JOURNAL OF AGROBIOTECHNOLOGY 2023, VOL 14(2):58-70
e-ISSN: 2180-1983
http://dx.doi.org/10.37231/jab.2023.14.2.334
https://journal.unisza.edu.my/agrobiotechnology/index.php/agrobiotechnology/index

Fruit Set Capabilities and Yield Variability among Cucumber (*Cucumis sativus* L.) Germplasm Collections

Md. Amirul Alam[a*], Sarni Nani Marthen Karre[a] and M. M. Hasan[b]

[a]Faculty of Sustainable Agriculture, Horticulture and Landscaping Program, Universiti Malaysia Sabah, Sandakan Campus, Sandakan 90509, Sabah, Malaysia
[b]Plant Breeding Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh-2202, Bangladesh

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

Received: 17/05/2023, Accepted: 11/07/2023, Available Online: 26/10/2023

ABSTRACT

In cucumber (*Cucumis sativus* L.) male and female flowers' production rate is not the same in every variety, which is the main cause to create variation in fruit set. Though natural pollinators (honeybees and flies) are significant catalysts in fruit settings, but if genetically the female flower production rate is lower then we cannot expect more fruits from that plant. Knowing the female flower-bearing characteristics of selected cucumber plants is important otherwise cannot expect the desired yield from the plant. Considering the overall issues, a study was conducted for the evaluation of performance of five cucumber varieties namely, Timun Putih Besar (TPB), Timun Hijau Manis (THM), Timun Hijau Tanga (THT), Timun Susu Besar (TSB), and Timun Putih (TP). The study was carried out in Nethouse 7 at the Faculty of Sustainable Agriculture (FSA), Universiti Malaysia Sabah (UMS), Sandakan. Data on plant height (cm), numbers of leaves, days to first male and female flowering, total numbers of male and female flowers, fruit length (cm), fruit diameter (cm), fruit weight (g), total numbers of fruits per plant, total yield (kg), and leaf chlorophyll content were collected and analysed. The result showed that there were significant differences ($p<0.05$) among the varieties for days to first male and female flowering, total numbers of female flowers, fruit length (cm), fruit diameter (cm), fruit weight (g), total number of fruits per plant, total yield (kg) and chlorophyll content, respectively. Overall, Timun Hijau Manis (THM) significantly ($p<0.05$) exhibited the best performance for days to first female flowering (25.50 days), total numbers of female flowers (21.50), total number of fruits per plant (5.75), and total yield (1.99 kg) compared to other 4 varieties. Therefore, THM variety is highly recommended to farmers for the overall performances and yield followed by TBP, THT, TSB and TP cucumber varieties, respectively.

Keywords: Cucumber, *Cucumis sativus*, fruit setting, yield variability, germplasm

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is a freshly consumed fruit vegetables belongs to the Cucurbitaceae family. Other commonly consumed vegetables which belong to this family includes melon, squash, watermelon, and pumpkins (Abdulhammed and Owoeye, 2014). It comprises 70 genera and 750 species and is cultivated in warmer parts of the world (Nagamani *et al.*, 2019). *Cucumis sativus* was first found at the Himalayan foothills of Nepal.

Cucumber cultivation goes back at least 3000 years in India and 2000 years in China (Robinson and Walters, 2006). The cucumber plant is extremely variable both vegetative and in fruit characters. The plant has large, prickly, hairy triangular leaves that form a canopy over the fruit and yellow flowers which are mostly either male or female. The female flowers are recognized by the swollen ovary at the base, which will become the edible fruit (Haifa-group.com, 2021).

Cucumis sativus has several varieties, but the edible cucumber is classified under two groups: slicing and pickling cucumber. The slicing cucumbers are longer and thinner when compared to the pickling cucumber (Eifediyi and Ramison, 2010). Planting cucumber is usually done on a hill, rows or raised. Harvesting of the cucumber usually takes 50 to 70 days from planting and 3 to 4 months after seeding (Abbey *et al*., 2017). During the past few years, hybrid cucumber was intensively grown in different areas of the country, but the critical problem is low yield due to unfavourable soil properties, soil-borne diseases, and successive cropping methods (Mihaljlovic *et al.,* 2017). In addition, vegetable farming adversely affects cucumber production, especially in a greenhouse (Lee, 1994). Therefore, to overcome these problems, crop rotation is the most effective way to remediate such issues by avoiding cucumber cultivation in the same field for at least five years. Some factors that cause low cucumber yield in the zone are lack of appropriate cultural practices and non-accessibility of varieties well suited for its agro-climatic condition (Ekwu *et al*., 2007). In addition, because of the differences in yield potential of different ecological zones, testing of new crop varieties across the country becomes an established practice in plant breeding (Iken and Anusa, 2004). Varietal differences affect or determine the growth and yield of crops. The growth characters of crops such as plant height, vine length, leaf area, number of leaves or branches, and fruit production were influenced by genetic factors of the different varieties (Sajjan *et al*., 2002).

Several types of research have been conducted on varietal performance and genetic diversity of cucumber varieties and majorities are from outside of Malaysia (Lee *et al*., 2020; Chakraborty *et al*., 2019; Panyanitikoon *et al*., 2018; Kathayat *et al*., 2018). But no research on the observation of fruit set capabilities among different varieties of cucumber. As cucumber is a monoecious crop, male and female flowers are different but in the same plant at different positions. Naturally, they are cross-pollinated, and the pollination depends on honey bees or other flies or someone has to do it manually. Normally numbers of male flowers are higher compared to females but genetically some varieties produce huge numbers of female flowers or sometimes produce 100% (or nearly 100%) female flowers which are known as gynoesious varieties. This gynoecious variety is very expected to have 100% fruit set from every female flower. None of the cucumber varieties in this study is known as gynoecious variety but from the findings at the end we were able to categorize all those 5 cucumber varieties based on morpho-physiological and yield performances regarding the variety which produced the highest numbers of female flowers and the highest numbers of fruits as well, through which the growers will be highly benefitted to select that variety for profitable commercial production.

MATERIALS AND METHODS

Study location and period

This study was conducted from the month of June to December 2021 at the Faculty of Sustainable Agriculture (FSA), Sandakan Campus, University Malaysia Sabah with a latitude of 5.93° N, and a longitude of 118.01 °E. The experiment was carried out into the Net house no. 7.

Media Preparation and planting

Peat moss was used for sowing seeds because it is good for seed germination. It also holds nutrients that the plant needs and can hold moisture longer (Azmi and Barakat, 2007). Soil mixture used for transplanting which is topsoil, organic matter, and sand with a ratio of 3:2:1. These media were mixed well and filled up in polybags of 16 x 16 cm^2. Five (5) different varieties of cucumber seeds were bought from locally well-known sellers Hien Huat Seeds (Sabah) Sdn. Bhd. (Fig. 1). These varieties are commonly used by farmers for commercialization. The seeds were soaked into water for six hours before sowing seeds to break the storage dormancy which allows

them to germinate faster (Sabongari and Aliero, 2004). After that, the peat moss was filled into the seed tray and moistened with water. Then one to two seeds were sown into each hole for 1 cm depth. After three to five days, the new leaves emerged. True leaves came out after three to four weeks. Then, the seedlings were transplanted into the polybags of 16 x 16 cm^2 with the depth of 6 cm into the prepared media described in media preparation above and arranged in completely randomized design (CRD) with four replications.

Fig. 1. Cucumber varieties and seeds that were used in this study

Crop Management Practices

At the germination stage, watering was done manually two times a day by using a sprayer. Then, watering plants that have been transferred to polybags was done manually two times a day. The volume of water given per day was 500 millilitres until the plant reached day fourteenth. Starting on day fifteenth, the volume of water was increased to 1 liter. Fertilizers were applied every two weeks using NPK blue (12:12:17) with 30mg into each polybag and mixed uniformly with the media. Cucumber is a heavy feeder so the additional application should be made every two weeks with the onset of harvest. All types of weeds were removed manually as and when noticed.

Pest and Disease Management in Cucumber

In this study, checking the undersides of leaves was done manually. Among insect pests' aphids attack was recognized. Only disease infection that noticed was powdery mildew. The organic pesticide namely "organic wood vinegar" @ 2 millilitres of organic wood vinegar mixed with 1 litre of water was applied at 7 days intervals

to prevent the disease attack from getting worse. Huang (2009) opined that cucumber crops are highly susceptible to drought and pathogens, including powdery mildew and several mosaic viruses.

Data collection

Plant height (cm), numbers of leaves, days to first flowering, days to first male flowering, days to first female flowering, total numbers of male flowers, total numbers of female flowers, fruit length (cm), fruit diameter (cm), fruit weight (kg), total number of fruits per plant, total yield (kg) and chlorophyll contents were measured. Measuring tape was used to measure the height of main stem from root collar until its top shoot, while fruit length was measured from the upper point (stalk) to the lower point (flower bud part) and fruit diameter was measured at the centre of the cucumber fruit. Fruit weight (g) was measured by using digital scales and total number of fruits per plant was counted according to the fruits that have been harvested per polybag. The total yield (kg) was the total weight of the fruits that have been harvested for each variety. Days to the first male and female flowers were counted as soon as the blooming observed and determined by counting the days from the day of transplanting. Female flowers were identified from the visible ovary and stigma. Total numbers of male and female flowers were recorded daily once plants began flowering because cucumber flowers opened in the morning and wither the following morning, daily counts were strongly indicative of male and female flowers production.

Numbers of leaves were calculated manually starting from lower part of the plant and branches to the upper part of plant. Laboratory digital balance was used to measure the weight of the fruit. Data collections were repeated four times from every plant of four replications and the final data was produced from the average. As physiological parameter total chlorophyll content was recorded at full maturity of the cucumber plants. SPAD meter was used to measure the total chlorophyll content and the data were record with unit of SPAD meter index ($nmol/cm^2$). Data collection was repeated four times from every plant of four replications and the final data was produced from the average.

Statistical Analysis

Recorded data were subjected to analysis by using the one-way analysis of variance (ANOVA) using Statistical Package for the Social Sciences (SPSS-22) software. The Least Significant Difference (LSD) test at 0.05 level of probability was used to compare between means of different varieties.

RESULTS

Plant Height

The one-way ANOVA exhibited non-significant ($p=0.409>0.05$) differences for plant height among cucumber varieties (Table 1a). However, the cucumber variety TP showed the highest plant height (214.5 cm), followed by TPB (197 cm), and TSB (189 cm), while the lowest was recorded in THT (187.25 cm), respectively (Table 1a).

Numbers of Leaves

Analysis results revealed that cucumber variety TP produced the maximum numbers of leaves (44.50), followed by TSB (43.5), TPB (38.50), and THT (34.5), while the minimum numbers of leaves (32.25), was produced by the variety THM, respectively (Table 1a). But those data were statistically non-significant ($p=0.053>0.05$).

Days to first male flowering and total numbers of male flowers

Based on results presented in Table 1a, the variety THM was the earliest (4.25 days) to produce male flowers over others followed by THT (10.75 days), TP (14 days), TPB (14.50 days), and TSB (15.25 days) respectively.

Data analysed using one-way ANOVA showed significant differences ($p=0.004<0.05$) for the days to first male flowering among different cucumber varieties. On the other hand, for the total numbers of male flower production a non-significant variation ($n=0.504>0.05$) was observed among different cucumber varieties (Table 1a). However, the variety TP produced the highest numbers of male flowers (55.89% higher over the lowest), followed by TSB (20.36% higher over the lowest), TPB (18.93% higher over the lowest), and THM (12.50% higher over the lowest) respectively, while THT produced the minimum numbers of male flowers (140.00).

Table 1(a). Growth and morphological attributes of different cucumber varieties

Variety	Plant height	Numbers of leaves	Days to first male flowers	Numbers of male flowers
TPB	197.0±1.08	38.5±4.13	14.5 ± 1.66^{ab}	166.5 ± 26.5^{b}
THM	173.25±4.8	32.25±1.88	4.25 ± 1.25^{c}	157.5 ± 44.57^{bc}
THT	187.25±13.8	34.5±4.17	10.75 ± 2.84^{b}	140 ± 24.04^{c}
TSB	189.0±20.18	43.5±2.53	15.25 ± 1.89^{a}	168.5 ± 19.08^{b}
TP	214.5±21.3	44.5±2.02	14 ± 0.91^{ab}	218.25 ± 35.28^{a}

Note, here mean values with standard error (±SE) differ significantly according to Least Significant Difference (LSD) test at 0.05 level of probability.

Days to first female flowering and total numbers of female flowers

Highly significant ($p=0.001<0.05$) differences were observed for days to first female flower production among varied cucumber varieties (Table 1b). The variety THM was the earliest (14 days) to produce female flowers followed by THT (25.50 days), TP (30.25 days) and TPB (38.75 days), respectively, while TSB was the most late (39.50 days) variety to produce female flower (Table 1b). Furthermore, the variety THM significantly ($p=0.001<0.05$) produced the highest numbers of female flowers (290.91% higher over the lowest), followed by THT (127.27% higher over the lowest) and TP (63.64% higher over the lowest), while non-significant variations was observed in between TPB (9.09% higher over the lowest) and TSB (5.50), respectively for the total female flower production (Table 1b).

Fruit Length (cm) and diameter (cm)

Analysis results revealed that the variety THM significantly ($p=0.001<0.05$) produced the longest (35.60 cm) fruit compared to other varieties and followed by TPB (26.93 cm), TP (24.13 cm), THT (22.43 cm), and TSB (22.25 cm), respectively (Table 1b; Fig. 2). On the other hand, based on statistical analysis significantly ($p=0.001<0.05$) the maximum (3.29 cm) fruit diameter was recorded in variety TPB, followed by TSB (3.20 cm), TP (3.13 cm) and THT (2.83 cm), while the minimum diameter (2.38 cm) was seen in the variety THM, respectively (Table 1b, Fig. 2).

Individual fruit weight (g)

Based on the results presented in Table 1b, the variety TPB produced the maximum individual fruit weight (63.23% higher over the lowest), followed by TP (43.33% higher over the lowest), TSB (34.35% higher over the lowest), and THM (12.41% higher over the lowest), while the minimum weight was measured in THT (320.25g). Data analysed using one-way ANOVA showed a significant difference ($p=0.005<0.05$) for the fruit weight of *Cucumis sativus*. (Table 1b).

Table 1(b). Growth and morphological attributes of different cucumber varieties

Variety	Days to first female flowers	Numbers of female flowers	Fruit length (cm)	Fruit diameter (cm)	Fruit Wt. (g)
TPB	38.75±3.96^{a}	6±2.43^{d}	26.93±0.42^{ab}	3.29±0.15^{a}	522.75±19.69^{a}
THM	14±0.58^{d}	21.5±2.90^{a}	35.6±0.48^{a}	2.38±0.11^{b}	360±22.39b^{c}
THT	25.5±4.99^{c}	12.5±2.18^{b}	22.43±1.52^{c}	2.83±0.19^{b}	320.25±62.48^{c}
TSB	39.5±2.59^{a}	5.5±1.26^{d}	22.25±0.85^{c}	3.20±0.13^{a}	430.25±19.78^{b}
TP	30.25±2.64^{b}	9±1.47^{c}	24.13±0.55^{b}	3.13±0.09^{a}	459±20.32^{b}

Note, here mean with Standard error values (±SE) differ significantly according to Least Significant Difference (LSD) test at 0.05 level of probability. The same alphabet indicates no significant mean difference

Fig. 2. (A) Timun Putih Besar; (B) Timun Hijau Manis; (C) Timun Hijau Tanga; (D) Timun Susu Besar; (E) Timun Putih.

Total numbers of fruits per plant

Statistically significant variations ($p=0.001<0.05$) was observed for the total numbers of fruits among different cucumber varieties (Fig. 3). The variety THM produced the highest numbers of fruits per plant (5.75) as compared to other varieties followed by THT (1.75), TP (1.5), TPB (1.5), and TSB variety (1.0), respectively (Fig. 3).

.

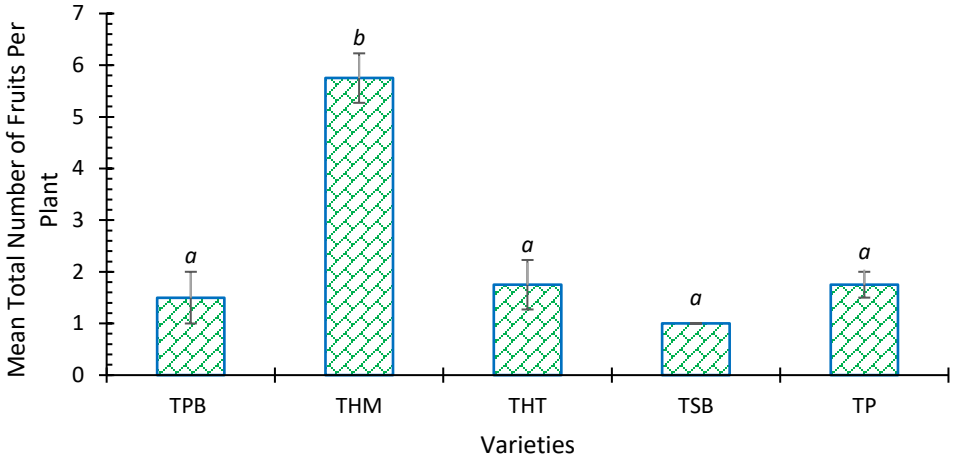

Fig. 3. Mean total numbers (with standard error bars) of fruits per plant of five different varieties of cucumber. The same alphabet indicates no significant mean difference

Fruit Yield (Kg)

Based on the Fig. 4, significantly ($p=0.001<0.05$) the highest total fruit yield was measured in THM (1.99 kg), compared to other varieties followed by TP (0.82 kg), TPB (0.80 kg), and THT (0.62 kg), while the variety TSB produced the lowest fruit yield (0.43 kg), respectively (Fig. 4).

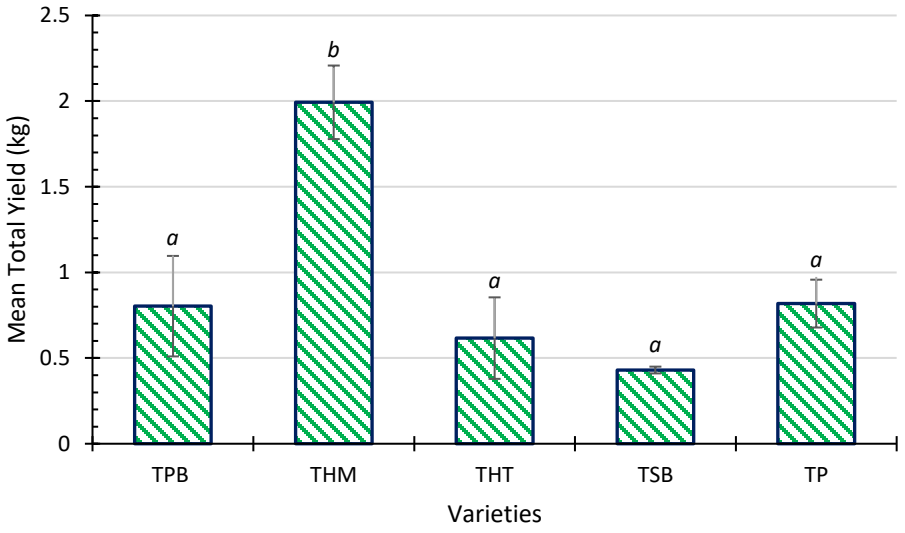

Fig. 4. Mean total yield (kg, with standard error bars) of five different varieties of cucumber. The same alphabet indicates no significant mean difference.

Total chlorophyll content

The data were recorded at three different stages which are 15 days after transplanting, at flowering, and at fruiting. The one-way ANOVA showed a significant difference ($p=0.006<0.05$) for total chlorophyll content only at day 15 after transplanting (Fig. 5). Meanwhile, at flowering and fruiting stages showed nonsignificant differences among cucumber varieties. However, at 15 days after transplanting the highest chlorophyll content was observed in the variety TPB (54.48 nmol/cm^2) compared to other varieties followed by THM (49.38

nmol/cm^2), THT (43.7 nmol/cm^2), TSB (47.23 nmol/cm^2) and the lowest total chlorophyll content was measured in TP (48.8 nmol/cm^2), respectively (Fig. 5).

At the flowering stage, the highest chlorophyll content was recorded in the variety TPB (57.43 nmol/cm^2), followed by TSB (52.68 nmol/cm^2), THM (52.65 nmol/cm^2), TP variety (51.68 nmol/cm^2) and lowest was found in THT (48.76 nmol/cm^2), respectively. Furthermore, at the fruiting stage the highest total chlorophyll content was determined in the variety TPB (55.65 nmol/cm^2), followed by THM (50.85 nmol/cm^2), THT (47.3 nmol/cm^2), TSB (51.7 nmol/cm^2), and the lowest was recorded in the variety TP (50.73 nmol/cm^2), respectively (Fig. 5).

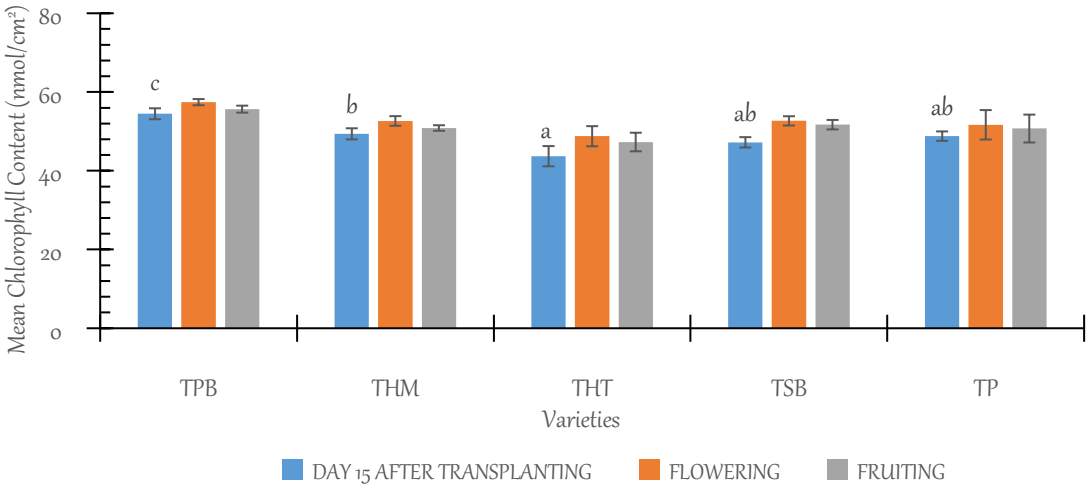

Fig. 5. Mean chlorophyll content (with standard error bars) for five different varieties of cucumber. The same alphabet indicates no significant mean difference.

DISCUSSION

Plant Height

The vine length in cucumber crops is generally a major growth trait and different cultivars can grow variably and their growth can be affected by environmental factors and the ability in nutrient absorption as well. From the results presented in Table 1(a), the maximum plant height was recorded in the variety TP which is about 55.89% increased plant height over the minimum plant height found in THM but this variation was statistically non-significant (Table 1a.). Thereby Majambu *et al.* (1996), reported that the growth characters of crops such as plant height, numbers of leaves, and fruit yields are controlled by genetic factors of different varieties. The results were also similar to the finding of Ibrahim *et al.* (2000), who reported that the differences in growth indices of the crops were normally influenced by their genetic constitution. The genetic nature of a cultivar enables it to adapt to the given climatic condition.

Number of Leaves

Similar with plant height non-significant differences were also observed among cucumber varieties for the total numbers of leaves (Table 1a). However, about 27.53% more leaves were counted in the variety TP (44.5±2.02) compared to the lowest numbers of leaf producers (THM; 32.25±1.88). Generally, the more is the vine length the greater will be the leaf numbers. It might be due to cucumber varieties or because of environmental changes. A similar difference in the distribution of the numbers of leaves was also stated by Ray and Sinclair (1997) in various cucumber varieties. This finding is also in harmony with the result of Baker and Reddy (2001) who reported that the temperature greatly influences the leaf appearance rate.

Flowering behavior

Based on the results presented in Table 1a and 1b, a highly significant differences were recorded for both the days to first male and female flowering. The variety THM took the shortest time which was only 4 days and about 73.13% early days over the variety TSB which took the longest days to produce first male flowers. Furthermore, the variety THM also took the shortest days; only 14 days to produce female flowers, which was about 64.56% early days compared to the longest days variety (TSB). It can be noted that the THM variety possesses the earliest flowering character or trait which is desired for the early maturity and marketing of the cucumber crop. According to Veena *et al.* (2012), the days to the first male and female flowering were controlled by the additive gene action. Therefore, the days taken to the first male and female flowering were not the same among the cucumber varieties.

Data were taken every morning because by that time the flowers are bloomed and only counted the number of open male and female flowers. The cucumber flowers started to open at 8 a.m. and by 11 a.m. usually, all of the cucumber flowers had opened. The flowers lasted for between one and three days before withering (Solange *et al.*, 2008). Statistically non-significant variation was observed for total numbers of male flowers production among different cucumber varieties with 35.85% more male flowers in TP compared to the lowest male flower producers in THT (Table 1a). On the other hand, a highly significant variations were recorded for total numbers of female flower production with the highest in THM which is 74.42% increased numbers compared to the minimum numbers of female flower production in the variety TSB (Table 1b).

Theoretically, the five different varieties of cucumbers were produced the highest numbers of male flowers than the female flowers based on the evidence from Table (1a) and Table (1b) and this will lead to a decrease in cucumber production. However, a perusal of (Fruit yield) showed that the THM variety had the potential to produce a high yield. The result was similar to the finding of Ahmed *et al.* (2004), who reported that the proportion of male and female flowers affects the yield. The higher female flowers will set more fruits resulting in higher yields. In terms of the higher production of male flowers compared to female flowers probably due to the ambient temperature which induces the production of male flowers because the daily average temperature was above 25°C. Therefore, the combination of high temperature and longer photoperiod might decrease the rate of the female flowers. This is in line with the results of Meng and Li (2003) who stated that when the environmental temperature exceeds 31°C it will affect the physiological functions of cucumber plants and affect the inflorescence of male and female flowers that is high temperature will encourage more male flowers than female flowers. In addition, Sudhakar and Choudhary (2020) who found that the environmental factor plays a significant influence on sex expression in cucumbers which indicates high temperatures encourage more male flowers production. Meanwhile, low temperature promotes more female flowers.

Fruit growth and yield

Significant differences were recorded for cucumber fruit length and fruit diameter among different varieties. In this study, the THM variety had the longest fruit length (35.6 cm), which is about 60.0% longer than the shortest fruit produced by the variety TSB (Table 1b; Figure 2). In addition, the maximum fruit diameter was observed in the variety TPB, which is about 27.66% increased diameter compared to the minimum fruit diameter produced by the variety THM (Table 1b; Figure 2). Fruit length and fruit diameter were important parameters which affect the total yield of cucumbers. According to Zhu *et al.* (1993), the different fruit sizes are due to their own genetic characteristics.

Fruit weight was affected by the water contained in the fruit and the fruit size as well. Whereas it is important for the fruit yield and market value. For this study, the highest fruit weight was obtained in the variety TPB, which is about 38.74% more compared to the lowest fruit weight produced by the variety TSB (Table 1b). The reason was that the variety TPB had the largest fruit diameter and the ideal fruit length. The lowest fruit weight was observed in the THT variety because that variety had the smallest fruit length and diameter which

was not ideal for the commercial production. It can cause a lower yield. The minimum fruit weight could be related to the water and nutrient uptake of the variety. This finding is in line with the result of Waseem *et al.* (2008) who found the contribution of nutrition and water uptake on fruit weight.

THM variety had the highest fruit set compared to other varieties. This is because the THM variety was the first variety to produce female flowers which are indicated in Table 1(b). Additionally, the THM variety also was the largest producer of female flowers compared to other varieties. Therefore, the THM variety had the potential to produce more fruit sets. Lopez-Sese and Staub (2002) found that the number of fruits was under the genetic control of both additive and dominant gene actions. Besides, the reason to other varieties produced fewer fruits than the THM variety is that they took the longest days to produce the female flowers because of sex expression or environmental factors. The result was similar to the finding of Wang *et al.* (2011) who reported that the strengthening of global warming and climate change is often subjected to high-temperature stress levels and the factor that inhibit the production of cucumber plants.

In terms of yield, it is evident from the Figure 4 that the THM variety produced the highest yield among the varieties, which was 78.42% higher compared to the lowest yield produced by the variety TSB (Figure 4). THM variety had the minimum fruit diameter, in spite of that the THM variety had the maximum fruit length that makes it the highest fruit yield and also the highest fruit producer among varieties. The variety TPB, TP, and TSB had the potential to gain a higher yield because they had quite a large fruit diameter. Unfortunately, late and lower production of female flowers leads to lower yield production. TSB variety had the lowest yield production due to the minimum fruit length and diameter. Therefore, the highest numbers of fruits per plant will be increasing the fruit yield. Clark *et al.* (1997), attributed that the differences in yield and its components among crop genotypes due to the variations in genetic structure, mineral concentration, and potential to transport photosynthetic materials within plants. Also, can be related to the previous finding of Abusaleha and Dutta (1988) found that the component characters influence the expression of yield.

Total Chlorophyll Content

The results showed a significant difference in chlorophyll content on day 15 after transplant ($p<0.05$). Meanwhile, the flowering and fruiting stages showed non-significant differences. Based on the result presented in Figure 5, the chlorophyll content was increased from day 15 after transplant until the flowering stage. Nevertheless, the chlorophyll content was decreased at the fruiting stage. The reason for the lower chlorophyll content in the leaf is one of the obvious signs which the leaves' senescence. When the senescence begins to occur in the leaves, the appearance of a yellowish color on the older leaves indicated that the crops are starting to terminate their growth and enter the next phase. The result was similar to the finding of Yurkovskii *et al.* (1977), the chlorophyll content in leaf tissue varies with the age and species of the plant. Moreover, the cucumber's leaves were infected by the powdery mildew and attacked by aphids. Based on the previous finding of Pavlovic *et al.* (2014), stated that the decrease in chlorophyll content is not only due to leaf senescence but also indicates the health of the plant.

Generally, the different varieties could have different leaf nutrient status even all the varieties got the same amount of fertilizer. The result was similar to the similar finding of Bojovic and Markovic (2009) who reported that several varieties were given the same amount of fertilizer, but the varieties showed different chlorophyll content in the leaf tissue. In addition, the decreasing of chlorophyll content is also related to the ability of nutrient absorption by the crops. Chikov (2017), reported that photosynthesis is not only related to the leaf photosynthesis pigments but also related to many other factors such as nutrient absorption and storage capacity for the nutrient and photosynthetic that are contained in the leaf.

CONCLUSION

From the overall findings it can be concluded that the variety THM has shown the best performance compared to the variety TBP, THT, TSB, and TP, especially in terms of yield production. It has been proven by the result

that the variety THM has taken the shortest time to produce female flowers and was the best producer of female flowers that indicating the production of the highest yield. However, the variety TPB, TP, and TSB also had the potential in producing a higher yield because it produced better weight and fruit diameter for each fruit as well. However, the weaknesses noted for those 3 varieties; TPB, TP, and TSB were they had taken the longest days to produce female flowers than the variety THM, also with lower numbers of female flower production. Moreover, as the crop yield grows, the return profit will be increased. Therefore, the findings from this study will be helpful for commercial growers as well as local farmers to make the best choice in the selection of cucumber variety. Besides, it is known that the market price for the THM variety was higher than the other varieties. So, it is better if farmers grow this variety for the high yield and also for high profit.

ACKNOWLEDGMENTS

The authors sincerely acknowledge to Faculty of Sustainable Agriculture, Universiti Malaysia Sabah (UMS), Sandakan Campus for the entire facilities and support to conduct this experiment and initiatives to publish the research findings.

REFERENCES

Abbey, Nwachoko, & Ikiroma (2017). Nutritional Value of Cucumber Cultivated in Three Selected States of Nigeria. *Biochemistry and Analytical Biochemistry, 6*, 1-3.

Abdulhammed, M., & Owoeye, G. (2014). Characterization of Gourd Fruit (Cucurbitaceae) for Dietary Values and Anti-Nutrition Constituent. *Journal of Pharmaceutical and Biological Science, 6*, 7575-7585.

Abusaleha, & Dutta, O. (1988). Interrelationship of Yield Components in Cucumber. *Journal of Vegetation Science, 15(1),* 79-85.

Ahmed, M., Hamid, A., & Akbar, Z. (2004). Growth and Yield Performance of Six Cucumber (*Cucumis sativus* L.) Cultivars under Agro-Climatic Conditions of Rawalakot, Azad Jammu and Kashmi. *International Journal of Agriculture and Biology, 6(2),* 396-399.

Azmi, A. A., & Barakat, E. A. (2007). Organic Germination Media for Vegetables Seeds. *Jordan Journal of Agriculture Sciences, 3(4)*, 429-438.

Baker, J. T., & Reddy, V. R. (2001). Temperature effects on Phonological Development and Yield of Muskmelon. *Annals of Botany, 87,* 605-613.

Bojovic, B., & Markovic, A. (2009). Correlation between Nitrogen and Chlorophyll Content in Wheat (*Triticum aestivum* L.)," Kragujevac *Journal of Science*, *31*, 69-74.

Chakraborty, D., Kumar, K., Wangchu, L., Singh, S., & Pandey, A. K. (2019). Genetic Diversity Among Landraces of Cucumber (*Cucumis sativus* L.) from North East India. *Bangladesh Journal of Botany, 48(3),* 481- 488.

Chikov, V. (2017). Regulation of Physiological and Biochemical Processes in an Intact Plant Is Determined by Interaction of Flows of Substance Bulk Transfer. *Journal of Plant Sciences, 5,* 110-119.

Clark, R. B., Zeto, S. K., Baligar, V. C., & Ritchey, K. D. (1997). Growth Traits and Mineral Concentrations of Maize Hybrids Grown on Unlimed and Limed Acid Soil. *Journal of Plant Nutrition, 20(12)*, 1773-1795.

Eifediyi, & Ramison (2010). Growth and Yield of Cucumber (*Cucumis sativus* L.) as Influenced by Yard Farm Manure and Inorganic Fertilizer. *Journal of Plant Breeding Crop Science, 2,* 216-220.

Ekwu, Utobo, & Oyesola (2007). Vegetative and Yield Response of Cucumber (*Cucumis sativus* L.) To Staking and Nitrogen Fertilizer Application. *Journal of Applied Science, 19,* 7509-7519.

Haifa-group.com: Haifa Multi-National Corporation and a Global Leading Supplier of Specialty Plant Nutrition. n.d. Crop Guide: Cucumber. Retrieved on 9 May 2021 at https://www.haifa-group.com/cucumber-0/crop-guide-cucumber**.**

Huang, S. (2009). The Genome of The Cucumber, *Cucumis sativus* L. *Nature Genetics, 41,* 1275-1280.

Ibrahim, K., Amans, A., & Abubakar, I. U. (2000). Growth Indices and Yield of Tomato (*Lycopesicon esculentum*) Varieties as Influenced by Crop Spacing at Samaru. *Proceeding of the 18th HORTSON Conference Proceeding, 1*, 40-47.

Iken, J. E., & Anusa, A. (2004). Maize Research and Production in Nigeria. *African Journal Biotechnology*, *3(6)*, 302-307.

Kathayat, K., Rawat, M., Kandpal, G., Pandey, G., Chauhan, P. and Tiwari, R. 2018. Genetic Variability in Cucumber (*Cucumis sativus* L.): A review. *Plant Archives, 18(2)*, 1223-1228.

Lee, H. Y., Kim, J. G., Kang, B. C., & Song, K. (2020). Assessment of the Genetic Diversity of the Breeding Lines and a Genome Wide Association Study of Three Horticultural Traits Using Worldwide Cucumber (*Cucumis* spp.) Germplasm Collection. *Agronomy, 10(11)*, 1736.

Lee, J. M. (1994). Cultivation of Grafted Vegetables: Current status grafting methods and benefits. *Horticultural Science, 29*, 235-239.

Lopez-Sese, A. I., & Staub, J. (2002). Combining Ability Analysis of Yield Components in Cucumber. *Journal of the American Society for Horticultural Science, 127(6)*, 931-937.

Majambu, I. S., Ogunlella, V. B., & Ahmed, M. K. (1996). Responses of Two Okra (*Abelmoschus esculentus* L.) Varieties to Fertilizer Growth and Nutrient Concentration as Influenced by Nitrogen and Phosphorus Applications. *Fertilizer Research, 8(3)*, 297-306.

Meng, L. B., & Li, S. M. (2003). On the Influence of High Temperature on Cucumber's Physical and Chemical Development. *Journal of Harbin University, 24*, 121-125.

Mihaljlovic, M., Rekanovic, E., & Tanovic, B. (2017). Methods for Management of Soilborne Plant Pathogens. *Pesticides and Phytomedicine, 32*, 9-24.

Nagamani, G. V., Kumar, J. S. A., Reddy, T. B. M., & Rajesh, A. M. (2019). Performance of different parthenocarpy cucumber (*Cucumis sativus* L.) hybrids for yield and yield attributing traits under shade net house. *International Journal of Current Microbiology and Applied Sciences, 8(3)*, 978-982.

Panyanitikoon, H., Khanobdee, C., Jantasuriyarat, C., & Samipak, S. 2018. Genetic Variation in Cucumber (*Cucumis sativus* L.) Germplasm Assessed Using Random Amplified Polymorphic DNA Markers. *Agriculture and Natural Resources, 52*, 497-502.

Pavlovic, D., Nicolic, B., Durovic, S., Waisi, H., & Andelkovic, A. (2014). Chlorophyll as a Measure of Plant Health: Agronomic Aspects. *Journal of Pesticides and Phytomedicine, 29(1)*, 21-34.

Ray, J. D., & Sinclair, T. R. (1997). Stomatal Closure of Maize Hybrid in Response to Drying Soil. *Crop Science, 37(30)***,** 803-807.

Robinson, R. W., & Decker, W. D. S. (1997). Cucurbits. *Crop Production Science in Horticulture Series*; Pp 226.

Sabongari, S., & Aliero, B. L. (2004). Effects of Duration on Germination and Seedling Growth of Tomato (*Lycopersicum esculentum* Mill). *African Journal of Biotechnology, 3(1),* 47-51.

Sajjan, A. S., Shekhargounda, M., & Badanur, I. (2002). Influence of Data of Sowing, Spacing, and Levels of Nitrogen on Yield Attributes and Seed Yield of Cucumber. *Journal Agriculture of Science, 15(2)*, 267- 274.

Solonge, A. B. S., Ana, C. R., & Luci, R. B. (2008). Pollination of Cucumber (*Cucumis sativus* L.), by the Stingless Bees and Lepeletier in Greenhouses. *Neotropical Entomology*, *37(5)*, 506-512.

Sudhakar, P., & Choudhary, B. R. (2020). Cucumber. *ICAR-Central Institute for Arid Horticulture, 3*, 121-149.

Veena, R., Sidhu, A. S., Pitchaimuthu, M., & Souravi, K. (2012). Genetic Evaluation of Cucumber (*Cucumis sativus* L.) Genotypes for some Yield and Yield-related Traits. *Journal of Plant Breeding, 3*, 945-948.

Waseem, K., Kamran, Q. M., & Jilani, M. S. (2008). Effect of Different Levels of Nitrogen on the Growth and Yield of Cucumber (*Cucumis sativus* L.). *Journal of Agricultural Research, 46,* 259-266.

Yurkovskii, A. K., Bramane, A. E., & Yurkovska, V. A. (1977). A Cycle of Variations of Phytoplankton Pigments and Bacterioplankton in the Baltic Sea. *Okenologiya, 16*, 830-838.

Zhu, J., Ji, D. F., & Xu, F. H. (1993). A Genetic Approach for Analyzing Intra-cultivar Heterosis in Crops. *Journal of Acta Genetica Sinica, 20(3)*, 262-271.

How to cite this paper:
Alam, M.A., Karre, S.N.M, & Hasan, M.M. (2023). Fruit setting capabilities and yield variability among cucumber (*Cucumis sativus* L.) germplasm collections. Journal of Agrobiotechnology, *14*(2), 58-70.