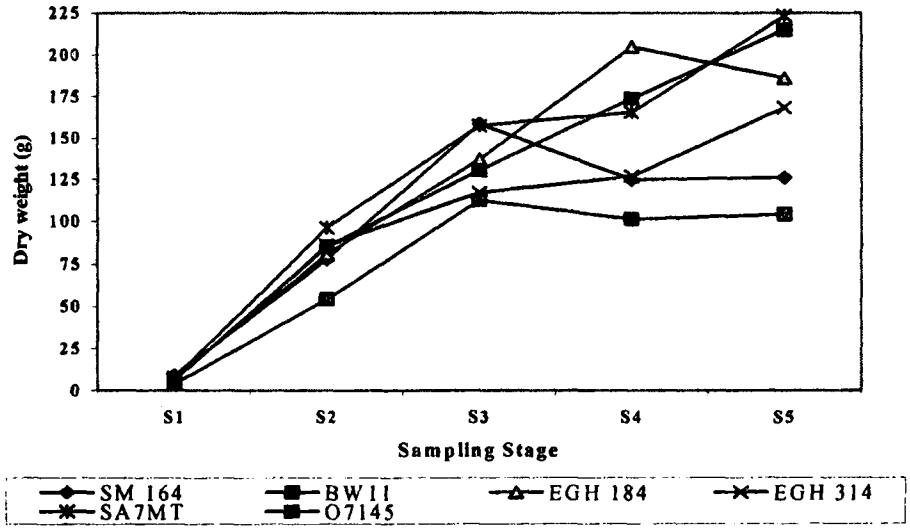

Fig. 2. Variation in the plant dry weight in the *Maha* season.

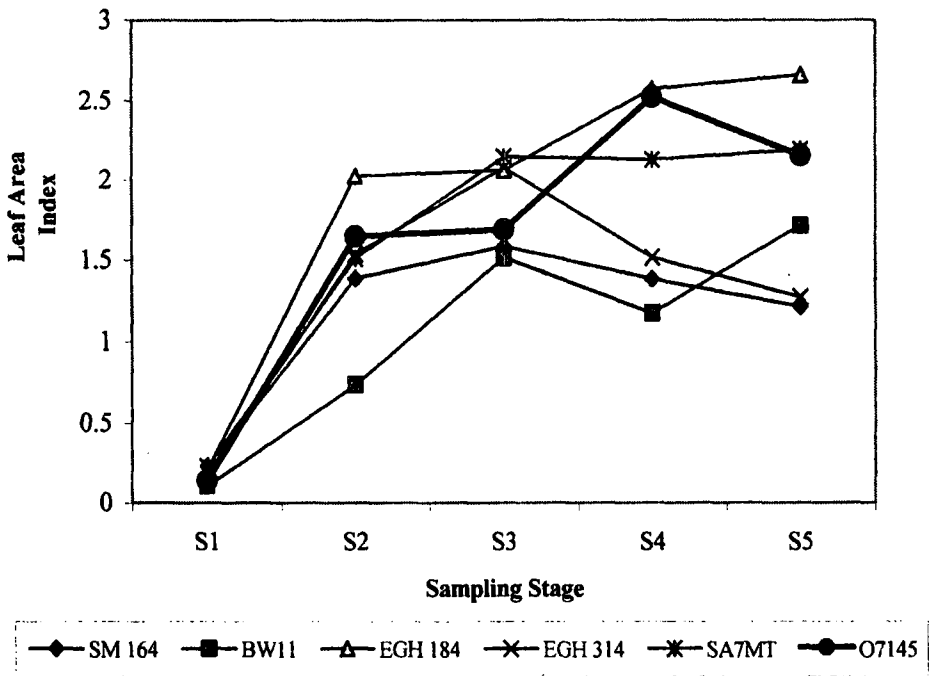

Fig. 3. Variation in leaf area index in the *Maha* season.

Fruit number and yield

Fruit number per plant is an important trait contributing towards yield. It varied from 12 to 44 in the *Maha* season and 10 to 32 in the *Yala* season among varieties (Table 2). The two hybrids and variety SA7MTE2 produced high fruit numbers in both seasons. Yield of a single plant was the most important trait studied and a wide variability was observed for this character among the varieties. It ranged from 1.37 to 3.43 kg in the *Maha* season and 1.88 to 3.89 kg in the *Yala* season (Table 2). Similar to the fruit number, the highest yields were observed for SA7MTE2 and EGH 184. Maximum potential yield of these exceeded 50 mt/ha (Table 2), which was much higher than the recorded potential yield of the recommended varieties. Even at the final harvesting stage, many plants of these varieties were observed to be healthy and productive, indicating the possibility of extended harvest. In contrast, varieties SM 164, BW 11 and 07145 produced the lowest fruit numbers as well as the lowest yields in both seasons. Even though, 50% flowering had a seasonal variability, neither fruit number nor yield varied in the two seasons.

Table 2. Variation in fruit number and yield in the *Maha* and the *Yala* seasons.

Variety	Fruit No./plant		Yield/plant (Kg)		Yield/ha (MT)	
	Maha	***Yala***	***Maha***	***Yala***	***Maha***	***Yala***
SM164	21±3.1c	20±3.5b	1.37±0.2d	1.88±0.4d	25.4	34.8
BW11	25±4.3c	28±3.7ab	2.09±0.6c	2.18±0.4c	38.7	40.3
EGH184	34±3.4b	32±4.9a	3.04±0.6b	3.89±0.7a	56.3	72.0
EGH314	33±3.8b	27±3.4ab	2.17±0.7c	2.74±0.5b	40.3	50.7
SA7MTE2	44±5.8a	30±4.1a	3.43±0.3a	2.77±0.5b	63.5	51.2
07145	12±2.9d	10±2.8c	1.48±0.3d	1.93±0.4cd	27.6	35.7
Mean	28±4.1	25±4.0	2.26±0.4	2.57±0.5	42.0	47.5

Values in each column with the same letter are not significantly different ($P<0.05$).

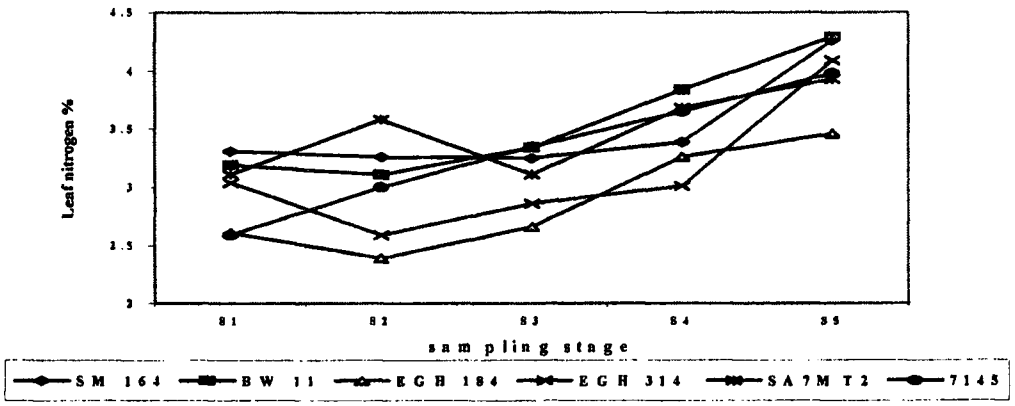

Fig. 4. **Variation in the leaf nitrogen content at different growth stages in the in the *Maha* season.**

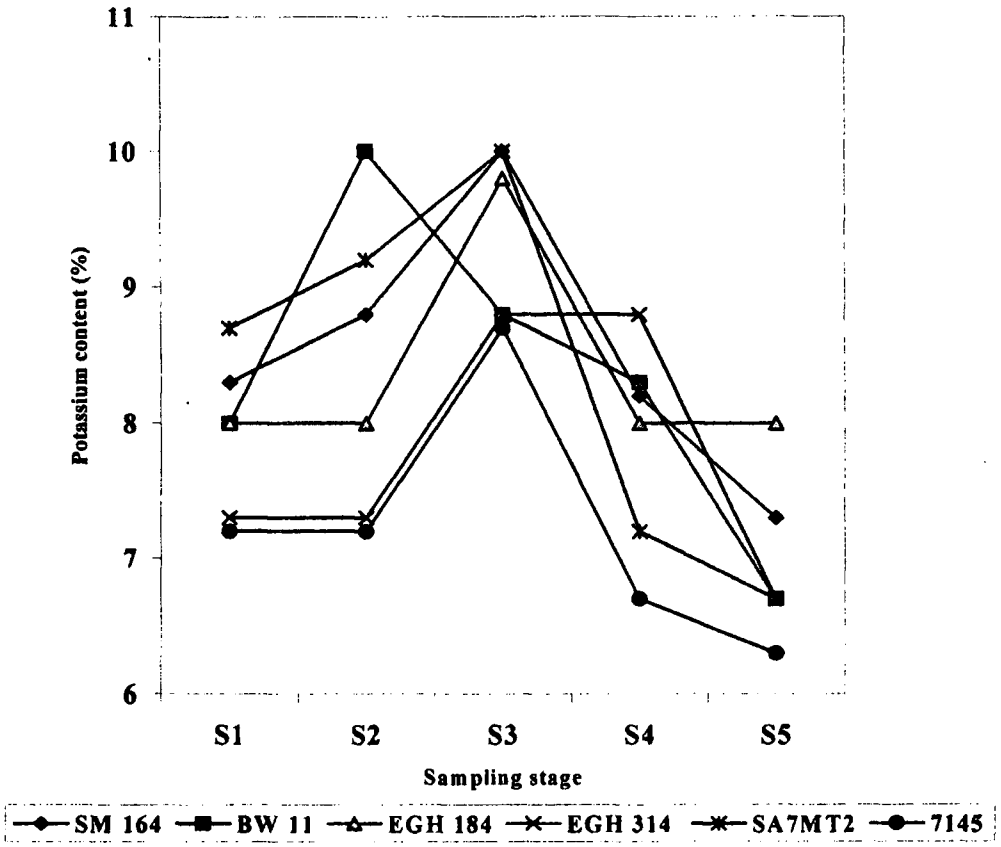

Fig. 5. **Variation in the petiole potassium contents at different growth stages.**

Next to nitrogen, potassium is the nutrient required in the largest amount by plants and it ranges from 2-5% of the plant dry weight of the vegetative parts under optimum plant growth (Marschner, 1995). In this study, the mean potassium content increased until the first harvest (S_3) and then decreased rapidly at the later harvesting stages (Fig. 5). A similar pattern was observed in tomato variety VFN-8 where petiole potassium increased upto 6.83% at early fruit setting and dropped down to 0.97% at 50% fruit ripening stage (Marschner, 1995). Home and Nylude (1978) reported that productivity is much higher in potato varieties, which have high rates of petiole potassium deterioration. In the present study, SA7MTE2 showed the highest rate of potassium deterioration from first harvest to the eighth harvest (0.47% per week) which was one of the highest yielding varieties recorded. Since potassium deterioration begins at the onset of harvesting, potassium application can be recommended during the harvesting period to prolong fruit production.

Correlation analysis

The correlation matrix provides useful information regarding the extent of correlation between each pair of variables (Table 3). Days to 50% flowering had a significant negative correlation with yield (-0.55) indicating varieties which flowered early had high yields compared to the late flowering varieties. This is evident from table 1 and 2 where, varieties EGH 184, EGH 314 and SA7MTE2 flowered early as well as gave high yields. Fruit number and yield were highly correlated (0.86) where yields of the varieties having high fruit numbers were also high. These results revealed that days taken to 50% flowering and the fruit number could be used in selecting high yielding

varieties in eggplant. Plant dry weight and leaf area index can also be included to enhance the efficiency of crop improvement programs since they significantly correlated with the yield.

Mid rank selection

The six varieties were given a rank from 1to 6 (1 = the most desirable character) based on their performance for each character (Table 4). Accordingly, variety SA7MTE2 was the best performer achieving the lowest score, 1.42. It had a combination of many desirable characters such as early flowering and high values for plant dry weight, fruit number and yield. Variety EGH 184 was the next best performer (score: 3.00) whereas EGH 314 had average rank for many of characters. The two recommended varieties and variety 07145 showed high scores and showed poor performances with respect to many important characters. Variety BW 11 was given the highest rank for days to 50% flowering, leaf area index and plant dry weight. These results imply that SA7MTE2 and the hybrids have better performances than the other varieties with regard to the characters evaluated in this study. Therefore, to increase the national yield level, it is necessary to replace the recommended varieties with better performing varieties.

Table 3. Correlation matrix of the physio-agronomic and chemical characters in the *Maha* season.

	DFF	LAI	DW	FN	LN	RPK	YD
DFF	1.00						
LAI	-0.52*	1.00					
DW	-0.88*	0.78*	1.00				
FN	-0.30	-0.05	0.02	1.00			
LN	0.20	-0.72	-0.34	-0.02	1.00		
RPK	0.36	-0.46*	-0.45*	-0.59*	0.2	1.00	
YD	-0.55*	0.42*	0.46*	0.86*	0.29	0.39	1.00

* significant at $P<0.05$

DFF = Days to 50% flowering; LAI = Leaf area index at the eighth harvest; DW = Dry weight of plant at the eighth harvest; FN = Fruit Number per plant; LN = Leaf nitrogen content at the eighth harvest; RPK = Rate of petiole potassium deterioration ($S_3 - S_5$); YD = Yield per plant

Table 4. Mid ranks of the physio-agronomic and chemical characters of eggplant (*Maha* season).

Variety	DFF	LAI	DW	FN	LN	RPK	YD	MID RANK
SM 164	5	5	5	5	1	2	6	4.14
BW 11	6	6	6	4	3	5.5	4	4.92
EGH 184	3	1	3	2	6	4	2	3.00
EGH 314	2	4	4	3	5	3	3	3.42
SA7MTE2	1	3	1	1	2	1	1	1.42
07145	4	2	2	6	4	5.5	5	4.07

DFF = Days to 50% flowering; LAI = Leaf area index at the eighth harvest; DW = Dry weight of plant at the eighth harvest; FN = Fruit Number per plant; LN = Leaf nitrogen content at the eighth harvest; RPK = Rate of petiole potassium deterioration ($S_3 - S_5$); YD = Yield per plant

Cluster analysis

The six varieties grouped into two major clusters (Fig. 6) at the average distance of 1.17 (major cluster 1: SM 164, BW 11, EGH 314 and 07145; major cluster 2: EGH 184 and SA7MTE2). Major cluster 1 was again grouped into two sub clusters where variety 07145 was separated to a single cluster. There was a marked difference between the clusters. Varieties in cluster 2 showed better performances for days to 50% flowering, plant dry weight, fruit number and the yield than those in cluster 1. Inter-cluster distances are created as a result of the genetic divergence and therefore crossing between varieties in clusters would bring about high heterosis, which will be useful in developing hybrids or desirable segregants.

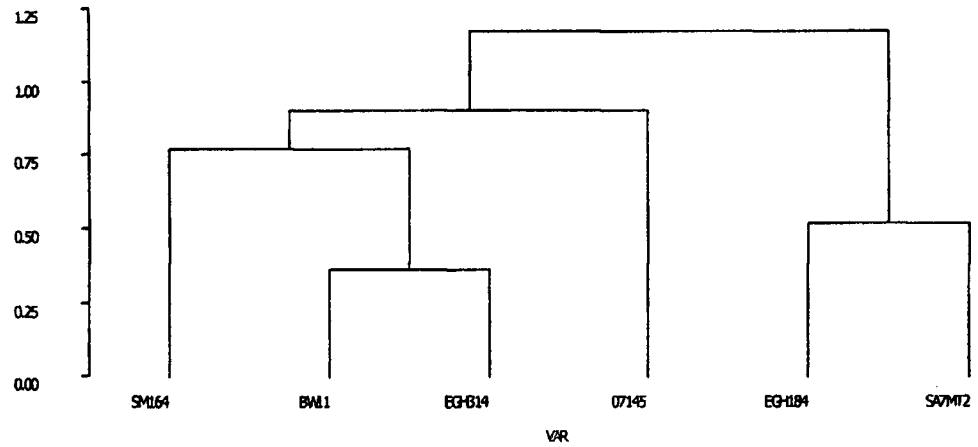

Fig. 6. Dendrogram produced by Average Linkage Cluster Analysis for Six varieties in the *Maha* Season.

CONCLUSIONS

The results of the present study revealed that a wide variability exists for most of the characters measured in the six varieties of eggplant. There was a seasonal variability in the days taken to 50% flowering where the flowering was achieved about two weeks earlier in the *Yala* season than in the *Maha* season due to slightly higher temperatures experienced during the *Yala* season. The highest fruit numbers were produced by varieties SA7MTE2 and EGH 184. This was reflected in the yields of these varieties, where potential yields exceeded 50 mt/ha, which was remarkably higher than the recorded potential yield of the recommended varieties. Based on the results of the mid rank method of scoring, these two varieties were identified as the most promising varieties. Variety EGH 314 had average performances with respect to early flowering, fruit number and the yield. Therefore, they should be included in future crop improvement programs of eggplant. In contrast, the presently recommended varieties and variety 07145 had poor performances with regard to many important characters contributing to the yield.

Days to 50% flowering, plant dry weight, leaf area, and fruit number can be incorporated in selecting high yielding varieties in eggplant since they were significantly correlated with the yield. The validity of using leaf nitrogen and petiole potassium contents to predict the yield must be verified.

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