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Morphological and Physiological Adaptation of *Synedrella nodiflora* (L.) Gaertn. in Various Altitudes

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Abstract. Nodeweed (*Synedrella nodiflora* (L.) Gaertn.) is a widely distributed tropical plant species. Nevertheless, it has taxonomically been the only member of genus *Synedrella*. Hence, it is interesting to study the morphological and physiological adaptation in different altitudes. Three altitudes were selected in this study, i.e. 0, 130, and 820 m above sea level (asl). The parameters examined included number of stomata and trichomes per leaf area unit, size of glandular and non-glandular trichomes, size of peripheral and central seeds, number of peripheral and central seeds. It was found that seed number and length, leaf structure, chlorophyll content show differences among altitudes. *S. nodiflora* from 0 m asl show lowest central seed number and length, non glandular trichomes number, but highest non-glandular trichomes length and chlorophyll a and carotene contents.

1. Introduction

Nodeweed (*Synedrella nodiflora* (L.) Gaertn.), which belongs to the family of Asteraceae, native to tropical America and is widely distributed to many other tropical regions. During intercontinental migration, the seeds are dormant and then germinate once reach the coastal and tidal areas or even estuaries. [1] and [2] noted that *S. nodiflora* growing in tidal areas feed by Galapagos turtles, which are known for inter-island mobility. The seeds have been reported found in animal feces. This indicates that turtles can assist the distribution of nodeweed from one land to another.

Nodeweed seeds can be divided into two parts, i.e. peripheral and central seeds. Both are morphologically different from each other. Peripheral seeds are thin with 5 to 12 awns enabling them to attach to the skin of animals, e.g. rats, rabbits and cats. Meanwhile, central seeds have 2 or 3 awns in certain position that facilitates the seeds to be blown by the wind over distant places. As well, the sharpness of awns in central seeds makes them more strongly attached to animal skins for easier dispersal.

This plant species can grow well from 0 to1,000 m above sea level. It grows very well in some locations, sometimes with pigmentation in stem and petioles [3]. This plant can grow not only in fertile soils but also in marginal lands, ditches, and even garbage dumps. It means that this plant species do not need specific requirements for growth. Hence, in this paper, we present our study on the morphological and physiological adaptation of *S. nodiflora* in various altitudes.

2. Methods

Samples of nodeweeds were collected from three locations of different altitudes, i.e. Jetis Beach (0 m asl), Purwokerto City (135 m asl) and Baturraden Botanical Garden (813 m asl). The plants were made as cuttings in 15 cm length and were grown for 2 weeks in a glasshouse. After 7 days roots began to

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emerge, so that within two weeks, the plants had been healthy and ready to be sampled the third leaves for chlorophyll content measurement following [4]. Also, second leaves were taken for trichome and stoma examination. Satured chloralhydrate was used to dissolve the chlorophyll for easier examination on trichome and stoma.

3. Results

The number and size of both pheripheral and central seeds of nodeweeds from the three different altitudes are presented in Table 1, while those of non-glandular and glandular trichomes, as well as the number of stomata, could be seen in Table 2. Physiological parameters, including chlorophyll and carotene contents, are provided in Table 3. The sizes of central seeds of nodeweeds from the three altitudes, along with their awns, are depicted in Figure 1.

Figure 1. Central seeds of *Synedrella nodiflora* collected from Jetis Beach (A), Purwokerto City (B), Baturraden Botanical Garden(C)

Table 1. Number of pheripheral and central seeds, length of pheripheral and central seeds, width of pheripheral and central seeds, length of pheripheral and central seed awns of *Synedrella nodiflora* from three different locations

location	number of seeds		seed length (mm)		seed width (mm)		awn length (mm)	
	peri-pheral	central	peri-pheral	Central	peri-pheral	Central	peri-pheral	Central
Jetis	5.40 a	6.00 b	3.09 a	0.40 b	1.43 a	0.77 a	2.56 a	0.46 - 2.10
Purwokerto	6.00 a	10.40 a	3.23 a	0.90 b	1.42 a	0.59 b	2.58 a	0.26 - 1.73
Baturraden	6.40 a	11.80 a	3.29 a	6.20 a	1.36 a	0.81 a	1.91 b	0.19 - 1.07

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Table 2. Number of trichomes and glandular trichomes, length of trichomes and glandular trichomes, number of stomata at lower and upper leaf surfaces of *Synedrella nodiflora* from three different locations

Location	number of trichomes		number of glandular trichomes		length of trichomes (mm)		length of glandular trichomes (mm)		number of stomata	
	Upper	Lower	Upper	lower	Upper	Lower	Upper	lower	upper	Lower
Jetis	43.60 ab	24.30 b	0.50 b	0.40 b	38.70 a	36.30 a	5.30 c	6.00 b	17.80 a	11.30 b
Purwokerto	47.40 a	33.80 a	0.60 b	0.90 b	36.20 a	32.90 b	7.20 b	6.00 b	11.60 b	11.80 b
Baturraden	42.30 b	37.60 a	18.50 a	6.20 a	27.70 b	26.90 c	8.20 a	7.90 a	8.10 c	21.00 a

Table 3. Chlorophyll a, chlorophyll b, total chlorophyll and carotene contents of *Synedrella nodiflora* from three different locations

location	chorophyll a (μg/ml)	chorophyll b (μg/ml)	total chorophyll (μg/ml)	carotene (μg/ml)
Jetis	23.05 a	6.47 b	1.43 b	4.09 a
Purwokerto	15.78 b	7.506 b	1.42 b	3.09 a
Baturraden	11.86 b	13.09 a	9.68 a	1.62 b

4. Discussion

ANOVA on the number, length, and width of peripheral seeds shows that no significant difference among locations is observed. On the other hands, that on the number, length, and width of central seeds shows significant difference among locations. Further analysis using LSD test (Table 1) reveals that the number of central seeds of nodeweeds from Jetis Beach is the lowest in comparison to those from Purwokerto and Baturraden. It is also the case with the length of central seeds, which is the lowest in comparison to those from the other two locations, as shown in the table as well as in Figure 1. Oppositely, the awns of central seeds from Jetis Beach are in general longer than those from Purwokerto and Baturraden.

Although the number and the length of central seeds from Jetis Beach are relatively lower than those from Purwokerto dan Baturraden, the length of awns in central seeds ranges from 0.46 to 2.10 mm. This is obviously longer than those from Purwokerto (0.26 – 1.73 mm) and Baturraden (0.19 – 1.07 mm). It seems likely that seawater restricts the number of seeds, formed, especially with respect to seed length. Sea water with high NaCl content increases osmotic pressure, so that water and nutrient absorption is inhibited. Water as a determining factor in photosynthesis provides electrons and protons that will play role in the formation of ATP and NADH during sunlight energy catching I both photosystem 1 and photosystem 2. Electrons, being transferred from P700* to ferredoxin, will be used to reduce NADPH into NADPH2. The less water entering xylem due to high osmotic pressure will in turn affect photosynthesis rate and carbohydrate produced in the carbon reaction. This will result in the limited formation of substances required for plant structures. Then, leaf size will also be affected. The small number of photosynthates will also influence the size and number of seeds formed.

The nodeweeds exposed to salt in soil solution will develop two responses to avoid stress [5][6]. First, increasing osmotic stress is plant response to increasing external osmotic pressure. This will make immediate effect on plant growth. Second, ionic stress is plant response in accumulating Na^+ in leaves. This stress develop with time, because of a combination of ion accumulation in shoots and incapability of plants in tolerating accumulated ions.

From leaf structure it can be said that the number of non-glandular trichomes in the lower surface, number of glandular trichomes in both lower and upper surface of nodeweeds from Jetis Beach are relatively low (Table 2). However, the length of non-glandular trichomes in both lower and upper surface is higher in comparison to those from Puwokerto and Baturraden. It seems likely that in high salinity up to 37 ppt nodeweeds develops protective mechanism by lengthening its trichomes. Dense and long trichomes indicate that trichomes change their function as salt glands excreting salt from plant bodies [6]. In this case, salt excretion is the mechanism by which plants increase their tolerance against salinity stress. Long trichomes will inhibit transpiration so that more water will be kept in plant bodies. Water sufficiency in plant tissues will reduce water and nutrient absorption by roots. Consequently, absorption of Na^+ and Cl^- ions will also decrease, so that their contents in plants are sufficiently low.

The low salt content is supported by the small number of stomata at leaf lower surface of nodeweeds from Jetis Beach. Meanwhile, a relatively large number of stomata at upper surface is observed. This indicates that stomata in *S. nodiflora* leaves are used for excreting salt which enters plant bodies.

Nodeweeds from Jetis Beach is considered as developing tolerance to sufficiently high salinity. This can be seen from its survival, relatively small leaves and imperfectly developing root system, shallow roots and less branch roots. Different condition is found with nodeweeds from Purwokerto and Baturraden, which in general have many fibrous roots.

It can be seen from Table 3 that chlorophyll a and carotene contents in nodeweeds from Jetis Beach are higher than those from Purwokerto and Baturraden. Both pigments involve sun light energy catching. Chlorophyll a is the centre of reaction in photosystem I, so that sunlight energy catching will be perfect, moreover with the help of high content of carotene. This is a colored compound serving as an antenna in sunlight energy catching as well as potential enough to prevent chlorophyll damage due to excessive light intensity and relatively high temperature in higher plants. Photosynthesis rate increases with the increment of chlorophyll a and carotene contents. [7] noted that high salinity will reduce chlorophyll a, b, and ab contents in soybean and cucumber. Soybean genotypes tolerant to salinity show higher chlorophyll content than those in susceptible genotypes.

To adapt in a high salinity environment, nodeweeds develops defending mechanism by excreting salt which has already entered plant body and isolating the salt in sites where metabolisms are active. Quick response is performed by increasing external osmotic pressure and accumulating Na^+ in leaves. Salt poisoning can be detected by examining the accumulation of Na^+ and Cl^- ions and chlorosis, necrosis, drying, wilting in leaves. These symptoms were not observed in nodeweeds from Jetis Beach.

Salinity stress may cause osmotic stress by decreasing plant turgor. A high number of stomata in leaf upper surfaces of nodeweeds from Jetis Beach was observed, assuming that the plants will excrete salt via stomata. However, a relatively low number of stomata in leaf lower surface was observed. This proves that nodeweeds is tolerant to high salinity condition.

Salinity affects seed filling and reduces seed yield up to 80%. Susceptible plants will show inhibited growth and leaf enlargement, which in turn will result in decreasing seed yield. In this study, high salinity proved to affect nodeweeds, which can be seen from high content of salt in the plant body, influencing the number and the length of central seeds [8]. However, nodeweeds from Jetis Beach has longer awns in the central seeds in comparison to those from the two other locations. It means that in addition to seawater, nodeweeds seed dispersal is also assisted by wind and animals around coastal areas.

5. Conclusion

Morphological adaptation of nodeweeds with respect to seed number and length as well as leaf structure was observed, particularly in relation to high salinity at low altitude. Similarly, the chlorophyll a and carotene contents as physiological adaptation shows the difference among altitudes.

References

[1] Blake S, Wikelski M, Cabrera F, Guezou A, Silva M, Sadeghayobi E, Yackulic C B and Jaramillo P 2012 Seed Dispersal by Galapagos Tortoises *J. of Biogeography* **39** 1-12

[2] Susanto A H 2018 *Genetika Populasi Synedrella nodiflora (*L.*)* Gaertn. *di Paparan Sunda berdasarkan Penyela Intergenik atp*B-*rbc*L (Universitas Jenderal Soedirman Purwokerto)

[3] Dwiati, M 2013 *Resistensi Gulma Synedrellan nodiflora* (L.) Gaertn. *dan Toleransi Tanaman Arachis hypogaea* L. *terhadap Herbisida Berbahan Aktif Fomesafen: Tinjauan Anatomis, Fisiologis, dan Molekuler* (Universitas Gadjah Mada, Yogyakarta)

[4] Dere S, Gonas T and Sivaci R 1998 Sphectrophotometric Determination of Chlorophyl A, B, and Total Carotenoid Contents of Some Algae Species using Different Solvents *Tr. J. of Botany* **22** 13-7

[5] Munns R and Tester M 2008 Mechanism of Salinity Tolerance *Annual Review Plant Biology* **59** 651-81

[6] Purwaningrahayu R D 2016 Karakter Morfofisiologi dan Agronomi Kedelai Toleran Salinitas *Iptek Tanaman Pangan* **11** 35-48

[7] Weisany W, Sohrabi Y, Heidari Y, Siosemardeh A and Gassemi-Golezani K 2011 Physiological Responses of Soybean (*Glycine max* L.) to Zink Application Under Salinity Stress *Australian Journal of Crop Science* **5** 1441-7

[8] Bustingorri C and Lavado R S 2013 Soybean Response and Ion Accumulation under Sprinkler Irrigation with Sodium-rich Saline Water *Journal of Plant Nutrition* **36** 1743-53

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