Analysis of changes in morphological characteristics of leaves and stems in some sweet potato cultivars (*Ipomoea batatas* L.) from Simalungun and Dairi highlands planting in the lowlands

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**Abstract.** Sweet potatoes can grow in the lowlands and highlands. The ability of sweet potatoes to grow outside their provenance is determined by their ability to adapt to new environments that can be seen from changes in agronomic character. This research aimed to analyse the changes in the morphological character of leaves and stems in some sweet potato cultivars from the Simalungun and Dairi Highlands planted in the lowlands. The experiment was conducted from April to August 2018 in the experimental garden in Cengkeh Turi Village, Binjai. The experiment was arranged in a randomized block design with one factor, namely the sweet potato plant genotype consisting of 5 genotypes from different accessions (accession of Saribu Dolok Simalungun, accession of Kesemak Simalungun, accession of Batang Beruh Dairi, accession of Binjai and variety of Beta-1). The results showed that cultivars of sweet potato G5 (Seribu Dolok), G6 (Kampung Kesemak) and G10 (Batang Beruh) originating from the highlands of Simalungun and Dairi as well as Beta-1 have leaf and character if planted in the lowlands. The three cultivars from the highlands were able to grow well in the lowlands while in the accession of a thousand land did not have differences in morphology.

1. **Introduction**

Sweet potato (*Ipomoea batatas* L.) originated from Central America; European explorers began to introduce this plant in early 1500 to Africa and India, spread to China in 1594, then to Taiwan and Japan in 1594 and its spread throughout Asia including Indonesia [1]. In 2015 Indonesia was the third producer of sweet potato in the world with a total production of 160.53 tons/ha. However, the development of planting area in Indonesia during 1995 to 2016 had decreased by 2.95% per year due to the conversion of agricultural land [2].

The growth of plants including sweet potatoes is influenced by the environment and the ability of plants to adapt. Sweet potatoes have good adaptability that allowed these plants to grow in any soil condition and without fertilization, but the temperature significantly affected the production of tubers in sweet potatoes. The optimum temperature for sweet potato tuber formation is 24°C, the low temperature at high locations causes tubers not to form well [3]. Metabolic processes and hormonal activity influence this difference in growth. Hormones affect the response in plants, such as the growth of roots, stems, shoots and flowering.
The response depends on the species, plant parts, developmental phase, hormone concentration, interactions between hormones, and various environmental factors. Auxin, cytokines and gibberellins can also promote cell extension and division [4].

Agronomic characterization of individual genotypes is an important step in plant breeding programs because it is an action strategy to assemble new cultivars formed through knowledge of agronomic characteristics [5].

The aim was to analyse the changes in the character of leaves and stems in some sweet potato cultivars from Simalungun and Dairi highland, planted in lowland environments as initial data to determine the adaptability of the sweet potato cultivars in a different environment from the place of its origin.

2. Materials and methods

The experiment was arranged in a randomized block design with one factor, namely the sweet potato plant genotype consisting of 5 genotypes from different accessions (accession of Saribu Dolok Simalungun, accession of Kesemak Simalungun, accession of Batang Beruh Dairi, accession of Binjai and varieties of Beta-1) with four replications. Sweet potato accession of Binjai (lowland) and Beta-1 national superior varieties are comparative genotypes. Planting materials were taken from different areas of origin that were planted in the lowlands with an altitude of 35 m above sea level. Plant maintenance included fertilizing, watering, pest, diseases and weeds control. The study of morphological characters in sweet potato leaves and stems was observed at 90 days of plant age, namely the ability to convolute, stem type, stem diameter, stem length, dominant stem colour, stem secondary colour, stem hair, general leaf shape, lobe type, number of lobes, middle lobe shape, leaf size, leaf colour, old leaf colour, shoot colour, leaf stalk length and leaf stalk colour.

3. Results and Discussion

The research results shown in Tables 1, 2 and 3 indicated that the three sweet potato cultivars could grow well in the lowlands. The visual observation data of the three sweet potatoes types showed the growth of some changes in morphological characters in the sweet potato leaves and stems.

Table 1. Changes of morphological character sweet potato genotype 5 accession Silimakuta, Seribu Dolok village, Simalungun

| No  | Parameters                           | In the Lowlands                  | In the Highlands                   |
|-----|-------------------------------------|----------------------------------|-----------------------------------|
| 1   | Twinning                            | Moderately twinning              | Slightly twinning                 |
| 2   | Plant type                          | Extremely spreading (>250 cm)    | Spreading (151-250 cm)            |
| 3   | Vine internode diameter             | Intermediate (7-9 mm)            | Thick (10-12 mm)                  |
| 4   | Vine internode length               | Short (3-5 cm)                   | Intermediate (6-9 cm)             |
| 5   | Predominant vine color              | Mostly purple                    | Green base                        |
| 6   | Secondary vine color                | Green tip                        | Purple spots                      |
| 7   | Vine tip pubescent                  | Moderate                         | Moderate                           |
| 8   | General outline of the leaf         | Triangular                       | Lobed                             |
| 9   | Leaf lobes type                     | Very slight                      | Deep                              |
| 10  | Leaf lobes number                   | 3                                | 6                                 |
| 11  | Shape of central leaf lobe          | Semi-Elliptic                    | Triangular                        |
| 12  | Mature leaf size                    | Medium (8-15 cm)                 | Large (16-25 cm)                  |
| 13  | Abaxial leaf vein pigmentation      | All veins mostly or totally purple | Purple spots in several veins     |
| 14  | Mature leaf color                   | Mostly purple                    | Green                             |
| 15  | Immature leaf color                 | Green with purple edge           | Slightly purple                   |
| 16  | Petiole length                      | Short (10-20 cm)                 | Intermediate (21-30 cm)           |
| 17  | Petiole pigmentation                | Totally or mostly purple         | Green with purple near leaf       |
Table 2. Changes of morphological character sweet potato genotype 6 accession Silimakuta, Kampung Kesemak village, Simalungun

| No | Parameters                      | In the Lowlands                        | In the Highlands                        |
|----|---------------------------------|---------------------------------------|----------------------------------------|
| 1  | Twinning                        | Slightly Twinning                     | Slightly Twinning                      |
| 2  | Plant type                      | Spreading (151-250 cm)                | Extremely spreading (>250 cm)          |
| 3  | Vine internode diameter         | Thin (4-6 mm)                         | Intermediate (7-9 mm)                  |
| 4  | Vine internode length           | Short (3-5 cm)                        | Intermediate (6-9 cm)                  |
| 5  | Predominant vine color          | Mostly dark purple                    | Purple base                            |
| 6  | Secondary vine color            | Green with mostly dark purple         | Green spots                            |
| 7  | Vine tip pubescent              | Heavy                                 | Sparse                                 |
| 8  | General outline of the leaf     | Lobed                                 | Lobed                                  |
| 9  | Leaf lobes type                 | Moderate                              | Deep                                   |
| 10 | Leaf lobes number               | 5                                     | 5                                      |
| 11 | Shape of central leaf lobe      | Semi-Elliptic                         | Triangular                             |
| 12 | Mature leaf size                | Medium (5-8 cm)                       | Large (16-25 cm)                       |
| 13 | Abaxial leaf vein pigmentation  | All veins mostly or totally purple    | Green                                  |
| 14 | Mature leaf color               | Green                                 | Green                                  |
| 15 | Immature leaf color             | Mostly purple                         | Slightly purple                        |
| 16 | Petiole length                  | Short (10-20 cm)                      | Intermediate (21-30 cm)                |
| 17 | Petiole pigmentation            | Green with purple stripes             | Green                                  |

Table 3. Changes of morphological character sweet potato genotype 10 accession Sidikalang, Batang Beruh village, Dairi

| No | Parameters                      | In the Lowlands                        | In the Highlands                        |
|----|---------------------------------|---------------------------------------|----------------------------------------|
| 1  | Twinning                        | Non-Twinning                          | Non-Twinning                           |
| 2  | Plant type                      | Spreading (151-250 cm)                | Semi-erect (75-150 cm)                 |
| 3  | Vine internode diameter         | Thin (4-6 mm)                         | Thin (4-6 mm)                          |
| 4  | Vine internode length           | Short (3-5 cm)                        | Intermediate (6-9 cm)                  |
| 5  | Predominant vine color          | Mostly dark purple                    | Green base                             |
| 6  | Secondary vine color            | Green tip                             | Absent                                 |
| 7  | Vine tip pubescent              | Moderate                              | Sparse                                 |
| 8  | General outline of the leaf     | Hastate                               | Lobed                                  |
| 9  | Leaf lobes type                 | Moderate                              | Deep                                   |
| 10 | Leaf lobes number               | 5                                     | 6                                      |
| 11 | Shape of central leaf lobe      | Semi-Elliptic                         | Semi-Elliptic                          |
| 12 | Mature leaf size                | Medium (8-15 cm)                      | Small (<8 cm)                          |
| 13 | Abaxial leaf vein pigmentation  | All veins mostly or totally purple    | Purple spots in several veins          |
| 14 | Mature leaf color               | Yellow-green                          | Green                                  |
| 15 | Immature leaf color             | Mostly purple                         | Purple both surfaces                   |
| 16 | Petiole length                  | Short (10-20 cm)                      | Short (10-20 cm)                       |
| 17 | Petiole pigmentation            | Some petioles purple, others          | Green with purple at both ends         |
Table 4. Morphological character of sweet potato Tanah Seribu accession genotype, Binjai Selatan, Binjai

| No | Parameters                      | In the Lowlands                  |
|----|---------------------------------|----------------------------------|
| 1  | Twinning                        | Non-Twinning                     |
| 2  | Plant type                      | Spreading (151-250 cm)           |
| 3  | Vine internode diameter         | Thin (4-6 mm)                    |
| 4  | Vine internode length           | Intermediate (6-9 cm)            |
| 5  | Predominant vine color          | Green with many purple spots     |
| 6  | Secondary vine color            | Green base                       |
| 7  | Vine tip pubescent              | Moderate                         |
| 8  | General outline of the leaf     | Triangular                       |
| 9  | Leaf lobes type                 | Very slight                      |
| 10 | Leaf lobes number               | 5                                |
| 11 | Shape of central leaf lobe      | Triangular                       |
| 12 | Mature leaf size                | Small (<8 cm)                    |
| 13 | Abaxial leaf vein pigmentation  | Green                            |
| 14 | Mature leaf color               | Green                            |
| 15 | Immature leaf color             | Green with purple edge           |
| 16 | Petiole length                  | Short (10-20 cm)                 |
| 17 | Petiole pigmentation            | Green with purple stripes        |

Table 5. Changes of morphological character sweet potato of varieties Beta 1 Malang, East Java, Indonesia

| Parameters                      | Beta 1 (in the lowlands) | Beta 1                        |
|--------------------------------|--------------------------|-------------------------------|
| 1 Twinning                     | Slightly Twinning        | Slightly Twinning             |
| 2 Plant type                   | Spreading (151-250 cm)   | Spreading (151-250 cm)        |
| 3 Vine internode diameter      | Very thin (<4 mm)        | Thin                          |
| 4 Vine internode length        | Very short (<3 cm)       | Short                         |
| 5 Predominant vine color       | Green with few purple spots | Green                       |
| 6 Secondary vine color         | Purple Base              | Purple nodes                   |
| 7 Vine tip pubescent           | Sparse                    | Sparse                         |
| 8 General outline of the leaf  | Lobed                     | Triangular                     |
| 9 Leaf lobes type              | Moderate                  | No lateral lobes               |
| 10 Leaf lobes number           | (4-5)                     | 1                             |
| 11 Shape of central leaf lobe  | Semi-Elliptic             | Toothed                        |
| 12 Mature leaf size            | Small (<8 cm)            | Medium                         |
| 13 Abaxial leaf vein pigmentation | All veins mostly or totally purple | All veins mostly purple |
| 14 Mature leaf color           | Green                     | Green                          |
| 15 Immature leaf color         | Purple Both Surface       | Green with purple edge         |
| 16 Petiole length              | Very short (<10 cm)      | Intermediate                   |
| 17 Petiole pigmentation        | Green                     | Green with purple at both ends |

Local sweet potato germplasm is an important genetic material for genetic recombination material and study material for environmental and genotype interaction, especially those related to soil chemical and climate changes in local or regional regions. Local sweet potatoes are related to the growing environment. Ex-situ conservation efforts will help prevent extinction. Ex-situ germplasm collection utilization can be
used as study material for local cultivar germplasm accession responses to environmental changes. Christopher [6] claimed that plant genotypes in different environments would show different expressions. Unpredictable environmental influences such as climate and soil chemistry are challenges in forming genotypes that are tolerant to environmental change.

The results of the three sweet potato cultivars have good adaptability. Sweet potatoes from Simalungun and Dairi show significant growth rates. The Tanah Seribu genotype of sweet potato crop yields is better to be planted in lowlands because of the appropriate conduction temperature. However, Beta-1 plants do not show suitable growth in the lowlands in terms of leaves and stems. Based on the research results of Rosmayati and Bakti [7], it was stated that sweet potato cultivars from the highlands had growth that was able to increase production based on the morphology of leaves and stems. This condition was in accordance with Gajanayake [8] statement, that the altitude of the place would affect soil conditions and climate. At high altitudes, the temperature will be lower so that it can damage and affect the tubers produced by sweet potatoes in both quality and quantity.

Furthermore, Rukmana [9] stated that lowlands usually have low rainfall (<1,500 mm/year), low humidity levels (30-40%) and high air temperatures (> 25 °C). Lowland soil conditions are generally crumb, loose, tend to clay until sandy clay and clump with low to moderate levels of organic matter and low productivity levels. While highlands have high rainfall (> 1,500 mm/year), high humidity levels (65-70%) and low air temperatures (<25 °C), the soil conditions are crumbs, loose, dusty clay and high levels of organic matter with moderate to high productivity.

The intensity of light in the highlands is higher than the intensity of light in the lowlands. The quality, intensity, and duration of radiation that affect plants have a great influence on various plant physiological processes. Light affects the formation of chlorophyll, photosynthesis, phototropism, and photoperiodic. The effect of light increases the work of enzymes to produce metabolic substances for chlorophyll formation. Meanwhile, in the photosynthesis process, light intensity affects the rate of photosynthesis during a bright reaction. Thus, light indirectly controls the growth and development of plants, because photosynthesis results in the form of carbohydrates are used for the formation of plant organs. The development of plant forms is also influenced by light (photo morphogenesis) [10]. Nai'em [11] stated that the factors that cause variations between plants due to genetic differences, growing environmental differences and the interaction between the two. In sweet potato plants, there is a high interaction between genotypes and environment to root growth [12]. Genotypes respond to environmental changes with adaptation mechanisms so that the environment is optimal for plant growth. All genotypes are spread in all environments, but the planting environment is only in certain environments [13]. Furthermore, Ching (2000) stated that sweet potatoes grown in the middle plains could increase the number and weight of roots [14].

Plants adapted to respond the unfavourable external conditions by starting changes in enzymes/hormones to changes in body morphology. This change does not occur instantaneously, the plant continues to develop to make itself last for a long time. Plant adaptation varies depending on domestication where the plant is cultivated, generally, plant adaptation is in response to the short length of sun irradiation intensity and temperature. The intensity of the sun and the temperature depends on the height of the area, the higher the place the sun's intensity and the temperature decreased.

4. Conclusions
Sweet potato cultivars G5, G6 and G10 originating from the highlands in Simalungun and Dairi showed some differences in the character of leaves and stemmed when planted in the lowlands. The three cultivars from the highlands were able to grow well in the lowlands which showed that the three sweet potato cultivars had excellent adaptability. Tanah Seribu genotype of sweet potato plants shows better results for planting in the lowlands due to suitable temperature conditions. However, Beta 1 plants do not show suitable growth in the lowlands in terms of leaves and stem characters.

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