



RESEARCH ARTICLE

Phenotypic appearance of maize plants in Langkat and Simalungun districts, North Sumatra, Indonesia

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Abstract

Maize is a potential commodity in Indonesia that is utilised as animal feed and raw material for the food industry. Plant breeding programmes are carried out to increase genetic diversity, which begins with observations of plant characterisation to identify phenotypic appearance and diversity of plant characters. This study aims to carry out the morphological characterisation of plants to identify the phenotypic appearance of the maize accessions in Langkat and Simalungun districts. This research was conducted in Langkat and Simalungun districts, North Sumatra, Indonesia. Morphological observations were made on qualitative and quantitative characters based on the maize descriptor guidebook of the International Union for the Protection of New Varieties of Plants (UPOV). Characters observed include leaf colour, stem colour, undulation of the margin of the blade, plant length, stem diameter and leaf length. The results showed that the 12 accessions of maize plants in Langkat and Simalungun districts displayed different and specific phenotypic appearances in some accessions based on qualitative and quantitative characters. The value of phenotypic variability in 12 accessions of maize plants also shows broad criteria for all characters.

Keywords: maize accession; morphological characterisation; plant breeding

Introduction

Maize is utilised as feed for poultry and cattle, household food needs and raw materials for the food industry. Maize is used for animal feed (75 %), non-feed and food industry (23 %) and the remainder for direct household consumption and seeds (1). Indonesia's maize productivity in 2023 was 14774432.52 tonnes. North Sumatra is the third largest national maize producer after East Java and Central Java with 1343290.59 tonnes (2).

Plant breeding programmes can be characterised by high genetic diversity, genetic variability in the base population and effective selection (3, 4). Plant breeding programmes begin with plant characterisation to identify the diversity of plant characters as basic information for selecting appropriate parents for variety establishment or development (5, 6). Plant characterisation is carried out on characters that are not influenced by environmental factors and are easily passed on genetically (7).

Plant morphological characters are used to identify germplasm variability and select desirable germplasm to develop and produce new varieties (8,9). Plant morphological characterisation is carried out by observing plant phenotypes through qualitative and quantitative characters to identify plant

accessions according to the desired characteristics (10, 11). The diversity of plant populations is studied using morphological characters by direct observation of the phenotype of the plant (12).

Phenotypic appearance through morphological characterisation is the initial stage to obtain basic information on plant diversity in Langkat and Simalungun districts, North Sumatra. The results of this study are expected to be developed for the assembly of superior maize plants.

Materials and Methods

Research place and time

This research was carried out from September to October 2024 in Langkat and Simalungun districts, North Sumatra.

Research materials

The materials used in this study included plastic labels, questionnaire sheets and other supporting materials. The tools used in this study included the global positioning system (GPS), cameras, callipers, rulers and other supporting tools. The number of maize samples observed was 12 accessions, consisting of 5 accessions in Langkat district and 7 accessions in Simalungun district.

Research methods

This research used a survey method. This method was carried out by direct observation and interviews in several locations in Langkat and Simalungun districts, North Sumatra. The research locations were selected based on literature study data and information from the local community. Sampling was done by the purposive sampling method. Morphological observations were carried out on qualitative and quantitative characters based on the maize descriptor guidebook of the International Union for the Protection of New Varieties of Plants (UPOV). Data analysis was carried out by observing phenotypic variation and standard deviation of phenotypic variation.

Phenotypic variation (σ^2p) can be calculated using the following formula:

$$\sigma^2 = \frac{\sum (x_i - \bar{x})^2}{n} \quad (13)$$

The extent or narrowness of the genetic diversity value of a character is determined based on the phenotypic variation and the standard deviation of phenotypic variation. The standard deviation of phenotypic variation ($S\sigma^2p$) can be calculated based on the variability or distribution of phenotype values within a population. If $\sigma^2p \geq 2S\sigma^2p$, the diversity is broad; if $\sigma^2p < 2S\sigma^2p$, the diversity is narrow (14).

Observation parameters

The parameters observed in this research were leaf colour, stem colour, undulation of the margin of the blade, plant length (cm), stem diameter (mm) and leaf length (cm). Leaf colour was observed by looking at the morphological appearance of the leaves. Stem colour was observed by looking at the morphological appearance of the stems. The undulation of the margin of the blade was observed by looking at the margin of the blade. Plant length was measured from the base of the stem to the longest leaf of the plant. The stem diameter was measured with a digital calliper. Leaf length was measured using a ruler. All observations in this research were made using the International Union for the Protection of New Varieties of Plants (UPOV) guidelines.

Results

Qualitative and quantitative character diversity of maize accessions in Langkat and Simalungun districts

Qualitative phenotypic observations showed variations in vegetative characteristics that could be visually distinguished among the 12 accessions, particularly in stem colour and undulation of margin. In

general, the leaf colour in all accessions was observed to be green, but the stem colour showed two main patterns, namely green and green-red, while the undulation of the leaf margins ranged from absent or very weak, intermediate to strong. This pattern indicates that the accession collection has fairly clear morphological diversity in characters that are relatively easy to assess in the field and commonly used in the initial characterisation of germplasm.

Quantitative data show a wide range of values for the three vegetative traits measured, namely plant height, stem diameter and leaf length, both in Langkat and Simalungun districts. At the accession level, there are accessions with relatively high vegetative performance (e.g. accessions with greater plant height and leaf length) and accessions with lower values. Descriptively, accessions from Simalungun also include groups with reddish-green stems and several quantitative values that tend to be larger in some accessions, indicating potential genetic differences, local adaptation or responses to the local growing environment. The phenotypic differences between maize accessions can be seen in Fig. 1. The diversity of qualitative and quantitative characteristics in the maize collection in Langkat and Simalungun districts can be seen in Table 1.

Fig. 1 shows that the maize accessions in Langkat and Simalungun districts differ in phenotypic appearances for each observed character. Differences in phenotypic appearance are based on qualitative and quantitative characters.

Table 1 shows that the maize accessions in Langkat and Simalungun districts have different appearances for each observed vegetative trait. The phenotypic appearance of each accession is different and specific.

Analysis of phenotypic variability of maize accessions in Langkat and Simalungun districts

Table 2 shows that the maize genotypes in Langkat and Simalungun districts have different values for mean, phenotypic variability, standard deviation and criteria for each observed character. The plant length, stem diameter and leaf length characters show broad criteria for maize accessions.

Discussion

Observation results of morphological characterisation in 12 maize plant accessions in Simalungun and Langkat districts, North Sumatra, Indonesia show different phenotypic appearances. This shows that the genotype and the environment influence the appearance of the phenotype. Morphological characterisation is the observation of characters on plant phenotypes. Phenotype is the result of the interaction between genotype and environment. Phenotype is used to detect the existence of morphological plant

Table 1. Phenotypic appearance of maize accessions observed in Langkat and Simalungun districts, North Sumatra, Indonesia

Phenotypic appearance		Vegetative traits					
District	Accession	Leaf color	Stem color	Undulation of margin of blade	Plant length (cm)	Stem diameter (mm)	Leaf length (cm)
Langkat	1	Green	Green	Strong	264.2	21.4	35.1
Langkat	2	Green	Green	Intermediate	273.2	15.9	33.0
Langkat	3	Green	Green	Strong	253.7	19.9	36.1
Langkat	4	Green	Green	Absent or very weak	196.3	13.6	30.1
Langkat	5	Green	Green	Strong	236.2	14.2	34.8
Simalungun	6	Green	Green Red	Intermediate	284.4	30.4	49.3
Simalungun	7	Green	Green Red	Intermediate	288.1	23.3	48.5
Simalungun	8	Green	Green	Absent or very weak	204.8	16.1	39.1
Simalungun	9	Green	Green	Intermediate	277.4	20.4	34.2
Simalungun	10	Green	Green	Intermediate	248.5	12.8	35.4
Simalungun	11	Green	Green	Intermediate	233.5	13.1	39.8
Simalungun	12	Green	Green	Intermediate	320.7	25.6	47.5

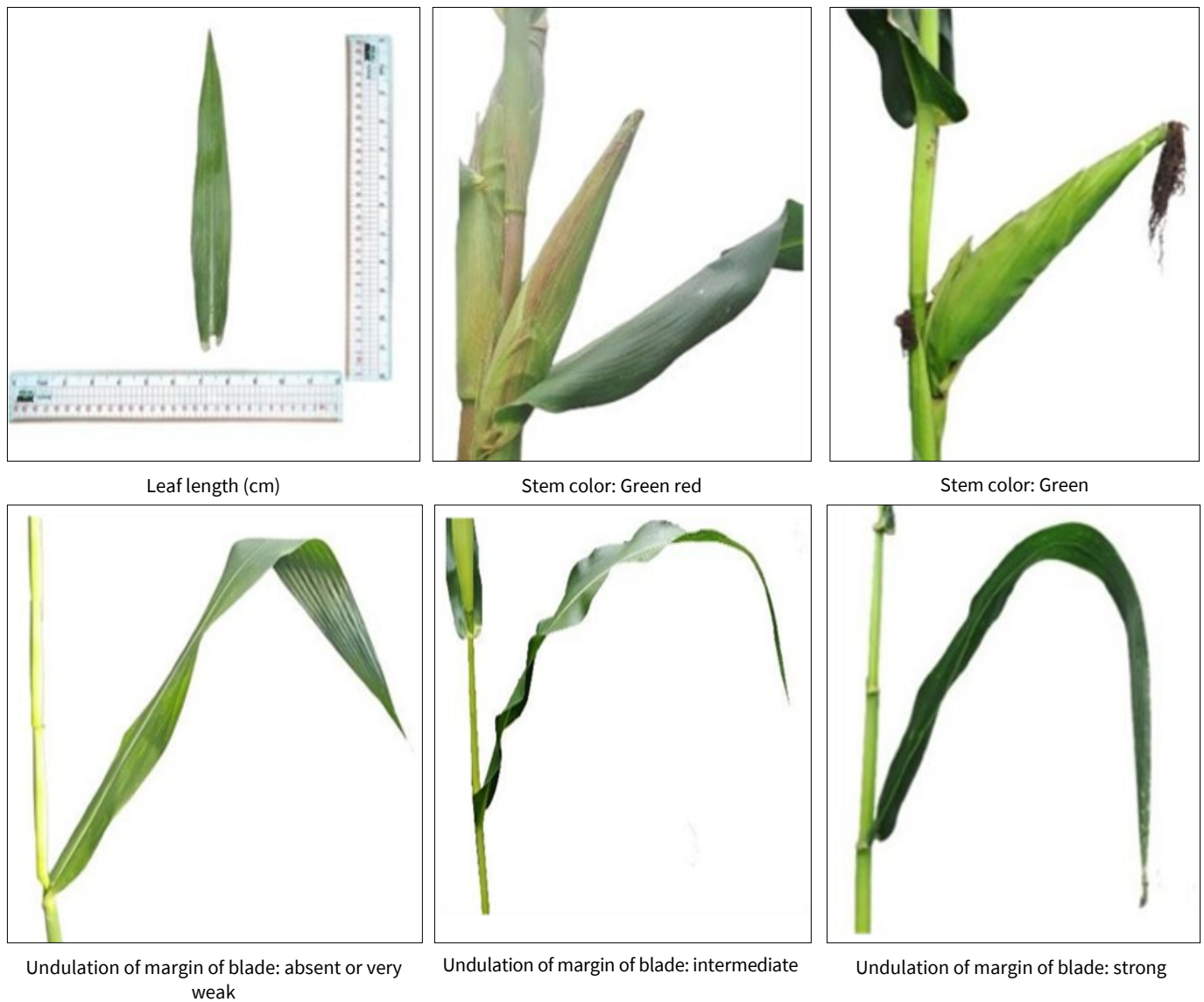


Fig. 1. Differences in phenotypic appearance in 12 accessions of maize plants in Simalungun and Langkat districts, North Sumatra, Indonesia.

Table 2. Mean values, phenotypic variability values, standard deviations and criteria for maize accessions in Langkat and Simalungun districts, North Sumatra, Indonesia

Phenotypic appearance	Mean	σ^2p	$S\sigma^2p$	$2S\sigma^2p$	Criteria
Plant length (cm)	256750	127116	3565	7131	Broad
Stem diameter (mm)	18892	3126	559	1118	Broad
Leaf length (cm)	38575	4178	646	1293	Broad

diversity (15). The phenotype of a character is not only influenced by genetic factors but also by environmental factors (16). Morphological traits are essential for characterising and estimating the variability of plant accessions caused by individual genotypic traits (17). The diversity of phenotypic appearance shows the relationship between the number of genes or environmental factors contained in each accession (18).

The morphological characterisation of 12 maize plant accessions in Langkat and Simalungun districts showed different and specific phenotypic appearances for some accessions (Table 1). This indicates that there is high genetic diversity, which can be harnessed to develop a superior variety that enhances crop productivity. Genetic diversity shows the variation between

individuals in a population. High genetic diversity allows the improvement of plant characters (19). Genetic diversity can protect and preserve plant genetic resources (20).

Analysis of phenotypic variation showed different and significant values in 12 maize plant accessions in Simalungun and Langkat districts. All phenotypic variability values show broad criteria, so that the phenotypic appearance of the resulting plants is diverse (Table 2). Analysis of variance (ANOVA) showed highly significant morphological variation among several maize accessions (21). Phenotypic diversity is used as genetic information and visual distinction of plants. If phenotypic variability is in the broad criteria, then the appearance of characters is diverse (22). Plant diversity is strongly influenced by the diversity of phenotypic characters and genetic makeup in plant populations (23).

Conclusion

The 12 accessions of maize plants in Langkat and Simalungun districts showed different and specific phenotypic appearances in some accessions based on qualitative and quantitative characters. The value of phenotypic variability in 12 accessions of maize plants also shows broad criteria for all characters.

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Authors' contributions

GR contributed in the conceptualisation of the research, development of methodology, software and investigation. DSH contributed in the execution of the research and provision of resources. S, MS and CH contributed in the analysis, curation and validation of data, as well as manuscript editing. M and MHA contributed in the writing, review and editing of the original manuscript draft, as well as visualisation of the results. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: The author has no conflicts of interest to declare.

Ethical issues: None

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