INTRODUCTION

The efforts to increase sugar production can be performed by increasing the production of the main sugar raw material, namely sugar cane. One of the efforts carried out is by utilizing marginal land that can potentially be used as cultivation land such as inundated land or tidal land. The flooding land conditions caused trouble to the growth and productivity of plants (Pezeshki & DeLaune, 2012). In the case, it is needed excellent varieties which have tolerance to inundation.

Mutation is one way to create tolerant sugarcane varieties that can be planted in inundated land. It is expected to produce genetic diversity and produce a mutagen genotype that has resistance to inundation. The morphological diversity of mutants is a result of genetic diversity expression. Identification of genetic diversity from mutants can be identified using RAPD (Random Amplified Polymerase DNA) molecular markers. Some researchers have tested genetic diversity of mutants by molecular method markers on some plants including rice plants (Tripathy et al., 2016), Jatropha curcas (Dhakshanamoorthy, Selvaraj, & Chidambaram, 2015), Zea mays (Erturk, Nardemir, Hilal, Arslan, & Agar, 2015), Banana (Nettyani, Miftahudin, & Sobir, 2016), Desmodium gangeticum (Linn.) DC (Cheruvathur, Abraham, & Thomas, 2013), and on Orchid plants Spathoglottis plicata Blume (Romeida, Sutjahjo, Purwito, Sukma, & Rustikawati, 2012).

Sugar cane mutants resistant to inundation are needed to overcome the problem of sugarcane cultivation in flooded land. In this study, sugarcane planting material used is sugar cane which has been given mutation treatment with EMS chemicals and has been tested for its tolerance to inundation at the plantlet level. EMS (Ethyl Methane Sulphonate) is the most common chemical mutation material.
used as a chemical mutagen. EMS causes guanine to be changed with thymine instead of cyanin, so the transition that occurs is G / C to - A / T (Talebi, Talebi, & Shahrokhifar, 2012).

The results of research on sugarcane mutants resistant to plantlet level inundation by Avivi, Sigit, Slameto & Rizki (2016) showed that PS 865 sugarcane mutants had the highest tolerance level compared to mutants PS863 and PS864 based on observations of plantlet height, number of shoots, number of leaves, number of roots, root length, and percentage live plantlet. Therefore, further research is needed on PS865 sugarcane mutants from in vitro studies to identify inundation stress responses in the greenhouse.

The sugarcane mutants need to be identified for their diversity of morphological characteristics and molecular characteristics with RAPD molecular markers in inundation conditions. The purpose of this study was to identify differences in morphological responses to inundation treatments of mutant plants, identify changes in sugarcane mutant tolerant genotypes with inundation with PCR-RAPD (Random Amplified Polymerase DNA) markers and choose inundated sugarcane mutants that produce high sucrose.

MATERIALS AND METHODS

The experiment was carried out at University of Jember from December 2015 to June 2016. The experimental materials consisted of polybags, sugarcane mutants from the PS865 variety which was given EMS treatment and had been tested in vitro prior to inundation, non-mutant PS865, timba, manure, sand, and soil. The experimental device consisted of a digital refractometer, Chlorophyll meter SPAD-502 Minolta, and equipment for sugarcane cultivation. DNA banding pattern analysis using a set of PCR and electrophoresis tools. Primers used to obtain RAPD molecular markers are OPA 19, OPC 19, OPE 02, OPF 04, OPN 11. This experiment used 21 sugarcane mutant genotypes and two non-mutant plants. The inundation treatment was carried out with a water level of 5 cm below the surface of the planting medium on the 1-17 mutants and non-mutants, while the inundation treatment was carried out on the 18-21 and non-mutant mutants.

This inundation treatment was carried out for 3 months and started when the plant was 3 months old. The tolerance characteristics of sugarcane plants were based on observational characters observed and consisted of plant height, number of segments, stem diameter, number of leaves, number of tillers, root volume (ml), fresh root weight, stem aerenkhim, chlorophyll content, brix and sucrose content. The molecular identification stages consisted of DNA isolation (tissue separation, lysis solving, genomic DNA binding, washing, DNA release), PCR amplification and electrophoresis. The PCR amplification stage consisted of initial denaturation at 94°C for 2 minutes followed by 40 amplification cycles, where each cycle begins with a temperature of 94°C for 15 seconds followed by annealing temperature (Ta) 36°C for 30 seconds and then 72°C for 1 minute. The final extension stage was carried out at 72°C for 10 minutes. The 7 µl PCR product was electrophoresed on 1.2 % agarose gel with a voltage of 100 volts. The distance measure of the genetic similarity of sugarcane plants was observed based on the similarity coefficient using the Unweight Pair Group Method Arithmetic (UPGMA) method.

RESULTS AND DISCUSSION

The effect of inundation treatment on 23 sugarcane plant genotypes based on morphological characters on the parameters of plant height, number of internodes, number of leaves, stem diameter, number of tillers, chlorophyll content, sucrose content of sugarcane juice and brix are presented in Table 1.

Based on Table 1, the mutant diversity occurs in all characters observed. If it is compared between plants treated with standing water and untreated inundation treatment, sugarcane mutant plants produced higher yields in submerged treatment on characters of plant height, number of leaves, number of segments, level of sucrose and brix. This shows that the inundation treatment of mutant plants has the potential to raise some production characters including the main character of sugar production which is shown in sucrose and brix content. The characteristic of mutant plants 1, mutants 3 and mutants 6 in inundation conditions showed plant resistance characteristics characterized by the character of plant height, number of internodes, number of leaves, sucrose content and brix value (%) which was better than non-inundated conditions. The percentage of sucrose and brix content in mutant plants is found in mutants 1, 3 and 6. Thus the three mutant plants have the potential to be tolerantly inundated and can produce high in inundated conditions.
In some characters, the sugarcane mutant produces a lower average value on stem diameter, number of tillers and leaf chlorophyll content after flooding treatment. The quantitative reduction in morphological characters is likely due to the influence of EMS chemical compounds in acting as active ingredients for mutations. Pratiwi, Pharmawati, & Astarini (2013) and Hakin & Arumingtyas (2014) stated that mutant plants originating from the treatment of chemical compounds showed a quantitative decrease in most observed morphological observations.

While the characteristics of non-mutant plants, in inundation conditions showed a decrease in stem diameter, number of tillers, chlorophyll content of leaves, sucrose and brix content. The inundation treatment resulted in the emergence of stem aerenchym and adventitious roots in mutant and non-mutant plants. Mickelbart, Hasegawa, & Bailey-Serres (2015) stated that tolerant plants in puddle conditions showed resistance characteristics characterized by faster growth as a avoidance mechanism and showed aerenchym appearance, whereas in intolerant plants showed stopping growth. The appearance of adventitious roots in puddle conditions causes the volume of stagnant roots to be greater compared to the treatment without puddles. (Fig. 1.)

Fig. 1 shows the conditions of flooding in mutant and non-mutant plants concerning the appearance of roots with volume and a greater amount than the roots of plants in conditions without flooding. The addition of root volume and number

| Treatment | Code | Height of plant (cm) | No. of leaves | No. of segments | Diameter of stems (cm) | No. of tillers | Chlorophyl (µmol/m²) | Sucrose contents (%) | Brix (%) |
|-----------|------|----------------------|---------------|-----------------|-----------------------|---------------|---------------------|---------------------|---------|
| Flooding  | mutant 1 | 309 | 12 | 10 | 1.5 | 5 | 340.3 | 19.6 | 18.2 |
|           | mutant 2 | 300 | 11 | 11 | 1.5 | 3 | 324.7 | 18.3 | 13.4 |
|           | mutant 3 | 314 | 12 | 8  | 1.8 | 4 | 345.1 | 19.7 | 18.2 |
|           | mutant 4 | 274 | 9  | 8  | 1.3 | 8 | 280.2 | 11.5 | 16.6 |
|           | mutant 5 | 318 | 11 | 10 | 1.6 | 5 | 315.6 | 13.5 | 15.4 |
|           | mutant 6 | 294 | 10 | 10 | 1.5 | 8 | 314  | 17.2 | 17.1 |
|           | mutant 7 | 267 | 10 | 8  | 1.4 | 4 | 348.3 | 10.4 | 12.8 |
|           | mutant 8 | 270 | 10 | 8  | 1.4 | 4 | 309.5 | 16.4 | 15.4 |
|           | mutant 9 | 304 | 10 | 9  | 1.6 | 4 | 309.5 | 11.7 | 15.5 |
|           | mutant 10 | 282 | 11 | 9  | 1.7 | 5 | 305  | 10.5 | 16.0 |
|           | mutant 11 | 276 | 10 | 9  | 1.6 | 6 | 302.1 | 16.4 | 14.0 |
|           | mutant 12 | 283 | 9  | 8  | 1.3 | 6 | 312.5 | 7.6  | 17.7 |
|           | mutant 13 | 301 | 11 | 9  | 1.9 | 4 | 290.3 | 14.9 | 17.2 |
|           | mutant 14 | 274 | 11 | 8  | 1.5 | 6 | 293.2 | 11.7 | 16.2 |
|           | mutant 15 | 283 | 10 | 8  | 1.8 | 4 | 288.8 | 14.6 | 13.7 |
|           | mutant 16 | 272 | 10 | 10 | 1.3 | 4 | 289.7 | 8.7  | 13.0 |
|           | mutant 17 | 231 | 11 | 11 | 1.8 | 3 | 298.2 | 8.4  | 13.1 |
|           | Mutant Average | 285.4 | 10.5 | 9.1 | 1.6 | 4.9 | 309.8 | 13.6 | 15.5 |
|           | Non mutant | 327 | 12 | 11 | 2.1 | 4 | 424.2 | 11.1 | 13.9 |
| Without flooding | mutant 18 | 230 | 10 | 8  | 1.8 | 8 | 368.6 | 8.9  | 10.6 |
|           | mutant 19 | 218 | 9  | 6  | 1.5 | 6 | 380.8 | 8.1  | 10.2 |
|           | mutant 20 | 290 | 11 | 9  | 1.7 | 6 | 410.1 | 13.2 | 10.4 |
|           | mutant 21 | 288 | 10 | 8  | 1.7 | 5 | 366.1 | 11.5 | 15.6 |
|           | Mutant Average | 256.5 | 10 | 7.8 | 1.7 | 6.3 | 381.4 | 10.4 | 11.7 |
|           | Non mutant | 315 | 13 | 11 | 1.9 | 6 | 494.6 | 18.1 | 14.9 |
of roots in higher inundation conditions showed an increase in the growth of adventitious roots and the resistance response of sugarcane plants to inundation conditions in both mutants and non-mutants. The results of volume and fresh weight of roots can be seen in Fig. 2.

Fig. 2 shows the highest fresh root weight was found in the combination of non-mutant and inundation treatment with 1150 cm³ and 1110 g respectively. Overall, the inundation condition results in a higher response to volume and fresh weight both mutants and non-mutants. The addition of volume and weight of the roots is likely due to adventitious root formation as a form of plant response to inundation conditions compared to conditions without flooding. The oxygen deprivation in inundation conditions allows the root plant to respond in the process of looking for oxygen, resulting in elongation and addition of root volume. Striker (2012) also states that adventitious roots that have high porosity will help the plant to continue uptake of water and minerals and oxygen in stagnant conditions, to replace the function of the main root system as a form of response to inundation stresses. The tolerant plants will be more resistant to inundation stresses when forming many aerenchymal tissues on adventitious roots (Bellini, Pacurar, & Perrone, 2014).
The inundation stress results in energy reduction due to the decreased of photosynthesis activity and oxygen availability, as well as storage and release of energy as a form of mechanism in dealing with inundation stresses. The character of tolerant sugarcane plants in the face of inundation stress is characterized by an increase in plant height, stem diameter, number of tillers, chlorophyll content, and brix value and appearance of aerenchym (Gomathi & Chandran, 2012; Gomathi, Gururaja Rao, Chandran, & Selvi, 2015; Morris & Tai, 2004; Tetsushi & Karim, 2007).

The characteristic analysis of genotype diversity with DNA markers began with taking fresh leaves from 23 sugarcane plants taken as much as 0.05 g for DNA isolation and then attaching five RAPD primers to the DNA template during PCR. The DNA isolation using mini KIT DNA and continued with PCR for the use of DNA template. Then the electrophoresis results were obtained. One of the PCR results with the OPN11 primer is presented in Fig. 3. The total DNA bands produced in electrophoresis were 37 DNA bands in all primers used. The results showed that DNA amplification in 23 sugarcane plants using 5 RAPD primers where four primers produced polymorphic bands. The results of the summary of the size and number of DNA bands of 23 sugarcane samples can be seen in Table 2.

Table 2 shows that this study obtained a RAPD band measuring 250 – 2000 base pairs. The number of DNA bands of sugarcane genotypes resulting from mutations and without mutations that were successfully amplified by each primer ranged from 3 bands to 11 bands or on average produced 7.4 bands per primer. The band polymorphism produced in this study was 72.9 % (27 bands) of the 37 total DNA bands obtained. The number of polymorphism bands that occur in this study is due to the influence of chemical mutations that occur in this study due to the influence of chemical mutations that occur so that the base structure changes from before. Talebi, Talebi, & Shahrokhifar (2012) added that the guanine base alkylated EMS chemical mutagen was alkylated with thymine instead of cyanine, resulting in a transition that occurred G/C to A/T.

| No. | Primer code’s | Sequent (5’–3’) DNA band | Polymorphic DNA band | Percentage polymorphisms | Size (bp) |
|-----|---------------|---------------------------|----------------------|----------------------------|-----------|
| 1.  | OPC 19        | GTTGCCAGCC                | 3                    | 0                          | 1000 – 2000 |
| 2.  | OPN 11        | TCGCCGGCAA                | 8                    | 6                          | 250 – 2000  |
| 3.  | OPA 19        | CAAACGTCGG                | 8                    | 3                          | 250 – 2000  |
| 4.  | OPE 02        | GGTGCGGGAA                | 11                   | 11                         | 250 – 1500  |
| 5.  | OPF 04        | GGTGATCAGG                | 7                    | 7                          | 250 – 1500  |
|     | Total         | 37                        | 27                   | 312.5                      |           |

Mean | 7.4 | 5.4 | 72.9
The molecular markers data function in determining the level of difference and similarity of each cultivar, in this case is used as a benchmark for genotype changes due to chemical mutations so that the higher kinship can be interpreted as the effect of lower mutations. The Fragments or ribbons of RAPD amplification are assumed to be one locus. The amplification results are scaled “1” if there is a ribbon and suspension “0” if there is no amplified tape. The similarity coefficient value of 23 sugarcane plant genotypes can be seen in Table 3.

The results of the similarity coefficient matrix of RAPD markers between 23 sugarcane plant genotypes were based on 37 amplified loci with a range of values ranging from 33.3 % to 97.1 % (Table 3). However, to see the level of genotype changes in mutant genotypes was done by comparing non-mutant genotypes, namely PS865G and PS865NG. The magnitude of the genotype changes that occur can be obtained from the magnitude of the similarity genotype (r) coefficient of mutant plants with both non-mutant plants, where the value of the change in genotype (t) is obtained from the calculation results (t = 1 - r * 100). The results of the genotype change analysis showed that the genotype changes with the non-mutant PS865NG comparison ranged from 15.6 % to 55.2 %, where the largest genotype change (55.2 %) occurred in mutants 1. The genotype changes by comparison with PS865G ranged from 14.7 % to 56.7 %, where the greatest genotype change also lies in mutants1. The results of the kinship program 23 cane genotypes based on RAPD can be seen in Fig. 4.

Hapsoro, Warganegara, Utomo, Sriyani, & Yusnita (2015), also used RAPD markers on some sugarcane genotypes from Australia, Africa, America and Asia, found genetic similarities ranging from 17-97 % with an average genetic similarity of around 57 %.

Fig. 4 shows the results of 23 sugarcane plant dendrograms based on DNA bands with the UPGMA method which produced 37 amplified loci. Twenty-three sugarcane plant genotypes can be grouped into four main groups. Group I consisted of one genotype (mutants 1), group II consisted of five genotypes (mutants 10, 16, 20, PS865G and PS865NG), group III consisted of two genotypes (mutants 5 and 18) and group IV consisted of fifteen genotypes (mutants 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 14, 15, 17, and 19). The closest kinship relationships of the plants tested were found between PS865 and PS865NG, mutants 10 and 20, mutants 5 and 18, mutants 11 and 12, mutants 4 and 6, mutants 13 and 21, mutants 14 and 15, mutants 3 and 19. Whereas the farthest relationship was found among mutants 1, 3, and 19.

Fig. 4. 23 dendrograms of sugarcane plant genotypes resulting from mutations and without mutations based on RAPD markers analyzed by UPGMA method.
Table 3. Similarity coefficients of sugarcane 23 genotypes based on 5 RAPD primers

|    | M1   | M2   | M3   | M4   | M5   | M6   | M7   | M8   | M9   | M10  | M11  | M12  | M13  | M14  | M15  | M16  | M17  | M18  | M19  | M20  | M21  | PS865G | PS865NG |
|----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|---------|
| M1 | 1.000|      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |         |
| M2 | 0.406| 1.000|      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |         |
| M3 | 0.394| 0.970| 1.000|      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |         |
| M4 | 0.433| 0.938| 0.909| 1.000|      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |         |
| M5 | 0.464| 0.818| 0.848| 0.839| 1.000|      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |         |
| M6 | 0.433| 0.938| 0.909| 0.935| 0.813| 1.000|      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |         |
| M7 | 0.464| 0.867| 0.794| 0.706| 0.611| 0.758| 1.000|      |      |      |      |      |      |      |      |      |      |      |      |      |       |         |
| M8 | 0.464| 0.875| 0.848| 0.933| 0.867| 0.933| 0.697| 1.000|      |      |      |      |      |      |      |      |      |      |      |      |       |         |
| M9 | 0.371| 0.889| 0.889| 0.806| 0.800| 0.857| 0.800| 0.800| 1.000|      |      |      |      |      |      |      |      |      |      |      |       |         |
| M10| 0.565| 0.719| 0.697| 0.767| 0.700| 0.767| 0.545| 0.821| 0.657| 1.000|      |      |      |      |      |      |      |      |      |      |       |         |
| M11| 0.324| 0.806| 0.857| 0.771| 0.765| 0.824| 0.765| 0.765| 0.914| 0.618| 1.000|      |      |      |      |      |      |      |      |      |       |         |
| M12| 0.333| 0.800| 0.829| 0.794| 0.788| 0.794| 0.735| 0.788| 0.886| 0.636| 0.969| 1.000|      |      |      |      |      |      |      |      |      |       |         |
| M13| 0.394| 0.912| 0.941| 0.853| 0.848| 0.909| 0.848| 0.848| 0.943| 0.697| 0.912| 0.882| 1.000|      |      |      |      |      |      |      |      |       |         |
| M14| 0.382| 0.941| 0.971| 0.882| 0.824| 0.824| 0.824| 0.824| 0.917| 0.676| 0.886| 0.857| 0.971| 1.000|      |      |      |      |      |      |      |       |         |
| M15| 0.382| 0.941| 0.971| 0.882| 0.824| 0.824| 0.824| 0.824| 0.917| 0.676| 0.886| 0.857| 0.971| 1.000| 1.000|      |      |      |      |      |      |      |       |         |
| M16| 0.481| 0.686| 0.667| 0.676| 0.571| 0.727| 0.571| 0.667| 0.772| 0.786| 0.686| 0.657| 0.714| 0.694| 0.694| 1.000|      |      |      |      |       |         |
| M17| 0.394| 0.806| 0.833| 0.800| 0.743| 0.800| 0.743| 0.743| 0.889| 0.647| 0.857| 0.829| 0.866| 0.861| 0.861| 0.750| 1.000|      |      |      |       |         |
| M18| 0.542| 0.697| 0.727| 0.688| 0.857| 0.688| 0.576| 0.677| 0.886| 0.621| 0.647| 0.667| 0.727| 0.667| 0.667| 0.545| 0.727| 1.000|      |      |       |         |
| M19| 0.394| 0.970| 1.000| 0.909| 0.848| 0.903| 0.794| 0.906| 0.889| 0.697| 0.857| 0.829| 0.941| 0.971| 0.971| 0.667| 0.833| 0.727| 1.000|      |       |         |
| M20| 0.520| 0.781| 0.758| 0.774| 0.955| 0.833| 0.606| 0.828| 0.714| 0.920| 0.676| 0.647| 0.758| 0.735| 0.735| 0.857| 0.706| 0.581| 0.758| 1.000|      |       |         |
| M21| 0.406| 0.882| 0.912| 0.879| 0.818| 0.938| 0.818| 0.875| 0.914| 0.719| 0.882| 0.853| 0.970| 0.941| 0.941| 0.735| 0.857| 0.697| 0.912| 0.781| 1.000|      |       |         |
| PS865G| 0.448| 0.794| 0.771| 0.844| 0.727| 0.844| 0.629| 0.839| 0.778| 0.793| 0.743| 0.765| 0.771| 0.750| 0.750| 0.806| 0.824| 0.656| 0.771| 0.800| 0.794| 1.000|       |         |
| PS865NG| 0.443| 0.824| 0.800| 0.818| 0.706| 0.875| 0.657| 0.812| 0.806| 0.767| 0.771| 0.743| 0.900| 0.778| 0.778| 0.839| 0.853| 0.636| 0.800| 0.833| 0.824| 0.967| 1.000|       |         |
CONCLUSION

There were 3 mutants tolerant to inundation conditions; they are mutant 1, mutant 3 and mutant 6. Changes in non-mutant sugarcane mutant genotypes based on PCR-RAPD method ranged from 14.7 % to 56.7 % which resulted in an average polymorphic band of 35.1 % from 37 DNA bands that appeared on five RAPD primers and produced four main groups based on the RAPD dendrogram.

ACKNOWLEDGEMENT

Many thanks to Postgraduate Program which support the research by Postgraduate Project Grant in contract number 187AE/UN25.3.1/LT/2015

REFERENCES

Avivi, S., Sigit S., Slameto, & Rizky, A. R. (2016). Physiological Characters of Sugarcane after Flooding Stress. Agriculture and Agricultural Science Procedia, 9, 31-39. https://doi.org/10.1016/j.asspro.2016.02.119.

Bellini, C., Pacurar, D. I., & Perrone, I. (2014). Adventitious roots and lateral roots: Similarities and differences. Annual Review of Plant Biology, 65, 639–666. https://doi.org/10.1146/annurev-plant-050213-035645

Cheruvathur, M. K., Abraham, J., & Thomas, T. D. (2013). Plant regeneration through callus organogenesis and true-to-type conformity of plants by rapid analysis in Desmodium gangeticum (Linn.) DC. Applied Biochemistry and Biotechnology, 169(6), 1799–1810. https://doi.org/10.1007/s12010-013-0117-2

Dhakshanamoorthy, D., Selvaraj, R., & Chidambaram, A. (2015). Utility of RAPD marker for genetic diversity analysis in gamma rays and ethyl methane sulphonate (EMS)-treated Jatropha curcas plants. Comptes Rendus Biologies, 338(2), 75–82. https://doi.org/10.1016/j.crvi.2014.12.002

Erturk, F. A., Nardemir, G., Hilal, A., Arslan, E., & Agar, G. (2015). Determination of genotoxic effects of boron and zinc on Zea mays using protein and random amplification of polymorphic DNA analyses. Toxicology and Industrial Health, 31(11), 1015–1023. https://doi.org/10.1177/0748233713485888

Gomathi, R., & Chandran, K. (2012). Physiological markers for screening waterlogging resistance in sugarcane. Paper presented at Proceedings of International Symposium on New Paradigms in Sugarcane Research: ISNPSR 2012 [Abstract No. 129]. Coimbatore: SSRD & SBI.

Gomathi, R., Gururaja Rao, P. N., Chandran, K., & Selvi, A. (2015). Adaptive responses of sugarcane to waterlogging stress: An over view. Sugar Tech, 17(4), 325–338. https://doi.org/10.1007/s12355-014-0319-0

Hakin, R., & Arumingtyas, E. L. (2014). Keragaman morfologi kenaf (Hibiscus cannabinus L.) KR 11 mutan EMS (Ethyl Methanesulfonate) berdasarkan panduan karakterisasi kenaf. Biotropika: Journal of Tropical Biology, 2(1), 6–13. Retrieved from https://biotropika.ua.ac.id/index.php/biotropika/article/view/207

Hapsoro, D., Warganegara, H. A., Utomo, S. D., Sriyani, N., & Yusnita. (2015). Genetic diversity among sugarcane (Saccharum officinarum L.) genotypes as shown by randomly amplified polymorphic DNA (RAPD). AGRIVITA Journal of Agricultural Science, 37(3), 247–257. https://doi.org/10.17503/agrivita-2015-37-3-p247-257

Mickelbart, M. V., Hasegawa, P. M., & Bailey-Serres, J. (2015). Genetic mechanisms of abiotic stress tolerance that translate to crop yield stability. Nature Reviews Genetics, 16, 237–251. https://doi.org/10.1038/nrg3901

Morris, D. R., & Tai, P. Y. P. (2004). Water table effects on sugarcane root and shoot development. Journal American Society Sugar Cane Technologists, 24, 42-59. Retrieved from http://www.asact.org/journal/JASSCT%20PDF%20Files/volume%2024/A03-05%20Morris%20Final.pdf

Nettyani, N., Mitahudin, & Sobir. (2016). Identifikasi morfologi dan marka molekuler terpaut sifat tidak berbunga jantan pada mutan pisang kepok. Jurnal Hortikultura, 24(1), 23–31. Retrieved from http://ejurnal.litbang.pertanian.go.id/index.php/jhort/article/view/3330

Pezeshki, S. R., & DeLaune, R. D. (2012). Soil oxidation-reduction in wetlands and its impact on plant functioning. Biology, 1(2), 196–221. https://doi.org/10.3390/biology1020196

Pratiwi, N. M. D., Pharmawati, M., & Astarini, I. A. (2013). Pengaruh Ethyl Methane Sulphonate (EMS) terhadap pertumbuhan dan variasi tanaman marigold (Tagetes sp.). Agrotrop, 3(1), 23–28. Retrieved from https://ojs.unud.ac.id/index.php/agrotrop/article/view/15313

Romeida, A., Sutjahjo, S. H., Purwito, A., Sukma, D., & Rustikawati. (2012). Variasi genetik mutan anggrek Spadoglossitis plicata Blume. Berdasarkan marker ISSRP. Jurnal Agromoni Indonesia, 49(3), 218–224. Retrieved from http://repository.unib.ac.id/1130/1/6829-19209-1-PB.pdf
Sholeh Avivi et al.: The Morphological Diversity and RAPD Analysis .................................................................

Shah, S., Gong, Z.-H., Arisha, M. H., Khan, A., & Tian, S.-L. (2015). Effect of ethyl methyl sulfonate concentration and different treatment conditions on germination and seedling growth of the cucumber cultivar Chinese long (9930). Genetics and Molecular Research, 14(1), 2440–2449. https://doi.org/10.4238/2015.March.30.2

Striker, G. G. (2012). Flooding stress on plants: Anatomical, morphological and physiological responses. In J. Mworia (Ed.), Botany (p. 1-28). InTech. Retrieved from https://www.intechopen.com/books/botany/flooding-stress-on-plants-anatomical-morphological-and-physiological-responses

Talebi, A. B., Talebi, A. B., & Shahrokhifar, B. (2012). Ethyl Methane Sulphonate (EMS) induced mutagenesis in Malaysian rice (cv. MR219) for lethal dose determination. American Journal of Plant Sciences, 3(12), 1661–1665. https://doi.org/10.4236/ajps.2012.312202

Tetsushi, H., & Karim, M. A. (2007). Flooding tolerance of sugarcane in relation to growth, physiology and root structure. South Pacific Studies, 28(1), 9–22. Retrieved from http://cpi.kagoshima-u.ac.jp/publications/southpacificstudies/sps/sps28-1/SouthPacificStudies28(1)pp9-22.pdf

Tripathy, S. K., Ranjan, R., Dash, S., Bastia, D. L., Baisakh, B., Satpathy, P. C., & Sahu, S. (2016). Isolation of useful scented rice mutants and comparative assessment of genetic diversity. Journal of Environmental Biology, 37(1), 65–73. Retrieved from https://europepmc.org/abstract/med/26930862