OPEN ACCESS Journal of Sustainable Dryland Agricultural Systems

Study of Genetic Diversity of Self-Crossed Lines of Corn (*Zea mays* L.) in Dryland

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Received: Januari 26, 2026
Revised: May 18, 2026
Accepted: June 20, 2026
Published: June 30, 2026

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DOI: 10.29303/josdas.v6i1.1506

Abstract: This study aims to examine changes in the genetic diversity of self-pollinated lines in maize (*Zea mays* L.) grown on dryland. The experiment was conducted on dryland in Gumantar Village, North Lombok Regency, from May to August 2024. A single factor randomised block design was used, with genotype as the factor. There were 61 genotypes, comprising selfing lines of generations S1, S2, S3 and S4 (15 lines each) and one F2 foundation population. Each treatment was replicated twice, resulting in 122 experimental units. The traits observed included growth characteristics, yield components and yield. The experimental data were Analysed Using Analysis of Variance (ANOVA). Subsequently, the Coefficients of Genetic Variation (CGV) and genotypic correlations were calculated. The results of the study showed that selfing lines up to the S4 generation exhibited narrow genetic variation for most quantitative traits, particularly vegetative traits. Some yield traits, such as the weight of shelled dry seeds in the S3 generation and stem diameter in the S4 generation, still exhibited relatively broader genetic variation and held potential for selection. Several growth traits of the first, second, third and fourth-generation selfing lines differed from those of the F2 population; however, these differences did not have a significant effect on yield components or total yield. Genotypic correlations between agronomic traits and yield were generally weakly positive to non-correlated. Taller maize plants could be selected for selfing in the fourth generation to improve yield in the fifth-generation lines.

Keywords: Maize, Self-Pollination, Genetic Diversity, Dryland, Genotypic Correlation.

Introduction

Maize (Zea mays L.) is one of Indonesia's main food commodities after rice, playing a vital role as a source of carbohydrates, an industrial raw material and animal feed. Domestic demand for maize continues to rise in line with population growth and the ever-increasing needs of the animal feed industry (Jauhari et al., 2022). Indonesia's population, which is projected to reach 281.64 million by 2024 and continue to grow in subsequent years, demands an ever-greater and more stable food supply (Badan Pusat Statistik, 2025b). Meanwhile, national maize production is showing a worrying trend. In October 2025, production of dried shelled maize reached only 1.24 million tonnes, down 7.47 per cent compared with the previous year, as the harvested area shrank from 0.21 million hectares in 2024 to 0.20 million hectares in 2025 (Badan Pusat Statistik, 2025a). Dryland areas in Indonesia hold enormous potential for the development of food crops, covering an area of around 148 million hectares, of which approximately 52 per cent is already utilised for agricultural activities (Mulyani & Mamat, 2019). However, dryland areas generally have low rainfall (<200 mm/year), a long dry season (>7 months), and limited availability of water and nutrients, which are the main limiting factors in increasing crop productivity. Under these conditions, maize varieties are required that are drought-adapted, early-maturing, water-efficient, and maintain high yield potential to support productivity on sub-optimal land (Sudika et al., 2018). Furthermore, from a plant breeding perspective, the successful development of adaptive varieties depends heavily on broad genetic diversity, as this provides the basis for selecting improvements in quantitative traits such as yield and tolerance to environmental stresses (Adriani et al., 2015).

The development of a new high-yielding, drought-tolerant hybrid maize variety was carried out by Sudika et al. (2021) through hybridisation between

How to Cite:
Rahman, A., Sudika, I. W., & Sutresna, I. W. (2026). Study of Genetic Diversity of Self-Crossed Lines of Corn (Zea mays L.) in Dryland. *Journal of Sustainable Dryland Agricultural Systems*, *6*(1), 15–23. https://doi.org/10.29303/josdas.v6i1.1506

the Sinta Unram line and NK212 and NK7328. The resulting hybrid population was then developed up to the F2 generation, followed by selfing in the first, second, third and fourth generations. The aim of self-pollination is to increase homozygosity; however, this process can also give rise to symptoms of inbreeding depression, namely a reduction in plant vigour due to the expression of deleterious recessive alleles (Ali et al., 2019). These symptoms are generally manifested as a reduction in plant height, seed yield, and adaptability to stressful environmental conditions, including drought (Somera et al., 2018).

Self-pollination is a method commonly used in the development of inbred maize lines. The primary aim of this method is to increase the level of homozygosity and improve the genetic purity of the population, thereby producing genetically stable and uniform lines. However, consecutive selfing can also lead to a narrowing of genetic diversity within the population due to increased homozygosity, a phenomenon known as inbreeding depression (Hikmah et al., 2023). Genetic diversity plays a vital role in breeding programmes as it forms the basis for successful selection of desirable traits, such as high yield, drought tolerance and environmental adaptation (Kurniawan et al., 2018). A drastic reduction in genetic diversity will limit plant breeders' ability to select for desired agronomic traits in subsequent generations.

Method

The method used in this study was an experimental approach involving field trials, conducted on dry land with water sourced from a pump well. The trials were carried out in Amor-amor Hamlet, Gumantar Village, North Lombok Regency, at an altitude of approximately 25 metres above sea level, on Entisol soil. The experiment ran from May to August 2024. The equipment used in this experiment included soil-tilling tools (hoes and a hand tractor), a dibble, buckets, an analytical balance, a tape measure, a sickle, a vernier caliper, a large protractor, a winnowing basket and writing materials. The materials used in this experiment were maize seeds of the S1, S2, S3 and S4 lines (15 lines each) and the F2 population, raffia twine, urea fertiliser, Phonska fertiliser, Saromyl 35 SD, Furadan 3G, Roundup 486 SL, Meurtieur 30 EC, bamboo stakes and plastic bags.

The experimental design used was a Randomised Block Design with a single factor, namely genotype. There were 61 treatments, comprising first-generation self-pollinated lines (S1), second-generation (S2), third-generation (S3) and fourth-generation self-pollinated lines (S4), with 15 lines of each and one F2 population, resulting in a total of 61 lines. Each treatment was replicated twice, resulting in 122 experimental units. Data analysis utilised analysis of variance (ANOVA) at a significance level of 5% to determine the coefficient of genetic variation (CGV) for each of the S1, S2, S3 and S4 lines.

Genetic variation is calculated as follows:

Genetic variance ($\sigma^2 g$) is calculated based on the mean squares from the analysis of variance table, namely:

$$\sigma^2_g = \frac{(KT_G - KT_E)}{r}$$

$$Sg = \sqrt{\sigma_g^2}$$

Coefficient of genetic diversity

High genetic diversity within a population is an essential prerequisite for the success of artificial selection. The higher the coefficient of genetic diversity, the greater the likelihood of achieving genetic progress through selection (Knight, 1979). The coefficient of genetic diversity is calculated using the following formula.

$$KKG = \frac{Sg}{\bar{X}} \times 100\%$$

The average trait test between selfing generations: if the calculated F-value is greater than the table F-value at a 5 per cent significance level for the genotype source of variation, a post-hoc test is conducted using the Least Significant Difference (LSD) test at a 5 per cent significance level.

LSD Formula Formula

$$LSD = t(1/2\alpha)\ (dbe) X \sqrt{(2KTG/r)}$$

Notes:

dbe	: degrees of freedom for the error
t(1/2α)	: value from the t-table
KTG	: mean square error
R	: number of blocks

Genotypic Correlation.

According to Knight (1979), genotypic correlation is a measure that indicates the genetic relationship between two traits controlled by the same gene or by genes that interact with one another. This correlation reflects the extent to which a genetic change in one trait will be accompanied by a change in the other trait due to the same genetic influence. The genotypic correlation coefficient can be positive, negative or zero, depending on the direction of the relationship between the traits.

Result and Discussion

This study evaluated the effects of four generations of selfing (S1, S2, S3 and S4) on genetic diversity, changes in mean traits, and genotypic

Table 1. Mean Square Values (MS) by Treatment

No	Characteristics observed	(Central Square) Treatment			
		S1	S2	S3	S4
1	Plant Height	251,74*	517,43ns	399,98ns	111,59ns
2	Number of Leaves	4,06*	1,94ns	0,47ns	0,89ns
3	Leaf Corner	12,47ns	16,44ns	12,33ns	6,09ns
4	Shaft Diameter	0,05ns	0,03ns	0,03ns	13,34ns
5	Leaf Area	2664,44ns	1198,98*	2127,14ns	1569,42ns
6	Cob Diameter	0,10ns	0,14*	0,09*	0,56ns
7	Cob Length	4,03ns	3,36ns	2,02ns	1,05ns
8	Weight of Dried Maize Cobs at Harvest	523,57*	1511,77ns	554,13ns	590,06ns
9	Weight of Shelled Dried Seeds	415,96*	326,86ns	561,07ns	192,04ns
10	Weight of 1,000 seeds	348,42ns	817,09ns	835,09*	749,10ns

Notes: *= Significant, ns= not significant

In table 1, based on the results of the analysis of variances, the Plant Height trait in generation S1 differed significantly, whilst generations S2, S3 and S4 did not differ significantly. The Number of Leaves in generation S1 differed significantly, whilst generations S2, S3 and S4 did not differ significantly. The Leaf Angle in all generations—S1, S2, S3 and S4—did not differ significantly. Stem diameter across all generations (S1, S2, S3 and S4) did not differ significantly. Leaf area in generation S2 differed significantly, whilst in S1, S3 and S4 there was no significant difference. Cob diameter in generations S2 and S3 differed significantly, whilst in S1 and S4 there was no significant difference. Cob length across all generations (S1, S2, S3 and S4) did not differ significantly. The dry ear weight at harvest for all generations (S1, S2, S3 and S4) did not differ significantly. The dry shelled seed weight differed significantly in generation S1, whilst there was no significant difference in generations S2, S3 and S4. The 1000-seed weight differed significantly in generation S3, whilst there was no significant difference in generations S1, S2 and S4.

Table 2 shows that all vegetative traits had coefficient of genetic variation (CGV) values falling within the 'narrow' category, except for stem diameter in the S4 generation, which was classified as 'moderate'. The plant height trait had GCR values of 4.86% in S1, 5.12% in S2, 4.79% in S3, and 1.18% in S4; all generations fell into the narrow category. The number of leaves also fell into the narrow category across all generations, with GCV values of 8.05% in S1, 3.51% in S2, 2.83% in S3, and 2.92% in S4. For Leaf Angle, the KKG values also fell within the narrow category across all generations, namely 2.33% (S1), 4.81% (S2), 5.33% (S3) and 3.99% (S4). Stem Diameter showed KKG values of 4.77% in S1, 3.74% in S2 and 4.66% in S3, which fall into the narrow category, whilst in S4 the value of 10.13% falls into the moderate category. Leaf area had KKG values of 3.94% in S1, 5.52% in S2, 2.71% in S3, and 4.32% in S4, all of which fell within the narrow category.

Table 2. Genetic Coefficient of Variation (GCV) values for quantitative traits and criteria for each generation of selfing

No	Parameter	Generation	KKG (%)	Kriteria
1	Plant Height	S1	4,86	Narrow
		S2	5,12	Narrow
		S3	4,79	Narrow
		S4	1,18	Narrow
2	Number of Leaves	S1	8,05	Narrow
		S2	3,51	Narrow
		S3	2,83	Narrow
		S4	2,92	Narrow
3	Leaf Corner	S1	2,33	Narrow
		S2	4,81	Narrow
		S3	5,33	Narrow
		S4	3,99	Narrow
4	Shaft Diameter	S1	4,77	Narrow
		S2	3,74	Narrow
		S3	4,66	Narrow
		S4	10,13	Moderate
5	Leaf Area	S1	3,94	Narrow
		S2	5,52	Narrow
		S3	2,71	Narrow
		S4	4,32	Narrow

Table 3 shows that the values of the coefficient of genetic variation vary more significantly between generations. For the cob diameter trait, the range in generation S2 is classified as moderate, whilst in generations S1, S3 and S4 it is classified as narrow. The cob length in all generations—S1, S2, S3 and S4—is classified as narrow. The dry cob weight at harvest for generations S2 and S3 is classified as moderate, whilst for generations S1 and S4 it is classified as narrow. The dry shelled seed weight for generation S3 is classified as wide, whilst for generation S1 it is classified as moderate, and for generations S2 and S4 it is classified as narrow. The 1,000-seed weight for all generations—S1, S2, S3 and S4—is classified as narrow.

Table 3. Genetic diversity values for yield component variables and yield

No	Parameter	Generation	KKG (%)	Coefficient of diversity
1	Cob Diameter	S1	4,57	Narrow
		S2	14,55	Moderate
		S3	4,49	Narrow
		S4	6,12	Narrow
2	Cob Length	S1	7,61	Narrow
		S2	7,50	Narrow
		S3	6,01	Narrow
		S4	2,09	Narrow
3	Weight of Dried Maize Cobs at Harvest	S1	4,57	Narrow
		S2	14,55	Moderate
		S3	11,83	Moderate
		S4	8,56	Narrow
4	Weight of Shelled Dried Seeds	S1	15,41	Moderate
		S2	7,89	Narrow
		S3	20,66	Wide
		S4	5,45	Narrow
5	Weight of 1,000 seeds	S1	2,09	Narrow
		S2	5,54	Narrow
		S3	6,54	Narrow
		S4	5,62	Narrow

Table 4. Mean Squares (MS) for all observed quantitative traits

No	Character Observed	Central Square	F hitung	F tabel	Note
1	Plant Height	150,02	7,26	6,39	S
2	Number of Leaves	6,96	37,71	6,39	S
3	Leaf Corner	89,60	49,69	6,39	S
4	Shaft Diameter	0,09	0,44	6,39	NS
5	Leaf Area	5273,72	10,49	6,39	S
6	Cob Diameter	0,08	1,95	6,39	NS
7	Cob Length	1,45	2,59	6,39	NS
8	Weight of Dried Maize Cobs at Harvest	634,19	1,64	6,39	NS
9	Weight of Shelled Dried Seeds	104,33	0,64	6,39	NS
10	Weight of 1,000 seeds	245,98	1,40	6,39	NS

Notes: S = Significant, NS = Non-Significant

Based on the results of the analysis of variance on the mean squared values of the quantitative growth traits of the self-pollinated lines of generations S1, S2, S3 and S4, as well as the F2 foundation population (Table 4), it was found that not all growth traits were significantly influenced by the self-pollination treatment. The results of the F-test showed that plant height exhibited a significant difference between the selfing generations and the F2 population, with a calculated F-value (7.26) greater than the 5% critical F-value (6.39). The number of leaves trait also showed a highly significant difference, with a calculated F-value of 37.71, which far exceeded the 5% critical F-value. Similarly, for the leaf angle trait, the calculated F-value (49.69) was greater than the table F-value. The leaf area trait also showed a significant difference, with a calculated F-value of 10.49, which was greater than the table F-value.

Table 5. Mean Growth Variables for Lines S1, S2, S3, S4 and F2

Treatment	Tt	Jd	Db	Sd	Ld
S1	187,47b	15,19b	1,74	41,95a	381,99a
S2	182,31a	15,17b	1,81	41,74a	381,58a
S3	165,63a	10,78b	2,01	30,81b	476,23b
S4	180,00a	12,62a	2,23	28,15b	366,15a
F2	171,98a	13,05a	1,75	41,00a	340,90a
LSD	12,61	1,17	-	3,72	62,25

Note: Figures followed by the same letter are not significantly different at the 5% significance level according to the BNT test. TT: Plant height. JD: Number of leaves. DB: Stem diameter. SD: Leaf angle. LD: Leaf area

Based on table 5, the mean values of the quantitative growth traits of maize plants in the selfing lines of generations S1, S2, S3 and S4, as well as the F2 foundation population, indicate variation across generations, although not all traits showed statistically significant differences. However, the traits that showed variation between generations were the quantitative traits of plant height, number of leaves, leaf angle and leaf area. The plant height of S1 was greater than that of F2, whilst S2, S3 and S4 were similar.

Table 6. Mean Values of Yield Components and Yields for Lines S1, S2, S3, S4 and F2

Treatment	CT	CL	WoDMC	WoSDS	B1000
S1	4,46	12,88	153,24	75,85	236,73
S2	4,43	12,76	142,14	71,01	223,40
S3	4,06	11,89	108,32	57,67	249,60
S4	4,58	12,71	127,01	69,57	243,26
F2	4,44	14,25	145,45	74,65	250,25
LSD	-	-	-	-	-

Note: Figures followed by the same letter are not significantly different at the 5% significance level according to the BNT test. Cob diameter (DT), cob length (PT), dry harvested cob weight (BTKP), dry shelled seed weight (BBKPL), weight of 1,000 seeds (B1000).

The mean yield components and total yield indicate that all parameters—namely, cob diameter, cob length, dry harvested cob weight, dry shelled kernel weight, and 1,000-kernel weight—did not differ significantly amongst the self-pollination treatments (S1–S4). This indicates that self-pollination up to the S4 generation has not yet had a significant effect on the yield components of maize, meaning that yield traits remain relatively stable, as shown in Table 6.

Table 7. Correlation coefficients between the parameters and the results.

No	Parameter	Genotypic Correlation Coefficient Value	Category
1	Plant Height	0,359	Weak
2	Number of Leaves	0,326	Weak
3	Leaf Corner	0,196	Not correlated
4	Shaft Diameter	-0,343	Weak
5	Leaf Area	-0,253	Not correlated
6	Cob Diameter	0,410	Weak
7	Cob Length	0,114	Not correlated
8	Weight of Dried Maize Cobs at Harvest	0,414	Weak
9	Weight of 1,000 seeds (B1000)	-0,12	Not correlated

Note: Genotypic correlation coefficient values: r; 0.254–0.503 (weak), 0.504–0.753 (moderate), > 0.754 (strong).

Based on the results of the genotypic correlation analysis presented in Table 7, it is evident that the majority of the agronomic traits of maize plants show a positive but relatively weak relationship with dry shelled grain yield. The genotypic correlation coefficients range from 0.11 to 0.41, which falls within the 'weak' category, as seen for Plant Height, Number of Leaves, Leaf Angle, Cob Diameter, Cob Length and Dry Harvested Cob Weight, whilst several traits such as stem diameter, leaf area and 1,000-seed weight showed a negative correlation or no correlation with yield.

The results of the study indicate that the selfing process over four generations (S1–S4) in maize (Zea mays L.) has a significant effect on changes in genetic diversity, average growth, and crop yield in dryland conditions. Analysis of variance, the coefficient of genetic variation (CGV), and the relationships between traits indicate a progressive narrowing of genetic diversity as the level of selfing increases; however, some yield traits still retain genetic variation that is beneficial for breeding selection.

Changes in Genetic Variation of Vegetative Variables

Based on the results of the analysis of variance (Table 1) and the KKG values (Table 2), all vegetative traits—including plant height, number of leaves, leaf angle, stem diameter and leaf area—exhibited relatively low KKG values (<10%), indicating that genetic diversity is limited. Narrow genetic diversity indicates that variation between lines for these traits is decreasing due to increasing homozygosity from one self-pollinated generation to the next.

For plant height, the KKG values for S1 to S4 were 4.86%, 5.12%, 4.79% and 1.18% respectively, all of which are classified as narrow. This pattern shows a decline in plant height variability between lines, indicating genetic homogenisation. This is consistent with the finding by Hikmah et al. (2023) that the selfing process causes a 50 per cent reduction in the proportion of heterozygous genes in each generation, thereby reducing genetic diversity between individuals. The number of leaves trait also showed a similar pattern, with the KKG value decreasing from 8.05% in S1 to 2.92% in S4. These results indicate that the number of leaves is relatively stable in later generations and is most likely controlled by genes that have already been fixed. According to Cantika & Sugiharto (2022), the higher the level of selfing, the narrower the genetic diversity in vegetative traits becomes, as genetic segregation decreases and the traits begin to stabilise. Leaf angle exhibited narrow genetic diversity across all generations (2.33–5.33%). This trait plays a crucial role in light absorption efficiency and photosynthesis; however, as it is controlled by a small number of additive genes, its level of diversity declines rapidly due to selfing (Cyplik et al., 2022). Interestingly, for the stem diameter trait, the KKG value in the S4 generation reached 10.13 per cent, falling into the moderate category. This indicates that although most vegetative traits are already homogeneous, stem diameter still possesses genetic diversity that can be utilised. This variation may be linked to morphological adaptation to dry environmental stress (Sudika et al., 2018). Genotypes with larger stems tend to be more resistant to lodging and more efficient in water transport; consequently, this trait is important in the selection of lines adapted to dryland conditions.

Changes in the Variability of Yield Component Variables

Genetic diversity in yield components and yield exhibits a more dynamic pattern than that observed for vegetative traits (Table 3). KKG values vary from narrow to broad depending on the trait and the selfing generation. The cob diameter trait exhibited a moderate KKG value in the S2 generation (14.55 per cent), whilst in other generations it was classified as narrow. This indicates that in the early stages of selfing (S2), there was still genetic segregation resulting in variation in cob size. As the number of generations increased, this segregation decreased and the trait became more stable. Harvested dry cob weight (BTKP) showed a moderate KKG in S2 (14.55%) and S3 (11.83%), but decreased to a narrow range in S4 (8.56%). This pattern illustrates a decline in yield diversity due to increased homozygosity. Nevertheless, the moderate diversity observed in S2 and S3 can still be utilised for selection, as the DYWH trait is directly related to crop yield potential (Sudika et al., 2022). The trait 'dry shelled seed weight per plant'

(BBKPL) showed the widest variation in S3 (20.66%), indicating that this generation possesses the greatest genetic variation for yield traits. This is important in breeding as yield traits are a combination of many genetic and physiological factors. The wide variation in S3 can serve as a basis for selecting superior lines. This phenomenon was also reported by Somera et al. (2018) and Ali et al. (2019), who noted that in the early generations of selfing, despite the occurrence of deep inbred depression, yield traits still exhibited sufficiently high variation to be utilised in selection. Meanwhile, cob length and 1,000-seed weight showed narrow variation across all generations, indicating that these traits are relatively stable and have not undergone significant genetic change as a result of selfing. The stability of these traits can be an advantage in the later stages of pure-line development, as stable traits are more easily inherited (Kurniawan, 2017).

Changes in the Average Growth and Yield of Maize Plants between Generations S1, S2, S3, S4 and F2

Based on observations of the mean values of maize growth traits in the selfing lines of generations S1, S2, S3 and S4, as well as the F2 foundation population (Table 5), it is evident that the selfing process significantly affects some growth traits, whilst others remain relatively stable across generations. Traits showing significant differences between generations included plant height, number of leaves, leaf angle and leaf area, whilst stem diameter showed no significant differences. These results are consistent with the findings of (Salamah et al., 2017), who reported that selfing in maize causes significant variation in agronomic traits such as plant height and ear length, but not in stem diameter.

Plant height in the S1 generation showed a higher mean value compared to the F2 population, whilst in the S2, S3, and S4 generations, it did not differ significantly from the F2. This pattern indicates that in the early generations of selfing, residual heterosis vigour from the parental population is still expressed; however, as the number of selfing generations increases, rising homozygosity leads to a decrease or stabilisation in plant height. The decrease in plant height in the S3 generation, in particular, reflects the onset of deep inbreeding depression, which is common in cross-pollinating crops such as maize due to the expression of less favourable recessive alleles. This is supported by research (Somera et al., 2018b), which found that selfing reduces plant height and ear weight due to inbreeding depression, as well as by (Faizah et al., 2016), which demonstrated a positive correlation between the level of homozygosity and the degree of inbreeding depression in selfing populations. Leaf number also showed variation across generations, with the highest values observed in S1 and S2, followed by a decline in S3 and S4. This reduction in leaf number is closely linked to a decline in vegetative vigour resulting from repeated selfing. Leaf number is a key component of the photosynthetic process; consequently, its reduction reflects a diminished capacity of the plant to optimally produce vegetative biomass. This phenomenon is consistent with reports by (Salamah et al., 2017) and (Somera et al., 2018b), which state that selfing reduces vegetative vigour through a reduction in the number of leaves and the active photosynthetic area due to deep inbred depression.

Leaf angle characteristics showed significant differences, with the S3 and S4 generations exhibiting smaller leaf angles than S1, S2 and F2. This change in leaf angle can be interpreted as a form of morphological adaptation to dry land conditions, as a narrower leaf angle tends to reduce the rate of transpiration and water loss. However, this change may also reflect a shift in genetic expression resulting from increased homozygosity during the selfing process. This is supported by findings (Subaedah et al., 2018) showing that maize genotypes adapted to drought exhibit narrower leaf angles as a water-efficiency strategy without significantly reducing yield. Leaf area showed quite distinct variation across generations, with the highest values observed in the S3 generation. Although a large leaf area has the potential to increase photosynthetic capacity, under dry field conditions this is not always advantageous as it can increase water loss through transpiration. Therefore, the large leaf area in the S3 generation does not necessarily correlate directly with increased yield, as reflected in the yield component data. These findings are consistent with studies by Puspitasari et al. (2018) and Nurhana et al. (2020), which explain that an increase in leaf area does not always correlate with an increase in yield, particularly in water-stressed environments. In contrast to growth characteristics, observations of yield components and maize seed yield (Table 4.6) indicate that all parameters observed—namely cob diameter, cob length, dry harvest cob weight, dry shelled seed weight, and 1,000-seed weight—did not differ significantly between selfing generations or when compared with the F2 population. This indicates that the selfing process up to the fourth generation has not yet caused a significant reduction in yield. A similar phenomenon was reported by (Setyowidianto et al., 2017) and (Rahmania et al., 2025), who found that maize yield components remained relatively stable across generations and locations despite a decline in vegetative vigour.

The stability of the mean values of these yield components indicates that, despite a narrowing of genetic diversity and a decline in vigour for some vegetative traits, maize plants are still able to maintain a relatively normal capacity for grain filling. This suggests that yield traits are controlled by many genes with small effects and possess sufficiently robust physiological compensatory mechanisms, meaning they are not easily affected by increased homozygosity during the early stages of inbred line development. Similar results were reported by (Nurhana et al., 2020) and (Salamah et al., 2017), who stated that yield traits are more stable than growth traits during the process of line purification through progressive selfing.

Overall, the results of this study indicate that selfing up to the S4 generation has a greater impact on changes in vegetative growth traits than on yield components. Later generations of selfing exhibited a tendency towards higher phenotypic homogeneity with relatively stable yields. These findings indicate that the S4-generation selfing lines have achieved an adequate level of average stability and have the potential to be used as breeding material in the development of dryland-adapted maize hybrid varieties. This is in line with the recommendations of (Somera et al., 2018b) and (Nurhana et al., 2020), which state that the S4–S5 generations represent a crucial stage in genetic purification and the development of inbred lines for the production of high-yielding hybrid maize varieties.

Genotypic correlation

Based on the results of the genotypic correlation analysis presented in Table 5, it was found that most of the agronomic traits of maize plants showed a positive, albeit weak, relationship with shelled dry grain yield. The genotypic correlation coefficients ranged from 0.11 to 0.41, which falls within the ‘weak’ category, whilst several traits such as stem diameter, leaf area and 1,000-grain weight showed a negative correlation or no correlation with yield. This indicates that the direct contribution of most traits to yield increases is relatively small, yet they still exert an indirect influence that can be utilised in line selection within maize breeding programmes on dryland.

Plant height had a genotypic correlation coefficient of 0.36, which falls within the weak category, suggesting that an increase in plant height is accompanied by an increase in yield, albeit to a small extent. This relationship suggests that growth vigour contributes to an increase in plant biomass, which in turn influences seed formation. These findings are consistent with the research by Pennita et al. (2020) and Sudika et al. (2022), which stated that plant height has a positive relationship with yield as it is associated with an increase in light-absorbing area and the plant’s photosynthetic capacity.

The number of leaves also showed a weak positive correlation (r = 0.33) with yield, indicating that an increase in the number of leaves can support the accumulation of photosynthates for seed filling, although the physiological efficiency of each leaf also determines the extent of its influence on yield (Surtinah, 2018). Leaf angle exhibits a very weak positive correlation (r = 0.20), indicating that changes in leaf orientation relative to the stem do not directly influence seed yield. This may be due to dryland environmental conditions that limit photosynthetic efficiency even when leaf arrangement is optimal (Hikmah et al., 2023). Meanwhile, stem diameter showed a negative correlation (r = –0.34) with seed yield, suggesting that varieties with larger stems do not necessarily produce more seeds. This phenomenon is likely due to a greater allocation of biomass to the stem than to the seeds, as explained by Afandi & Samudin (2022). Leaf area also showed a negative correlation (r = –0.25), meaning that an increase in leaf area under dryland conditions can increase the rate of transpiration and water loss, thereby reducing assimilation efficiency and seed yield. Similar results were reported by Farhad et al. (2011), who found that excessive leaf area in maize plants in arid environments actually caused water stress and reduced yield.

The traits of cob diameter (r = 0.41) and dry cob weight at harvest (r = 0.41) showed a weak positive correlation with seed yield. Although the correlation values were relatively low, these traits still hold significant potential for selection as both are directly related to the number of rows and seeds per cob (Pennita et al., 2020). Ear length (r = 0.11) also showed a very weak positive correlation with yield, indicating that variation in ear length between lines does not yet fully influence seed productivity, likely due to differences in ear fertility. Meanwhile, 1,000-seed weight (r = –0.12) showed a negative correlation with yield, meaning that an increase in seed size is not always accompanied by an increase in total yield, as the number of seeds per cob tends to decrease. This is consistent with the findings of Cyplik et al. (2022), who reported a reciprocal relationship between seed size and the number of seeds per cob in self-pollinating maize plants.

In general, the low genotypic correlations between these traits and yield suggest that seed yield is a complex trait controlled by many genes and strongly influenced by environmental interactions. Nevertheless, traits such as plant height, number of leaves, cob diameter and dry harvest weight of the cob can still serve as a basis for indirect selection aimed at increasing yield, particularly during the early stages of inbred line development on dryland. The positive correlations observed for these traits indicate that improvements in vegetative performance and certain yield components still contribute to increased grain yield, albeit to a limited extent (Ali et al., 2019. Sudika et al., 2022). Therefore, selection strategies in later stages need to prioritise stable yield traits whilst taking into account the plants’ adaptation to dryland conditions, in order to develop high-yielding and drought-tolerant maize inbred lines.

Conclusion

Selfing lines up to the fourth generation (S4) exhibit a narrow range of genetic variation for most quantitative traits, particularly vegetative traits. Two traits—namely, the weight of dehulled dry seeds in the S3 generation and stem diameter in the S4 generation—still show relatively broader genetic variation and hold potential for selection. Several growth traits of the first, second, third and fourth generations of selfing lines differed from those of the F2 population; however, they did not have a significant effect on yield components or total yield. Genotypic correlations between agronomic traits and yield were generally weakly positive to non-correlated.

Acknowledgments

Self-pollination should be continued up to the S5–S6 generations to ensure genetic stability and obtain a more homogeneous line as a candidate for an inbred line. Taller maize plants can be selected for self-pollination in the fourth generation to improve yield in the fifth-generation line.

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