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Evaluation of varietal performance for yield and yield contributing attributes of local brinjal (*Solanum melongena* L.) germplasm collections

Md. Amirul Alam[a]*, Asmaiyah Binti Kamarzaman[a], Mohamadu Boyie Jalloh[b] and Mohammad bin Mohd. Lassim[b]

[a]Faculty of Sustainable Agriculture, Horticulture and Landscaping Program, Universiti Malaysia Sabah, Sandakan Campus, Sandakan 90509, Sabah, Malaysia.

[b]Faculty of Sustainable Agriculture, Crop Production Program, Universiti Malaysia Sabah, Sandakan Campus, Sandakan 90509, Sabah, Malaysia.

***Corresponding author: amirulalam@ums.edu.my**

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ABSTRACT

Brinjal is the second most important vegetable crop after Tomato in relation to its total production. Better production from any crop can only be achieved from a better variety. But in most cases the producers especially the rural farmers are not aware about the selection of high yielding varieties. Without any justification they just buy those seeds are easily available in nearby shops resulting harvest a poor yield with very unsatisfactory return. In this regard five different brinjal (*Solanum melongena* L.) germplasm collections were evaluated for their major yield and yield contributing attributes along with total chlorophyll content as physiological parameter. The study was conducted in rain shelter 10, at the Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, arranged in Complete Randomized Design (CRD) with five replications. Research findings revealed significant variations for all the measured parameters among different brinjal cultivars. Round purple brinjal (V1=Mte2) had the highest fruit weight (238.60g; which is about 88.14% increased fruit weight over V4), followed by long red purple brinjal (V2=H117) with 167.50g (about 83.10% increased fruit weight over V4), long green brinjal (V3=H249) with 119.70g (about 76.36% increased fruit weight over V4) and the lowest fruit weight (28.30g) was found in brinjal variety V4 (Telunjuk), respectively. On the other hand red purple brinjal (V2) was the longest (24.23 cm) in size with 5.60 cm in diameter, but the highest fruit diameter (12.24 cm) was recorded in V3 brinjal. Long red purple brinjal (V2) showed the shortest days to 50% flowering with 49 days compared to Kermit brinjal (V5) which took the longest 61 days to 50% flowering. The highest total leaf chlorophyll content was detected in V5 (51.02 nmol/mg) while the lowest (44.06 nmol/mg) was in V3. From the correlation analysis significant correlation were detected among days to 1st flowering and days to 50% flowering; plant height and fruit diameter, while significant but negative correlation was seen among numbers of leaves and fruit diameter; plant height and fruit weight with chlorophyll content. From the cluster analysis primarily; V1, V2, and V3 were grouped into one cluster while V4 and V5 into another clusters, while in secondary clustering V1 alone in one group, V2 and V3 in 2nd group and finally V4 and V5 were in third groups which indicated a significant diversity among cultivars. On an average; considering varietal performance for yield and yield contributing attributes of five (5) different brinjal cultivars, it was revealed that the fruits of V1 gained the highest weight, while the fruits of V2 had the highest length and the fruits of V3 gained the highest diameter. Regarding earliness; variety V2

was the earliest among all 5 varieties, which is one of the desirable characteristics for any crops; especially in vegetables.

Keywords: Brinjal (*Solanum melongena*) varietal performance, yield, germplasm, evaluation

INTRODUCTION

Vegetables are one of the essential items of daily requirement. Brinjal or eggplant (*Solanum melongena* L.) is a warm-weather crop mostly cultivated in tropical and subtropical regions of the world. Among different types of fruit vegetables brinjal is the most important vegetable grown extensively in Asian countries both in kitchen and commercial gardens throughout the year mainly for its tender, fleshy and fresh fruits. Brinjal also known as eggplant by its scientific name, *Solanum melongena* L. is belong to the family of Solanaceae. The top five brinjal producing countries are China (28.4 million tons; 57% of world's total), India (13.4 million tons; 27% of world's total), Egypt (1.2 million tons), Turkey (0.82 million tons), and Iran (0.75 million tons) (National Horticulture Board, 2015; Taher, 2017). In Asian countries, brinjal is the common and one of the important vegetables that is consumed in various ways with high nutritional value. Brinjal is the second most important vegetable crop after Tomato in relation to its total production (Taher et al., 2017). However, based on data from Department of Agriculture Malaysia (2017), brinjal is one of the ninths (9) main crops produced in Malaysia (DOA, 2017).

In Malaysian context, vegetable production-especially eggplant-has been low with only 39,311.5 metric tons (DOA, 2018), and one of the major factor identified was due to lack of genetic resources. This has forced the country to rely on imported vegetable seeds to meet 265 tons annually, but locally they can only meet 13 tons (Zainol et al., 2003), leading to a deficit of 252 tons/year, which is being imported from overseas (Mahmood, 2006). With limited eggplant cultivation and studies, there is a duty call for awareness of the importance of utilization and development of our available varieties gearing towards food security and the high-value vegetable market of Malaysia. The local production could improve through the exploration of germplasm. The existence of compelling high genetic variation is critical for expanding the stricken eggplant genetic base and advancing current germplasm, whether it is local or commercial germplasm.

The Solanaceae family in one of the largest family having several of edible fruit vegetable varieties and brinjal is one of the widely consumed vegetable (Suhana et al., 2016). Each of varieties can be found growing at different warmer part of the world (National Horticulture Board, 2015). Those different varieties can be identified from it obvious color of fruits. According to the Naidu (2016), brinjal is categorized as a non-woody plant and can grows only until 1.5m. Fine hairs are covered in whole diameter of brinjal stem and leaves and the formation of flowers will occur from the leaf axils. Its flower formation has a star-shape with light purple color. Brinjal fruits have many seeds inside it and the fruit production occur year round as it is categorized as perennial plant. The color and shape of fruits can be various based on different varieties. Varietal differences of brinjal can be identified from its yield performance.

Several researches are already conducted on varietal performance of brinjal varieties, but majorities are hybrids and from outside Malaysia (Quamruzzaman et al., 2019; Ashraf et al., 2017; Abhimanyu et al., 2016). Local people usually cultivate brinjal varieties those are easily available around them without justification of yield performances as well as without cost benefit analysis. So, for this they never achieve the optimum output from their produce. Sometimes they can loss their whole capital rather than getting profits. In this regard it is very urgent to evaluate the local brinjal germplasms for their yield and yield contributing attributes and to select the better varieties for commercial and profitable cultivation.

Generally, morpho-physiological characterization is the first step in exploring eggplant genetic variation. Hence, there is a wide variation in eggplant habitats as well as vegetative and agro-morphological characteristics (Ullah et al., 2014). Besides, the evaluation of genetic variation and adaptation to climatic conditions using agronomic traits has been the focus of research in the last decade (Daunay et al., 2001). Recently, taste, texture, and appearance are among the considered factors alongside nutrient compositions (Causse et al., 2010) that are being emphasized to meet consumer demand.

The performance of yield is directly correlated with the overall growth and morpho-physiological development. Total plant growth and morpho-physiology of brinjal varieties can be observed throughout the

plant growth and development and data from its originality. So, in this study data from germination of seeds until fruit production are recorded to evaluate the differences and similarities among cultivars.

MATERIALS AND METHODS

Planting materials and experiment set up

Among the 5 different varieties of brinjal; V2 (H117) and V3 (H249) were bought from Hein Huat Seeds (Sabah) Sdn Bhd located at Batu 8, Sandakan, Sabah, while the V1 (Mte2) seeds was bought directly from MARDI, Serdang and another two varieties V4 (Terung Telunjuk) and V5 (Terung Kermit) Kampung brinjal varieties were collected from local growers. After collection all those seeds were soaked overnight in distilled water for boosting up the germination process and sown in different germination trays. One month aged seedlings were planted in polybags and arranged in Complete Randomized Design (CRD) with five replications at rain shelter 10, Faculty of Sustainable Agriculture, Universiti Malaysia Sabah (UMS), Sandakan campus.

Media for seedling preparation and final transplanting in polybags was prepared using the appropriate mixtures of topsoil, sands and organic matter with the ratio of 3:2:1 amounting a 6 kg of media was filled into every polybags (18 cm x 15 cm) until ¾ parts and then seedlings were transplanted of about 1 ½ inch to 2 inches depth into the media.

Agronomic practices

After transplanting watering is one of the main requirements for plant growth. Watering was done 2 times per day; at morning and evening. Weeding is only necessary if its presence affects the growth or may become host for pest and diseases. Same as seed germination in transplanting, the maintenance only required at the stage where its cause critical yield loss and in case of severe attack of pest and diseases were controlled by applying recommended pesticides (e.g, Malathion @ 2 ml/L of water). Observation on pest and disease presence can help to indicate the control practices. According to standard production methodology, fertilizer application (N:P:K=15:15:15 @ 5.0 g/polybag; the first application was at 15 days after transplanting and the 2nd application at the time of flowering and fruit setting) and other intercultural operations were followed as and when necessary. Special care was taken during flowering and especially at fruiting stage.

Data Collection

Plant height (cm), numbers of branches, numbers of leaves, days to first flowering, days to 50% flowering and fruit weight (g) were recorded in every week interval. Measuring tape was used to measure the height of main stem from root collar until its top shoot. Numbers of branches and leaves were calculated manually starting from lower part of plant and branches to the upper part of plant. Laboratory digital balance was used to measure the weight of the fruit. Data collection were repeated five times from every plant of five replications and the final data was produced from the average. As physiological parameter; total chlorophyll content was recorded at full maturity of the brinjal plants. SPAD meter was used to measure the total chlorophyll content and the data were record with unit of SPAD meter index (nmol/mg). Data collection was repeated five times from every plant of five replications and the final data was produced from the average.

Cluster analysis

A cluster analysis was performed to construct a dendrogram based on the similarity matrix data using the unweighted pair group method with arithmetic averages (UPGMA) and the *SHAN* clustering program. All of the analyses were performed with the *NTSYS-pc 2.10* software (Rohlf, 2002).

Statistical Analysis

Recorded data was subjected to one-way analysis of variance (ANOVA) using Statistical Analytic Software (SAS) Version 9.4 software. Least Significant Difference (LSD) test at 0.05 level of probability was used to compare between means when ANOVA showed significant treatment effects of this study. Pearson's correlation coefficient analyses were also done to assess the associations between different parameters and brinjal cultivars.

RESULTS AND DISCUSSION

Morphological and physiological characteristics

Analysis results on morpho-physiological parameters are presented in Table 1. Based on the Table 1, highly significant ($P<0.001$) variation was observed for plant height where, the highest plant height was recorded in V3 with 76.12 cm (42.41% increased height over V5) followed by V4 with 64.12 (31.63% increased height over V5) cm then V1 and V2 with 54.26 cm (19.20% increased height over V5) for each of plant height. Meanwhile, V5 shows the lowest plant height which was 43.84 cm. Significant ($P<0.05$) variation was also observed for numbers of leaves among cultivars. The highest numbers of leaves (74.80; 21.39% more leaves compared to V3) were counted in V5 and the lowest (58.80) was recorded in V3, respectively. On the other hand non-significant ($P>0.05$) differences were observed for numbers of branches with the highest in V5 (15.20) and lowest in V4 (14.80), respectively (Table 1). Furthermore, highly significant ($P<0.001$) variations were observed for days to 1st and 50% flowering as well. The shortest days to 1st flowering (41 days; 8 days earlier over V5) and 50% flowering (49 days) was observed in V2 while longest days to 1st flowering (49 days) and 50% flowering (61 days) was observed in V5, respectively (Table 1). The similar types of morpho-agronomic and yield variability is also reported by Sulaiman et al. (2020); who conducted an experiment on 29 different types of eggplant varieties collected from Thailand, China and Malaysia.

Table 1. Morho-physiological parameters among five different brinjal varieties.

Variety	Plant height (cm)	Numbers of leaves	Numbers of branches	Days to 1st flowering	Days to 50% flowering	Fruit diameter (cm)	Fruit length (cm)	Fruit weight (g)	Chlorophyll content (nmol/mg)
V1	54.26^{c}	60.20^{bc}	12.80^{ab}	45.40^{ab}	55.00^{b}	9.74^{b}	7.04^{c}	238.60^{a}	48.12^{ab}
V2	54.26^{c}	70.40^{ab}	14.00^{ab}	41.00^{c}	49.00^{c}	5.60^{c}	24.23^{a}	167.50^{b}	46.94^{bc}
V3	76.12^{a}	58.80^{c}	11.00^{b}	42.00^{bc}	51.80^{bc}	12.24^{a}	10.56^{b}	119.70^{c}	44.06^{c}
V4	64.12^{b}	68.40^{abc}	15.20^{a}	42.40^{bc}	52.60^{bc}	9.10^{b}	3.60^{e}	28.30^{e}	46.46^{bc}
V5	43.84^{d}	74.80^{a}	14.80^{a}	49.40^{a}	60.60^{a}	4.13^{d}	4.29^{d}	49.9^{d}	51.02^{a}
CV (%)	2.48	12.87	19.26	7.35	5.59	16.40	18.74	24.16	5.71
F value	402.62	3.18	2.12	5.57	7.51	11.86	5.69	3.49	4.43

Values in each column with the same letter are not significantly different ($P<0.05$ or $P<0.001$).

Highly significant variation ($P<0.001$) was also observed for brinjal fruit shape, size and weight among all those 5 cultivars (Table 1, Figure 1). The fruit of V3 achieved the largest fruit diameter (12.24 cm) while the shortest diameter (4.13 cm) was seen in variety V5 (Table 1). The longest fruit (24.23 cm) was produced by V2 and the shortest (3.60 cm) brinjal was produced by V5 variety. The V1 brinjal showed the highest fruit weight (238.60 g), while the lowest fruit weight (28.30 g) brinjal was produced by V4 brinjal variety, respectively (Table 1). Variations in brinjal fruit shape, size and weight among different varieties was also opined by Sulaiman et al. (2020); who studied 29 varied types of brinjal varieties collected from 3 different countries; Malaysia, Thaniland and China.

Significant variations were observed among all the five (5) brinjal varieties for most of all the measured attributes except for the number of leaves (Table 1). A wide range of plant height (76.12 – 43.84 cm) was observed among the varieties evaluated. Differences in plant height either the tallness, shortness or other growth development are controlled and expressed by certain gene and climatic factors (Gogoi et al., 2017).). Our finding is supported with those findings of Singh et al. (2014) and Mohantry et al. (2001) who also reported a significant variation for plant height among varied types of brinjal cultivars. A significant variation was also observed for numbers of branches among different brinjal cultivars; specific gene might be responsible for such branching behavior of any plant (Suhana et al., 2016). Significant differences are observed also for days the days to 1st flowering and days to 50% flowering among those brinjal varieties. Early flowering represent the early fruiting and early harvesting as well which is a much desired characteristics for any crop variety. Sometimes timely flowering may be affected or delayed due to pests attack and other environmental stress like nutrient deficiency, drought, salinity, high temperature, very low temperature and so on. In our study just before flowering brinjal

variety V1 was affected by brinjal shoot and fruit borer resulting the top shoot had to cutoff. So, in our observation we assumed that it is one of the reason for late flowering by brinjal variety V1 compared to others. The variations in fruit yield, total yield, fruit shape, size, color and weight are also genotype based specific characteristics (Zaliza, 2011).

Lastly, significantly ($P<0.001$) the highest leaf total chlorophyll content (51.02 nmol/mg) was measured in V5 leaf followed by V1 brinjal (48.12 nmol/mg) and the lowest (44.06 nmol/mg) was recorded in V3 brinjal (Table 1). Chlorophyll content was the only physiological character measured by using SPAD meter. There were only small differences for total chlorophyll content among five varieties (51.02 – 44.06 nmol/mg). According to Francisco (2019); time of day and exposure to sunlight could influence the reading of chlorophyll content. Since the brinjal plants were placed under the rain shelter, the penetration of sunlight has been filtered by the netting which may contribute to the high chlorophyll content reading.

Fig. Brinjal fruit of Var. Mte2

Fig. Brinjal fruit of Var. H117

Fig. Brinjal fruit of Var. H249

Fig. Brinjal fruit of Var. Tehunjuk

Fig. Brinjal fruit of Var. Kermit

Figure 1. Mc

Pearson Correlation Coefficient

The correlation matrixes for 9 different morpho-physiological and yield attributes in 5 different brinjal varieties are presented in Table 2. Days to 50% flowering had positive correlation ($P \leq 0.05$) with days to 1st flowering, while fruit diameter had significant ($P \leq 0.05$) correlation with plant height but had negatively significant ($P \leq 0.05$) correlation with numbers of leaves. On the other hand, total chlorophyll had negatively significant correlation ($P \leq 0.05$) both with plant height and fruit fresh weight (Table 2).

Table 2. Correlation coefficient between growth and yield performance of five brinjal variety.

	PH	NL	NB	D1F	D50F	DF	LF	WF	CC
PH	1.0								
NL	-0.71^{ns}	1.0							
NB	-0.64^{ns}	0.85^{ns}	1.0						
D1F	-0.70^{ns}	0.39^{ns}	0.29^{ns}	1.0					
D50F	-0.59^{ns}	0.36^{ns}	0.29^{ns}	0.98*	1.0				
DF	0.88*	-0.93*	-0.73^{ns}	-0.48^{ns}	-0.39^{ns}	1.0			
LF	0.02^{ns}	0.04^{ns}	-0.18^{ns}	-0.59^{ns}	-0.71^{ns}	-0.19^{ns}	1.0		
WF	-0.05^{ns}	-0.56^{ns}	-0.52^{ns}	-0.18^{ns}	-0.30^{ns}	0.23^{ns}	0.45^{ns}	1.0	
CC	-0.96*	0.68^{ns}	0.62^{ns}	0.87^{ns}	0.80^{ns}	0.81^{ns}	-0.29^{ns}	-0.12*	1.0

Note; here mean values (±SE) followed by different letters differ significantly according to Tukey's multiple range tests at $p < 0.05$.

Here, *significant at P<0.05, ns = Non-significant at P>0.05. PH = plant height, NL = number of leaves, NB = number of branches, D1F = days of 1st flowering, D50F = days to 50% of flowering, DF = diameter of the fruit, LF = length of the fruit, WF = weight of the fruit and CC = total chlorophyll content.

Cluster analysis

To assess the patterns of variation, a UPGMA cluster analysis were performed using the measured parameters. All 5 different varieties of brinjal were primarily grouped into two vital groups and secondly clustered into 3 groups at 0.6 similarity coefficient level (Figure 2). In the primary two vital groups; V1, V2 and V3 is clustered into first group (A), whereas V4 and V5 in another groups (B). In the secondary grouping; V1 alone formed the 1st cluster (I), V2 and V3 itself formed the 2nd cluster (II) and V4 and V5 formed the 3rd clusters (III), respectively (Figure 2).

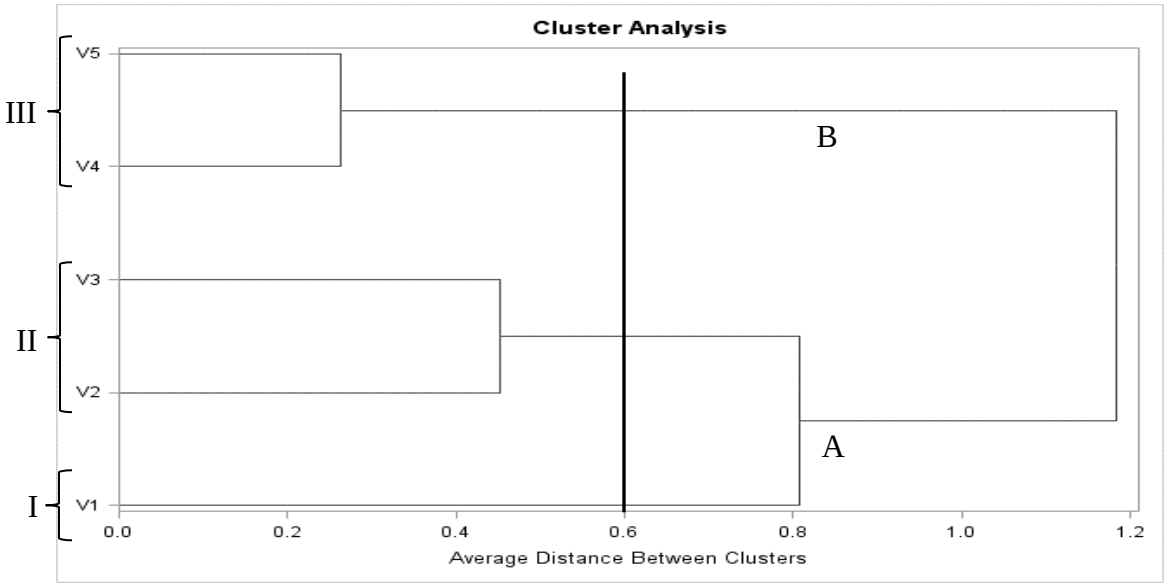

Figure 2. A UPGMA dendrogram of measured traits derived from 5 different varieties of brinjal.

The Pearson's similarity coefficient obtained through morpho-physiological traits ranged between 0.6 and 1.2 (Figure 2) indicating the strong diversity among brinjal varieties. Cluster analysis, as a multivariate technique, can group individuals or objects on the basis of their characteristics. Individuals with similar descriptions are mathematically congregated within the same cluster (Alam et al., 2014; 2015). Distance, similarity and relatedness of varieties are the foundation of this method. The UPGMA constructed dendrogram revealed 3 clusters (at 0.6 similarity coefficient level) where V1 was the most different from all of the others,

indicating the highest diversity compared to other accessions. To improve variety development, the most judicious crossing combination can be made with V1 with V2 or V3 and V4 or V5, which would bring about the greater genetic diversity (Alam et al., 2016).

CONCLUSIONS

After the evaluation of varietal performance for yield and yield contributing attributes of five (5) different brinjal germplasm collections, it was revealed that the fruits of V1 gained the highest weight (238.60 g), while the fruits of V2 was the highest in length (24.23 cm) and the fruits of V3 was the highest in diameter (12.24 cm). Regarding earliness; variety V2 was the earliest both in days to 1st flowering and days to 50% flowering and harvesting as well. On the other hand total chlorophyll content was the highest in variety V5 (51.02 nmol/mg) but overall there were very minimum variations among those five brinjal varieties for total chlorophyll content. Correlation coefficient analysis also revealed significant correlation among days to 50% flowering and days to 1st flowering. Cluster analysis grouped all those five varieties of brinjal into 3 clusters at 0.6 similarity coefficient level where V1 solely formed a single cluster; V2 and V3 formed the 2nd clusters, while V4 and V5 formed the 3rd clusters, which indicated greater diversity among them. To develop new variety as well as for desired improvement in future, the most judicious crossing combination can be made with V1 with V2 or V3 and V4 or V5, which would bring about the greater genetic diversity.

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