

Morpho-agronomic description of local red chili 'Justiber' based on limited field observations in North Sumatra

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ABSTRACT

Local chili pepper germplasm is an important genetic resource for crop improvement because it may harbor useful phenotypic variation in vegetative vigor, plant architecture, reproductive timing, and productivity. This study examined the morpho-agronomic traits of the local red chili 'Justiber' as preliminary baseline information for future descriptor-based evaluation and population expansion. The study was conducted in Simpang Selayang Village, Medan Tuntungan District, North Sumatra, Indonesia, from January to March 2026. The observed parameters included dichotomous height, plant height, stem diameter, days to flowering, number of branches, leaf length, and days to first harvest. From an initial field planting of 30 plants, only 10 normally growing plants that could be monitored consistently until first harvest were used as observation units; stunted or abnormal plants were excluded and are acknowledged as a limitation. This exploratory study did not compare treatments or genotypes; therefore, the data were analyzed descriptively using the mean, standard deviation, range, coefficient of variation, and 95% confidence interval. The results showed mean values of 77.40 ± 9.70 cm for plant height, 9.40 ± 0.97 mm for stem diameter, 57.00 ± 1.49 days after planting for flowering, 4.70 ± 1.25 branches, 8.10 ± 0.76 cm for leaf length, and 89.70 ± 1.64 days after planting for first harvest. The highest coefficient of variation was observed for number of branches (26.63%), whereas days to first harvest showed the lowest variation (1.82%). These findings indicate that the observable variation of 'Justiber' was concentrated mainly in vegetative architecture, while reproductive timing was relatively synchronized.

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1. INTRODUCTION

Chili peppers (*Capsicum* spp.) are an important horticultural commodity with high economic value, whether as a vegetable, spice, ingredient in the food industry, or source of bioactive compounds. In the context of plant breeding, increasing chili pepper productivity depends not only on cultivation technologies but also on the availability of genetic resources with variation in growth traits, reproductive lifespan, plant architecture, fruit quality, and adaptability. Therefore, local chili pepper varieties, or landraces, hold a strategic position as a source of germplasm that can be used in the development of new varieties.

Local chili peppers, or local varieties, are strategically important because they have been maintained through farmer selection and adaptation to specific agroecological conditions. These materials can preserve allelic and phenotypic diversity that is absent in more uniform commercial cultivars. In North Sumatra, the documentation of local chili germplasm is also urgent because informal seed exchange, replacement with high-yielding varieties, and repeated farmer selection may narrow the genetic base before these materials are formally characterized. Similar concerns regarding the conservation value of local chili pepper varieties have been reported in Capsicum collections from various regions (Gerakari et al., 2025; Occhiuto et al., 2014; Vanlalremruatsaka et al., 2025).

A local red chili known as 'Justiber' is widely cultivated by farmers in Sidodadi Ramunia Village, Beringin Subdistrict, Deli Serdang Regency, North Sumatra. It is locally recognized as a red chili variety cultivated by smallholder farmers, but its descriptor-based morphological-agronomic profile has not yet been systematically reported. Therefore, basic information regarding vegetative vigor, branching patterns, flowering synchronization, and harvest time is still insufficient to determine whether this material should be conserved, expanded, or developed as a candidate foundation population.

Morpho-agronomic characterization is a crucial step because it provides foundational information on plant variation. Traits such as plant height, stem diameter, number of branches, leaf length, flowering time, and harvest time can reflect vegetative vigor, plant architecture, and the dynamics of the reproductive phase. Studies on Capsicum collections from various regions have shown that characterization based on morphological descriptors can distinguish accessions, describe phenotypic variation, and enrich information on the conservation of genetic resources (Brilhante et al., 2021; Ibarra-Legarda et al., 2025).

For undocumented local germplasm, a small preliminary dataset can be useful when its limitations are clearly stated. The value of such data lies not in proving genetic superiority, but in identifying traits that appear variable or relatively synchronized and in guiding descriptor selection for the next evaluation cycle. This cautious position is consistent with descriptor-based Capsicum characterization and with sample-size discussions emphasizing that adequate sample size is required for precise breeding evaluation (Martínez-Ispizua et al., 2022). Alves et al., (2022), who emphasized that sample size and evaluation precision are critical when Capsicum genotypes are characterized for breeding purposes.

In breeding, a base population is an initial population that should retain sufficient variation for selection and population improvement. For a local chili material such as 'Justiber', preliminary characterization can help breeders decide whether the population should first be enlarged, whether individual plants should be tagged for further observation, and which descriptors need to be added before selection is attempted. This is important because farmer seed selection can change the genetic composition of pepper landraces across generations (Portis et al., 2004; Liu et al., 2025).

Therefore, this study aims to: (1) describe the initial morphological and agronomic characteristics of the local red chili pepper variety 'Justiber'; (2) measure the degree of phenotypic variation using descriptive statistics and the coefficient of variation; (3) formulate practical implications for the conservation and expansion of 'Justiber' as a breeding foundation population.

2. METHOD

2.1 Place and time of research

This study was conducted in Simpang Selayang, Medan Tuntungan District, North Sumatra Province, from January to March 2026.

2.2 Research tools and materials

The tools used in this study were mulch, a hand sprayer, a measuring tape, a ruler, a vernier caliper, writing utensils, and other supporting tools. The plant material consisted of seeds of the local red chili 'Justiber' collected from Sidodadi Ramunia Village, Beringin Subdistrict, Deli Serdang Regency. The supporting cultivation inputs included NPK fertilizer, TSP, Amophost, insecticides, fungicides, and other supporting materials used to maintain plant growth under field conditions.

2.3 Research design and justification of sample size

This study employed a descriptive-exploratory design without comparisons of treatments or genotypes. The field planting initially consisted of 30 'Justiber' plants. During plant establishment, several plants showed stunted or abnormal growth and could not be measured consistently until first harvest; therefore, only 10 healthy plants with normal growth and complete observation records were retained as observational units. This choice was made to obtain a consistent preliminary morpho-agronomic profile of normally established 'Justiber' plants. However, the

exclusion of stunted or abnormal plants means that the results do not represent the full variability of the initial field population and may underestimate or bias the diversity estimate. For this reason, the study is positioned only as preliminary baseline documentation, not as evidence for variety release, confirmed genetic diversity, or formal base-population development.

2.4 Seed preparation and land preparation

Chili pepper seeds were sown before being transplanted into the field. Seedlings were transplanted 3–4 weeks after sowing or when they had 4–5 leaves. From an initial field planting of 30 plants, ten normally growing plants that remained healthy and could be monitored continuously until first harvest were used as observation units. The selection criteria were normal growth, absence of severe stunting, absence of severe mechanical damage, and complete observation records. Plants that were severely stunted, abnormal, or incomplete in observation records were excluded from descriptive measurement and were recorded as an establishment limitation of this preliminary study.

The research plot was divided into two sections, each measuring 15 m × 1 m. Planting distances were 1 m between rows and 60 cm between plants. The plot layout and planting distances were applied uniformly to all plants, so any differences observed among the plants were not due to variations in planting distances or plot management conditions.

Cultivation practices followed standard land management for red chili pepper production. Plastic mulch was used to suppress weed growth and help maintain soil moisture. Irrigation was performed once daily. Weeding was done manually as needed, and all maintenance practices were applied uniformly across all plots. Fertilization was applied uniformly to all plants. The base fertilizer consisted of NPK at 600 g and compost at 60 kg per unit area of the research plot, applied 3 days before planting. Follow-up fertilization was carried out once a week during the growing season using NPK fertilizer dissolved in water, which was then applied to the growing medium.

2.5 Research methods and observation variables

This study used an exploratory descriptive design. The observed variables included dichotomous height, plant height, stem diameter, time to flowering, number of branches, leaf length, and harvest age. The study did not conduct treatment or genotype comparisons; therefore, each observed plant was treated as an observational unit for preliminary population characterization.

Observation procedures were standardized as follows: dichotomous height was measured from the soil surface to the first dichotomous branching point; plant height was measured from the soil surface to the highest growing point; stem diameter was measured using a vernier caliper on the lower stem section; leaf length was measured on fully expanded leaves; number of branches was counted as visible productive vegetative branches; flowering age was recorded when the first flower appeared; and harvest age was recorded when the first fruit reached harvestable maturity. These operational definitions were added to improve reproducibility and to align the study with descriptor-based characterization practice.

2.6 Data Analysis

The data were analyzed using descriptive statistics to describe the central tendency, dispersion, and relative variability among traits. The analyses included mean, standard deviation, standard error, range, coefficient of variation, and 95% confidence interval.

This analysis is appropriate for initial characterization because the number of plants is still limited and the study has not yet compared different treatments or genotypes.

The coefficient of variation was calculated using the formula

$$CV (\%) = (SD / \bar{X}) \times 100. \quad (1)$$

The CV was interpreted as follows: low if $CV < 10\%$, moderate if $10\text{--}20\%$, and high if $> 20\%$. The 95% confidence interval was used only to show the precision of the mean estimate for each trait, not to test differences among treatments. Since no treatment or genotype comparisons were performed, no analysis of variance or mean separation test was conducted.

3. RESULTS AND DISCUSSION

3.1 Morphological and agronomic characteristics

The morpho-agronomic characteristics of the local red chili 'Justiber' are presented in Table 1. Plant height had a mean of 77.40 cm, a standard deviation of 9.70 cm, and a range of 58.70–89.00 cm, indicating moderate plant-to-plant variation in vegetative vigor. Using the plant-height descriptor classes applied in *Capsicum* characterization (<25, 25–45, 46–65, 66–85, and >85 cm), the mean plant height of 'Justiber' falls within the 66–85 cm class, while some individuals exceeded

85 cm. Therefore, under the present field conditions, 'Justiber' can be interpreted as a moderately tall to tall plant type rather than a short type (Gurung et al., 2020; IPGRI, 1995). Bozokalfa et al. (2009), whose mean plant heights ranged from 55.52 to 82.74 cm, 'Justiber' was positioned near the upper part of the reported range. Thus, under the present field conditions, 'Justiber' may be interpreted as a medium-to-tall local red chili population. Because the present study did not use replicated genotypes or controlled environmental gradients, the observed variation should be interpreted as phenotypic variation rather than confirmed genetic variation.

Stem diameter had a mean of 9.40 mm and a CV of 10.33%, placing it in the moderate-variation category. Stem robustness is agronomically relevant because it supports canopy structure and may influence lodging tolerance and fruit-bearing capacity. Flowering age averaged 57.00 days after planting (DAP) with a range of 55–59 DAP, while first harvest age averaged 89.70 DAP with a range of 87–92 DAP. Compared with pepper germplasm groups reported by Bozokalfa et al. (2009), where days to flowering were around 56.48–62.38 days across clusters and the earliest group flowered at 56.8 days, the flowering age of 'Justiber' may be described as relatively early to intermediate. However, it should not be considered a very early-flowering genotype because definitions of flowering, environments, and genetic materials differ across studies. The low CV values for flowering age (2.62%) and first harvest age (1.82%) indicate that reproductive timing was more synchronized than vegetative architecture in the observed plants.

Table 1. Morphological and agronomic characteristics of the local red chili 'Justiber'

Variabel	Average \pm SD	CI 95%	Min-Maks	Rentang	CV (%)	Category
TD	33.30 \pm 2.39	31.59–35.01	28.90–37.60	8.70	7.18	Low
TT	77.40 \pm 9.70	70.46–84.34	58.70–89.00	30.30	12.54	Medium
DB	9.40 \pm 0.97	8.71–10.09	7.80–10.50	2.70	10.33	Medium
UB	57.00 \pm 1.49	55.93–58.07	55.00–59.00	4.00	2.62	Low
JC	4.70 \pm 1.25	3.80–5.60	3.00–7.00	4.00	26.63	High
PD	8.10 \pm 0.76	7.56–8.64	7.00–9.60	2.60	9.35	Low
UP	89.70 \pm 1.64	88.53–90.87	87.00–92.00	5.00	1.82	Low

Note: SD (standard deviation), TD (dichotomous height), TT (plant height), DB (stem diameter), UB (flowering age), JC (number of branches), PD (leaf length), UP (harvest age), and DAP = days after planting.

Table 1 shows a clear contrast between relatively stable reproductive timing and more variable vegetative architecture. The low CV for flowering age and harvest age suggest that the observed plants entered reproductive development within a narrow time window, whereas the medium CV for plant height and stem diameter, and the high CV for number of branches, indicate that vegetative growth and canopy form still vary among individuals. This pattern is useful for early population screening because it helps identify which traits may be maintained for uniformity and which traits may be used as selection criteria in the next cycle.

The wide range in plant height (58.70–89.00 cm) should be interpreted with caution because the study involved only 10 plants. Nevertheless, the difference between minimum and maximum plant height indicates that individual plants did not express identical vegetative vigor under the same field condition. In practical breeding terms, taller plants with thicker stems may be tagged for further observation, but selection should not be based on height alone because excessive height without fruit productivity may not be agronomically desirable.

This type of descriptive statistical characterization is consistent with various studies on red chili that consider vegetative and reproductive traits as fundamental information on germplasm. Orobiyi et al (2025) reported that morpho-agronomic traits can characterize chili landrace variation, while Paredes Andrade et al (2020) demonstrated that a combination of morphological, sensory, and chemical traits can enhance the documentation of chili genetic collections. Similar results were also reported by Moon et al (2023); Silva et al (2021), who found extensive variation in the agro-morphological and phytochemical traits of various red chilli germplasm.

The CV pattern in this study was also consistent with the general pattern reported in chili pepper germplasm characterization, where vegetative and architecture-related traits commonly show greater variability than reproductive timing traits. In 'Justiber', number of branches showed high variation (CV = 26.63%), plant height and stem diameter showed moderate variation (12.54% and 10.33%), whereas flowering age and first harvest age showed low variation (2.62% and 1.82%). Compared with the wider *Capsicum* landrace collections reported by Karkee et al. (2022), which included several traits with CV values above 20% and a maximum CV of 68.44% for stem length, the CV of 'Justiber' is not extremely high for a multi-accession germplasm context. Nevertheless, for a farmer-maintained local population observed under uniform field management, the high CV for branch number is important because it identifies canopy architecture as the main trait to prioritize in subsequent larger-scale evaluation.

3.2 Phenotypic diversity and source base population

Phenotypic diversity is a key starting point for identifying characters that require further evaluation before any breeding decision is made. In the local red chili 'Justiber', the most prominent trait in terms of relative variation was the number of branches. This result suggests that canopy architecture was not yet fully uniform in the observed normal plants. Branching pattern is relevant because it may influence leaf distribution, light interception, flowering-site distribution, and the spatial arrangement of fruits within the canopy.

The high CV of branch number (26.63%) is the strongest descriptive signal in the current dataset. In comparison, Karkee et al. (2022) reported CV values ranging from 5.54% for average days to flowering to 68.44% for average stem length in *Capsicum* landraces, with several traits showing CV values above 20%. Thus, the branch-number CV in 'Justiber' is clearly high according to the practical threshold used in this study, but it is still within the broader range commonly observed in *Capsicum* germplasm studies. Nevertheless, the branch number should be treated as an indirect selection trait. It is useful for breeding only when associated with economically relevant traits such as fruit number per plant, fruit weight per plant, marketable yield, fruit uniformity, or stress tolerance. Therefore, the present finding should be used to design a larger observation cycle rather than to make a final selection decision.

Additional diversity indicators based on the available plant-level summary showed that variation was not evenly distributed across traits. The relative range was highest for the number of branches (85.11%), followed by plant height (39.15%), leaf length (32.10%), stem diameter (28.72%), and dichotomous height (26.13%). In contrast, the relative ranges for flowering age and harvest age were narrow, at 7.02% and 5.57%, respectively. This pattern indicates that the observable diversity of 'Justiber' in this preliminary population is concentrated mainly in vegetative architecture rather than reproductive timing.

Table 2. Derived phenotypic diversity indicators based on raw plant-level data

Trait	Variance	SE	Relative range (%)	CV (%)	Diversity signal
TD	5.71	0.76	26.13	7.18	Low CV; moderate spread in dichotomous height
TT	94.16	3.07	39.15	12.54	Moderate diversity in plant height
DB	0.94	0.31	28.72	10.33	Moderate diversity in stem robustness
UB	2.22	0.47	7.02	2.62	Low diversity; flowering relatively synchronized
JC	1.57	0.40	85.11	26.63	Highest diversity; main source of architectural variation
PD	0.57	0.24	32.10	9.35	Low CV but visible leaf-size spread
UP	2.68	0.52	5.57	1.82	Lowest diversity; harvest age synchronized

Note: TD (dichotomous height), TT (plant height), DB (stem diameter), UB (flowering age), JC (number of branches), PD (leaf length), and UP (harvest age)

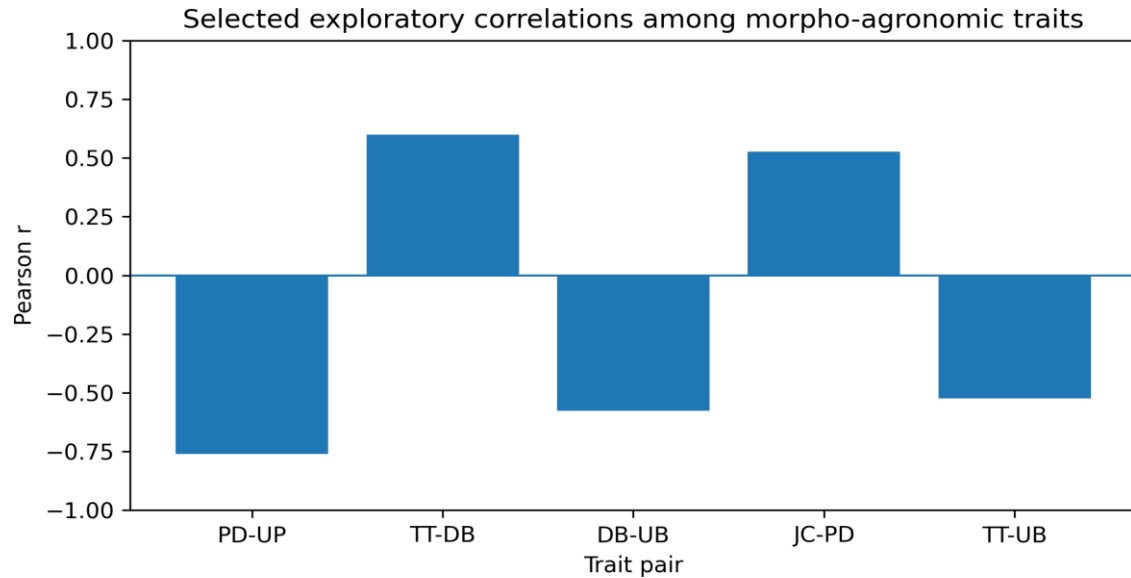
The correlation analysis provided additional insight into possible relationships among the observed traits (Table 3). The strongest reported association was between leaf length and days to first harvest ($r = -0.762$; $p = 0.010$), suggesting that plants with longer leaves tended to reach first harvest earlier in this preliminary dataset. Moderate exploratory tendencies were also observed between plant height and stem diameter, stem diameter and flowering age, number of branches and leaf length, and plant height and flowering age. These relationships may reflect the coordination between vegetative vigor and reproductive development, but they must be verified in a larger population before they are used as selection criteria.

Table 3. Main exploratory correlations among morpho-agronomic traits

Trait pair	r	p-value	Interpretation
PD - UP	-0.762	0.010	Longer leaves tended to be associated with earlier first harvest
TT - DB	0.600	0.067	Taller plants tended to have thicker stems; exploratory trend
DB - UB	-0.576	0.081	Thicker stems tended to flower earlier; exploratory trend
JC - PD	0.528	0.117	More branches tended to accompany longer leaves; weak-to-moderate trend
TT - UB	-0.525	0.119	Taller plants tended to flower earlier; weak-to-moderate trend

Note: r = Pearson correlation coefficient. Correlations are reported as exploratory patterns because $n = 10$; they should not be generalized without confirmation in a larger population.

Figure 1. Selected exploratory Pearson correlations among measured traits. The figure visualizes only the trait pairs reported in Table 3.



4. CONCLUSION

This study shows that observable morpho-agronomic variation in the local red chili ‘Justiber’ was concentrated mainly in vegetative architecture. The most variable trait was number of branches (CV = 26.63%; high), followed by plant height (CV = 12.54%; moderate) and stem diameter (CV = 10.33%; moderate). In contrast, flowering age (CV = 2.62%) and first harvest age (CV = 1.82%) were relatively synchronized, indicating low variation in reproductive timing among the ten normally established plants. Based on descriptor comparison, the mean plant height of 77.40 cm suggests a moderately tall to tall plant type, while flowering at 57 DAP should be interpreted as relatively early to intermediate rather than as strong evidence of very early flowering. Because only ten normal plants were observed and no yield traits, progeny testing, or molecular analysis were included, these results should not be used to claim confirmed genetic diversity or formal base-population development. Further research should expand the population size, include systematic records of abnormal or stunted plants, compare ‘Justiber’ with other local and commercial chili materials, evaluate fruit and yield traits, and conduct multi-season or multi-location observations. Progeny testing and/or molecular characterization is also recommended before ‘Justiber’ is used as a formal breeding source population.

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