

Stability of watermelon phenotype characters (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) from crossing ♀ ‘Putri Delima’ with ♂ ‘Maduri’

Deris Trian Rahmandhias¹, Wiko Arif Wibowo¹, Aprilia Sufi Subiastuti¹, Budi Setiadi Daryono^{1*}

¹Laboratory of Genetics and Breeding, Faculty of Biology, Universitas Gadjah Mada

Jl. Teknik Selatan, Sekip Utara, Sleman, D.I.Yogyakarta, Indonesia. 55281

*Email: bs_daryono@mail.ugm.ac.id

ABSTRACT. Watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) is a horticultural plant that belongs to the Cucurbitaceae family with high public demand, however, local markets sometimes have limited supply. The existence of watermelon varieties that are not pest-resistant causes its production to be erratic. Therefore, plant breeding efforts are required to produce superior varieties through the stability test of plant characters. For watermelon to be certified as a new variety, it needs to possess a stable and adaptive character to various conditions. The F₁ watermelon from crossing ♀ ‘Putri Delima’ with ♂ ‘Maduri’ produces inole-shaped fruit, red flesh, and a sweet taste. Therefore, this study aims to determine the stability of the phenotypic character of watermelon F₂ from crossing ♀ ‘Maduri’ with cultivar ♂ ‘Putri Delima’ and was conducted in Jamusan, Bokoharjo, Prambanan, Sleman, D.I.Yogyakarta fields from August to December. There are five samples of ripe watermelons that were selected randomly while their phenotypic characters were observed qualitatively and quantitatively. Each F₂ watermelon character was compared to F₁, and the quantitative analysis was conducted using one-factor ANOVA with a confidence level of 5%. The results of quantitative character analysis between F₂ and F₁ showed a P (P-value) > 0.05. Meanwhile, the results of qualitative observations of F₂ watermelon showed different flesh and skin color, while the harvest time from F₁ was caused by the segregation of heterozygous crosses. Therefore, it is necessary to select superior phenotypic characters as desired for the next breeding.

Keywords: Maduri; phenotypic characters; plant breeding; Putri Delima; stability test

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INTRODUCTION

Indonesia is an agricultural country with rapid development in growing horticultural plants, such as watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) which belongs to the Cucurbitaceae family with high public demand and is classified as a seasonal creeping plant with a tool holder like gyre (Hannah & Krishnakumari, 2015; Pan *et al.*, 2020). The surface of this plant has sharp fine hairs that cover the stems and leaves (Wei *et al.*, 2020). Guo *et al.* (2013), stated that watermelon is a type of fruit that is very popular among people. Furthermore, the plant has high water content and also rich in minerals such as Ca, Mg, P, niacin, riboflavin, thiamin, and carotenoid (Grassi *et al.*, 2013; Ilahy *et al.*, 2019) and as stated by Syukur *et al.* (2012), an average watermelon has a solid content of 8-10% and 20-25% sucrose.

Due to its fresh, sweet taste, and popularity with the public, the demand for watermelons in

Java is high which leads to an increase in market demand every year. In 2019, Kementerian Pertanian stated that watermelon had an average production yield of 13.86 tons/ha, while in 2014, it was 18.27 tons/ha. This increase in market demand becomes an obstacle for farmers due to the absence of local seeds that are stable and superior enough to balance needs. Meanwhile, one of the efforts of producing superior and stable seeds is the use of plant breeding techniques through quality development on hybrid varieties of watermelon seeds (Ceccarelli, 2015; Cardi, 2016; Dou *et al.*, 2018). With the development of hybrid watermelon seeds' quality, it is expected that new certified cultivars with high stability and adaptability created for large-scale cultivation.

Some of the superior watermelons that have been tested for stability are cultivars ‘Putri Delima’ and Maduri. Meanwhile, the ‘Putri Delima’ watermelon cultivar has an oblate or oval (inole) fruit shape, dark green skin color,

and red flesh with an average fruit weight of 3.5-6 kg, and Brix or a sweetness level of 13. This cultivar is harvested in the range 60-75 day after seeding/sowing (DAS). The Maduri watermelon is a superior cultivar with the code WM 2479 (Kementerian Pertanian, 2016). Furthermore, Maduri has an oval fruit shape (inole), dark green skin color with blackish stripes, and yellow flesh. Meanwhile, this cultivar is harvested in the range 56-60 DAS, has a long shelf life, and tolerant of fusarium wilt with a leaf crackle.

This study aims to test the stability of the phenotypic character of F₂ watermelon from crossing watermelon cultivar ♀ 'Putri Delima' with ♂ 'Maduri' and comparing with the F₁ results of a previous study by Putri & Daryono (2017) which is stable and superior.

MATERIALS AND METHODS

This study was conducted in Jamusan (Greenhouse), Bokoharjo, Prambanan, Sleman, D.I. Yogyakarta, and the Laboratory of Genetics and Breeding, Faculty of Biology, Universitas Gadjah Mada.

Cultivation. Watermelon cultivation consists of three stages, namely, land preparation, seed germination, and maintenance. Land preparation was carried out by cultivating through taxation and the establishment of good irrigation channels. Meanwhile, the seed germination stage began with soaking for one day, followed by sorting and planting in warm conditions with a temperature of $\pm 28^{\circ}\text{C}$ which is equipped with a 10-watt lamp. The 10 days old germinated seeds were transferred to the field for permanent planting while the third stage was carried out by routine fertilizers and irrigation. Moreover, watermelons that have male and female flowers were pollinated manually and lateral branches were trimmed by removing seven to eight leaves and separating them into two leaves. This process was carried out on subsequent branches until the 20th or 25th internode is reached. After obtaining the ovaries from the crosses, the watermelons were nurtured until ripe and ready to be harvested. Meanwhile, the watermelon that is ready for harvest has a dark yellow spot and a loud sound

when tapped.

Phenotype characterization. Generally, the reference for sampling and testing the difference, uniformity, and stability of watermelons is according to UPOV (2012). In this study, five samples were tested for stability and the phenotypic character which include qualitative and quantitative data. The qualitative data were measured by observing the fruit and seed shape, skin and flesh color, together with pulp texture according to Kementerian Pertanian (2016). Moreover, the fruit color observations refer to the RHS mini chart 2015. Furthermore, the quantitative characters observed include fruit size, thickness, skin and flesh weight, sweetness level, storage capacity, number of seeds, and weight of 100 seeds.

Data Analysis. The quantitative data obtained were tested using one-way ANOVA with a confidence level of 5% through a comparison of the results between F₂ and F₁ watermelon.

RESULTS AND DISCUSSION

Watermelon has a distinctive phenotypic character which is the external appearance or other characteristics of every organism that are observed. This character is determined by the interaction results between proteins in the cell. Meanwhile, observations of phenotypic characters are classified into two types based on the measurement and variety continuity, namely the qualitative and quantitative phenotype character (Daryono *et al.*, 2019). In this study, F₂ was from hybrid crosses (heterozygous) with unstable phenotypic characters and there was segregation. Therefore, there is a need to select the desired phenotypic characters.

Qualitative characters. These are visible characters that are not measured in certain measurement units. Also, qualitative characters have discontinuous diversity and are controlled by each single gene (Govindaraj *et al.*, 2015; Cao *et al.*, 2016; Peterson & Müller, 2016). From the results, as shown in Table 1, the fruit of the F₂ watermelon from crossing ♀ 'Putri Delima' with ♂ 'Maduri' has the same shape as the F₁ breeders, namely oblate/innole, while the

fruit skin color and the flesh color are different. The F₁ fruit skins, namely (RHS 2015 137A, RHS 2015 N 189A, RHS 2015 12B) showed more diverse colors than in F₂ (RHS 2015 139A; RHS 2015 145A). Moreover, fruit skin is one of the important qualitative phenotypic characters in watermelon breeding because it determines consumer interest. The green skin color of the watermelon is the wild type and the changes in skin color that occur are caused by evolution, artificial selections, and gene mutations (Yang *et al.*, 2015; Li *et al.*, 2019; Sun *et al.*, 2020). These gene mutations occur on chromosome four with a single gene dominant pattern of inheritance (Guo *et al.*, 2013; Dou *et al.*, 2018).

Table 1. Qualitative characters of watermelon fruit phenotypes resulting from crossing ♀ ‘Putri Delima’ with ♂ ‘Maduri’.

Parameter	F ₁	F ₂
Fruit shape	Oblate/innole	Oblate/innole
Fruit skin color	RHS 2015 137A; RHS 2015 N 189A; RHS 2015 12B	RHS 2015 139A; RHS 2015 145A
Flesh color	RHS 2015 42A (Red)	RHS 2015 5A; RHS 2015 21A (Yellow)
Fruit flesh texture	Crunchy	Crunchy
Seed color	RHS 2-15 200A	RHS 2015 10C; RHS 2015 200A

The watermelon pulp produced by F₁ shows a different appearance compared to F₂ while the color of F₂ has similar properties with the parental ‘Maduri’, which is yellow to dark (RHS 2015 5A; RHS 2015 21 A). This is due to the existence of two loci (C locus and i-C locus) which play a role in inhibiting and controlling the color of watermelon flesh (Bang *et al.*, 2010; Zhao *et al.*, 2013; Liu *et al.*, 2016). In addition, several exogenous factors that affect

the phenotypic characters and fruit quality include light and temperature conditions, pathogen attacks, as well as pre-and post-harvest manipulations (Ilahy *et al.*, 2019).

Moreover, the color of the seeds produced by F₁ watermelon is blackish (RHS 2015 200A) while the color of the F₂ is black with yellow spots (RHS 2015 10C, RHS 2015 200A). The color of the seeds in F₂ is similar to the yellow watermelon cultivar ‘Maduri’ while F₁ is similar to the red watermelon broodstock of the ‘Putri Delima’ cultivar. Meanwhile, the difference in seed color is due to the instability of phenotypic characters or certain genes that regulate the watermelons pigment.

The F₁ watermelon from crossing ♀ ‘Putri Delima’ with ♂ ‘Maduri’ has a shorter harvest age than F₂, due to the difference in planting time and season. When the rainy season is high, rainfall is higher and the phosphorus content of the soil decreases as it is eroded by the rainfall. This inhibits plant growth, fruit, and seed maturity (White & Veneklaas, 2012; Bai *et al.*, 2013; Emongor *et al.*, 2017). Meanwhile, F₂ watermelon which is the result of crossing ♀ ‘Putri Delima’ with ♂ ‘Maduri’, was planted during the rainy season to have a low intensity of irradiation was low that reduces photosynthate accumulation. Unlike F₁ which is planted in the dry season, F₂ shows a shorter harvest life due to more radiation. Meanwhile, more radiation causes the fruit to ripen quickly due to the higher accumulation of photosynthate. In addition to adequate radiation, watermelons grow optimally when planted with a temperature range of 22°C-30°C, humidity less than 80%, an average rainfall of 40 to 50 mm/month, and influenced by the soil structure as well as microbial composition (Liu *et al.*, 2018, Wang *et al.*, 2019).

The differences in the appearance of the flesh and seed color between the F₁ watermelon from crossing ♀ ‘Putri Delima’ with ♂ ‘Maduri’ with F₂ watermelon shown in Fig. 1.

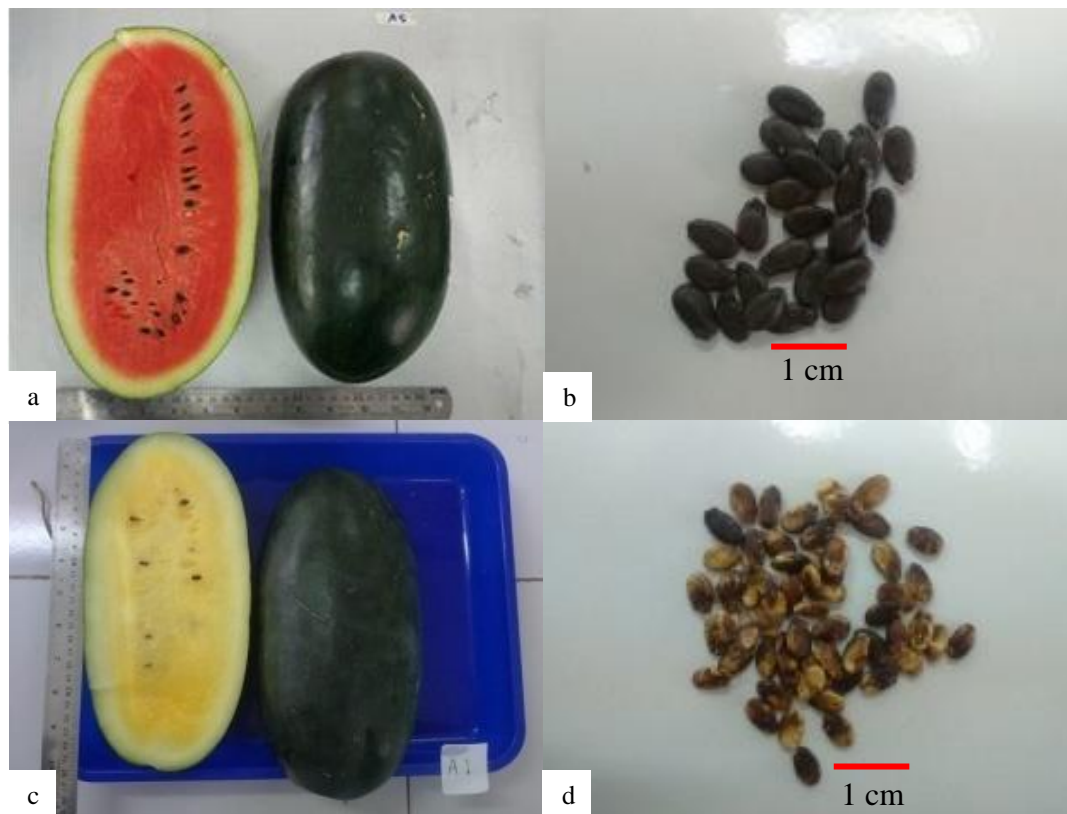


Fig. 1. Morphology of watermelon: a. F₁ fruit; b. F₁ seeds, c. F₂ fruit; d. F₂ seed (cross of ♀ 'Maduri' with ♂ 'Princess Delima').

Quantitative characters. Phenotypic characters are quantitative that is measured clearly and have continuous diversity which forms a spectrum, and when the population is large enough it forms a normal distribution curve (Daryono *et al.*, 2012). This quantitative character is controlled by several genes (polygene) that have little influence and complement each other for clear observation of quantitative changes. Based on One way ANOVA test, there was no significant difference ($P < 0.05$) in the quantitative phenotypic characters between F₂ and F₁ watermelon. It is shown in Table 2 where the F₂ watermelon from crossing ♀ 'Putri Delima' with ♂ 'Maduri' has a fruit weight of 2.82 kg, horizontal and vertical circumference of 43.60 cm and 68.40 cm respectively while the upper and bottom diameters were 9.60 cm and 10.40 cm. Furthermore, the skin thickness of 1.64 cm, thick flesh of 11.40 cm, horizontal and vertical diameters of 14.68 cm and 26.70 cm, Brix of 9-13, fruit skin and flesh weights was 1.6 kg and 1.22 kg while the number of seeds per fruit was 234, and 4.01 gr weight of 100 seeds.

Therefore, the overall quantitative character of F₂ watermelon from crossing 'Putri Delima' with ♂ 'Maduri' was higher than F₁. In this study, the fruit weight is greater than the results of Putri & Daryono (2017). Meanwhile, heavier fruit weight is associated with an increase in fruit diameter, pulp and seeds weight, as well as fruit skin. The sweetness level of Brix in F₂ watermelon is of a higher range than F₁ due to different harvesting times. In F₂ watermelon, it is estimated that the harvest is on time to produce good fruit and an optimal level of sweetness compared to F₁. The level of sweetness was influenced by the accumulation of sucrose, depends on genotype expression and environmental factors (Verma *et al.*, 2017; Kyriacou *et al.*, 2018). Moreover, the genotypes express the taste of sweet flesh due to the high accumulation of sucrose from metabolic processes while the environmental factors influence genotype during the accumulation period. Furthermore, low temperatures in the rainy season cause sugar accumulation in form of starch, while high

temperatures in the dry season accumulate the starch into sucrose.

Table 2. Quantitative characters of watermelon fruit phenotype resulting from crossing ♀ ‘Maduri’ with ♂ ‘Putri Delima’

Parameter	F ₁	F ₂
Fruit weight (kg)	1.50	2.82
Horizontal circumference (cm)	38.18	43.60
Vertical circumference (cm)	49.70	68.40
Top diameter (cm)	9.80	9.60
Bottom diameter (cm)	9.32	10.40
Skin thickness (cm)	1.23	1.64
Meat thickness (cm)	9.94	11.40
Horizontal diameter (cm)	12.24	14.68
Vertical diameter (cm)	18.46	26.70
Brix	8–12	9–13
Skin weight (kg)	0.75	1.60
Flesh weight (kg)	0.80	1.22
Number of seeds	208	234
Weight of 100 seeds (gr)	2.66	4.01

Generally, the phenotypic characters between F₂ watermelons from crossing ♀ ‘Putri Delima’ with ♂ ‘Maduri’ with F₁ watermelon by Putri & Daryono (2017) show different results a previous study stated that the difference in location, time, and weather conditions affect the resulting fruit. Furthermore, Daryono *et al.* (2012), stated that the differences in phenotypic characters produced between the two studies were caused by the interaction between the genotype and the environment. Meanwhile, polygene interacts with various environmental factors which affect plant growth.

Influencing environmental factors are water, nutrients, temperature, light intensity, soil moisture, and others (Liu *et al.*, 2018; Ilahy *et al.*, 2019; Wang *et al.*, 2019). Meanwhile, Suprpto & Jaya (2000) stated that the ideal environmental conditions for growing watermelons include an altitude of 100-300 m above sea level, basic topography soil which sandy or loam with a loose texture, and crumbs that contain several organic substances with a pH of 5.9-7.2, full radiation and an open space with a temperature range of 22°C to 30°C, humidity less than 80%, and an average rainfall between 40-50 mm/month.

CONCLUSION

The qualitative character of the F₂ watermelon phenotype from crossing ♀ ‘Putri Delima’ with ♂ ‘Maduri’ shows segregation and non-uniformity (unstable). Therefore, it is necessary to select the desired phenotypic characters for breeding according to the consumer's point of views such as fruit shape, skin and flesh color, pulp texture, sweetness level, harvesting age, and disease resistance.

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REFERENCES

- Bai Z, Li H, Yang X, Zhou B, Shi X, Wang B, Li D, Shen J, Chen Q, Qin W, Oenema O, Zhang F. 2013. The critical soil P levels for crop yield, soil fertility and environmental safety in different soil types. *Plant and Soil*. vol 372(1): 27–37. doi: <https://doi.org/10.1007/s11104-013-1696-y>.
- Bang H, Davis AR, Kim S, Leskovar DI, King SR. 2010. Flesh color inheritance and gene interaction among canary yellow, pale yellow, and red watermelon. *Journal of the American Society for Horticultural Science*. vol 135(4): 362–368. doi: <https://doi.org/10.21273/JASHS.135.4.362>.
- Cao K, Zhou Z, Wang Q, Guo J, Zhao P, Zhu G, Fang W, Chen C, Wang X, Tian Z, Wang L. 2016. Genome-wide association study of 12 agronomic traits in peach. *Nature Communications*. vol 7(1): 1–10. doi: <https://doi.org/10.1038/ncomms13246>.
- Cardi T. 2016. Cisgenesis and genome editing: Combining concepts and efforts for a smarter use of genetic resources in crop breeding. *Plant Breeding*. vol 135(2): 139–147. doi: <https://doi.org/10.1111/pbr.12345>.
- Ceccarelli S. 2015. Efficiency of plant breeding. *Crop Science*. vol 55(1): 87–97. doi: <https://doi.org/10.2135/cropsci2014.02.0158>.
- Daryono BS, Hayuningtyas SD, Maryanto SD. 2012. Perakitan melon (*Cucumis melo* L.) kultivar Melodi Gama 3 dalam rangka penguatan industri pertanian nasional. Prosiding Seminar Nasional dan Call For Paper EP UNNES. October 30, 2012. Semarang: Jurusan Ekonomi Pembangunan, Fakultas Ekonomi, Universitas Negeri Semarang. ISBN 978-602-17035-0-5. pp 245–256.
- Daryono BS, Subiastuti AS, Fatmadanni A, Sartika D. 2019. Phenotypic and genetic stability of new Indonesian melon cultivar (*Cucumis melo* L. ‘Melonia’) based on ISSR markers. *Biodiversitas Journal of Biological Diversity*. vol 20(4): 1069–

1075. doi: <https://doi.org/10.13057/biodiv/d200419>.
- Dou J, Lu X, Ali A, Zhao S, Zhang L, He N, Liu W. 2018. Genetic mapping reveals a marker for yellow skin in watermelon (*Citrullus lannatus* L.). *PloS One*. vol 13(9): 1–15. doi: <https://doi.org/10.1371/journal.pone.0200617>.
- Emongor EV, Thatayaone M, Tshwenyane SO. 2017. The influence of nitrogen and phosphorus on watermelon fruit quality. *International Journal of Plant & Soil Science*. vol 18(6): 1–9. doi: <https://doi.org/10.9734/IJPSS/2017/36211>.
- Govindaraj M, Vetriventhan M, Srinivasan M. 2015. Importance of genetic diversity assessment in crop plants and its recent advances: an overview of its analytical perspectives. *Genetics Research International*. vol 2015: 1–15. doi: <https://doi.org/10.1155/2015/431487>.
- Grassi S, Piro G, Lee JM, Zheng Y, Fei Z, Dalessandro G, Giovannoni JJ, Lenucci MS. 2013. Comparative genomics reveals candidate carotenoid pathway regulators of ripening watermelon fruit. *BMC Genomics*. vol 14: 1–20. doi: <https://doi.org/10.1186/1471-2164-14-781>.
- Guo S, Zhang J, Sun H, Salse J, Lucas WJ, Zhang H, Zheng Y, Mao L, Ren Y, Wang Z, Min J, Guo X, Murat F, Ham BK, Zhang Z, Gao S, Huang M, Xu Y, Zhong S, Bombarely A, Mueller LA, Zhao H, He H, Zhang Y, Zhang Z, Huang S, Tan T, Pang E, Lin K, Hu Q, Kuang H, Ni P, Wang B, Liu J, Kou Q, Hou W, Zou X, Jiang J, Gong G, Klee K, Schoof H, Huang Y, Hu X, Dong S, Liang D, Wang J, Wu K, Xia Y, Zhao X, Zheng Z, Xing M, Liang X, Huang B, Lv T, Wang J, Yin Y, Yi H, Li R, Wu M, Levi A, Zhang X, Giovannoni JJ, Wang J, Li Y, Fei Z, Xu Y. 2013. The draft genome of watermelon (*Citrullus lanatus*) and resequencing of 20 diverse accessions. *Nature Genetics*. vol 45(1): 51–58. doi: <https://doi.org/10.1038/ng.2470>.
- Hannah MAC, Krishnakumari S. 2015. Profiling of lipid and vitamin contents in the extract of watermelon (*Citrullus vulgaris* Schrad.) seed. *Journal of Pharmacognosy and Phytochemistry*. vol 4(3): 247–252.
- Ilahy R, Tlili I, Siddiqui MW, Hdider C, Lenucci MS. 2019. Inside and beyond color: comparative overview of functional quality of tomato and watermelon fruits. *Frontier in Plant Science*. vol 10: 1–26. doi: <https://doi.org/10.3389/fpls.2019.00769>.
- Kementerian Pertanian. 2016. Pedoman pendaftaran varietas (revisi). Jakarta: Direktorat Perbenihan Hortikultura, Kementerian Pertanian Republik Indonesia. pp 116–117. <https://www.pertanian.go.id>.
- Kyriacou MC, Leskovar DI, Colla G, Roupheal Y. 2018. Watermelon and melon fruit quality: The genotypic and agro-environmental factors implicated. *Scientia Horticulturae*. vol 234: 393–408. doi: <https://doi.org/10.1016/j.scienta.2018.01.032>.
- Li B, Zhao S, Dou J, Ali A, Gebremeskel H, Gao L, He N, Lu X, Liu W. 2019. Genetic mapping and development of molecular markers for a candidate gene locus controlling rind color in watermelon. *Theoretical and Applied Genetics*. vol 132(10): 2741–2753. doi: <https://doi.org/10.1007/s00122-019-03384-3>.
- Liu S, Zhu Q, Wu C, Amanullah S, Gao P, Wang X, Ma H, Zhu Z, Luan F, Davis AR. 2016. Mapping the major genes related to lycopene content and flesh color traits in watermelon (*Citrullus lanatus*). Proceeding of Cucurbitaceae. July 24–28, 2016. Poland: Wydawnictwo SIGMA. ISBN 978-83-7987-896-3. pp 186–190.
- Liu L, Chen S, Zhao J, Zhou X, Wang B, Li Y, Zheng G, Zhang J, Cai Z, Huang X. 2018. Watermelon planting is capable to restructure the soil microbiome that regulated by reductive soil disinfestation. *Applied Soil Ecology*. vol 129: 52–60. doi: <https://doi.org/10.1016/j.apsoil.2018.05.004>.
- Pan Y, Wang Y, McGregor C, Liu S, Luan F, Gao M, Weng Y. 2020. Genetic architecture of fruit size and shape variation in cucurbits: a comparative perspective. *Theoretical and Applied Genetics*. vol 133: 1–21. doi: <https://doi.org/10.1007/s00122-019-03481-3>.
- Peterson T, Müller GB. 2016. Phenotypic novelty in EvoDevo: the distinction between continuous and discontinuous variation and its importance in evolutionary theory. *Evolutionary Biology*. vol 43(3): 314–335. doi: <https://doi.org/10.1007/s11692-016-9372-9>.
- Putri AC, Daryono BS. 2017. Assembly of hybrid watermelon (*Citrullus lanatus* (Thunberg.) Matsum&Nakai) result of crossing between ♀ ‘Putri Delima’ and ♂ ‘Maduri’ Cultivars. Proceeding Seminar Nasional Agrotechnology Days. December 4, 2017. Bandung: Universitas Padjadjaran.
- Sun Y, Zhang H, Fan M, He Y, Guo P. 2020. A mutation in the intron splice acceptor site of a GA3ox gene confers dwarf architecture in watermelon (*Citrullus lanatus* L.). *Scientific Reports*. vol 10(1): 1–15. doi: <https://doi.org/10.1038/s41598-020-71861-7>.
- Suprpto S, Jaya NA. 2000. Budidaya Semangka dengan Teknologi Embung. [Laporan Akhir]. Penelitian SUT Diversivikasikan Lahan Marginal di Kecamatan Gerokgak. Buleleng, No. Agdex: 235/28, No. Seri: 12/Buah/2000/Oktober 2000. Jakarta: Badan Penelitian dan Pengembangan Pertanian, Kementerian Pertanian Republik Indonesia. <https://nad.litbang.pertanian.go.id/>.
- Syukur M, Sujiprihati S, Yuniarti R. 2012. Teknik pemuliaan tanaman. Jakarta: Penebar Swadaya. pp 269–270.
- UPOV. 2012. Guidelines for the conduct of tests for distinctness, uniformity, and stability: watermelon. Geneva: International Union for The Protection of New Varieties of Plants. pp 5–30.

- <https://www.upov.int>.
- Verma I, Roopendra K, Sharma A, Jain R, Singh RK, Chandra A. 2017. Expression analysis of genes associated with sucrose accumulation in sugarcane under normal and GA 3-induced source–sink perturbed conditions. *Acta Physiologiae Plantarum*. vol 39(6): 1–12. doi: <https://doi.org/10.1007/s11738-017-2433-6>.
- Wang T, Hao Y, Zhu M, Yu S, Ran W, Xue C, Ling N, Shen Q. 2019. Characterizing differences in microbial community composition and function between Fusarium wilt diseased and healthy soils under watermelon cultivation. *Plant and Soil*. vol 438: 421–433. doi: <https://doi.org/10.1007/s11104-019-04037-6>
- Wei C, Zhu C, Yang L, Zhao W, Ma R, Li H, Zhang Y, Ma J, Yang J, Zhang X. 2020. A point mutation resulting in a 13 bp deletion in the coding sequence of Cldf leads to a GA-deficient dwarf phenotype in watermelon. *Horticulture Research*. vol 6: 1–12. doi: <https://doi.org/10.1038/s41438-019-0213-8>.
- White PJ, Veneklaas EJ. 2012. Nature and nurture: the importance of seed phosphorus content. *Plant and Soil*. vol 357(1): 1–8. doi: <https://doi.org/10.1007/s11104-012-1128-4>.
- Yang HB, Park SW, Park Y, Lee GP, Kang SC, Kim YK. 2015. Linkage analysis of the three loci determining rind color and stripe pattern in watermelon. *Horticultural Science & Technology*. vol 33(4): 559–565. doi: <https://doi.org/10.7235/hort.2015.14070>.
- Zhao W, Lv P, Gu H. 2013. Studies on carotenoids in watermelon flesh. *Agricultural Sciences*. vol 4(7): 13–20. doi: <http://dx.doi.org/10.4236/as.2013.47A003>.