Agronomic performance of traditional rainfed lowland rice varieties in Lower Casamance (Southwestern Senegal).

Abstract:

In Senegal, local rice production covers 42% of national consumption needs. To achieve food sovereignty, the focus has been on the use of improved varieties to the detriment of farmers' traditional varietiesthreatened with disappearance in the context of climate change. Therefore, a study was conducted during the 2024 rainy season at the rice research station of the Agricultural Research Center of Djibelor in Lower Casamance. Specifically, the agro-morphological performance of a range of traditional rice varieties were evaluated under lowland rice cultivation conditions. A total of 14 varieties including thirteen (13) local rice ecotypes (V1 Diary; V2 Bilkissa; V3 Soumbane; V4 Bonty-Kolda; V5 Fouleme; V6 Diangue; V7 Bonty-Oukout; V8 Niji; V9 Oukout; V10 Lori; V11 Yangolale; V12 Agathia; V13 Alisor) and one improved variety (V14 ISRIZ 8), were tested according to a Fisher block design with four replicates. The results showed that the greatest plant heights at maturity stage were recorded for the ecotypes Diary (149.5 cm), Fouleme (144.9 cm), and Niji (144.7 cm). The highest tillering capacity was observed in the local ecotypes Oukout (380 tillers/m²), Lori (251 tillers/m²), and Niji (237 tillers/m²). Earliness in heading (85 days) and physiological maturity (115 days) was observed in the improved variety ISRIZ 8. The highest grain yields were obtained with the traditional varieties Oukout (4.895 ± 483 kg/ha), Agathia (4.691 ± 677 kg/ha), and Lori (4.275 ± 401 kg/ha), accounting yields increase of 45%, 39%, and 27% compared to the improved variety ISRIZ 8 (3.376 ± 606 kg/ha). Due to their resilience to climatic stresses, farmers' varieties deserve particular attention and may serve as valuable sources of genes of interest for future breeding and varietal improvement programs.

Keywords: rice cultivation, local varieties, Lower Casamance, food sovereignty, Senegal

Introduction

In Senegal, rice is the staple food of the population, with per capita consumption estimated at approximately 116 kg per year (DAPSA, 2024). White rice production has increased

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substantially, rising from 239.884 to 835,836 tons from period 2013-2023. However, this level of production remains insufficient to meet national demand, estimated at 1.302.317 tons, thereby requiring the country to rely on imports to bridge the deficit (DAPSA, 2024). Rice is mainly cultivated in the Senegal River Valley and in Casamance. In 2019, rice production in Casamance accounted for about 65% of total cereal production in the region (ANSD, 2020). With average annual rainfall ranging from 900 mm to over 1.000 mm, the agro-ecological zone of Casamance provides favorable conditions for rice cultivation, particularly in lowland ecosystems (Sagna, 2005).In line with the objective of achieving food sovereignty, the government, through agricultural policies such as the National Rice Development Strategy (SNRD 2020–2030) and the National Food Sovereignty Strategy (SNSA 2024–2028), aims to achieve rice self-sufficiency by 2030 (MAERSA, 2022; MAERSA–MPEM–MEPA, 2023). As a result, emphasis has been placed on the adoption of improved rice varieties at the expense of traditional varieties, which are increasingly threatened with disappearance due to the reduction of cultivated areas and constraints such as soil salinization and acidification (Manzelli et al., 2013). In addition, traditional varieties often fail to complete their growth cycle due to rainfall variability. Nevertheless, these varieties offer a comparative advantage in the context of agro-ecological transition characterized by low-input agricultural systems (Mbaye, 2019; Faty, 2020). Given their resilience to climatic shocks, traditional rice varieties deserve particular attention.

The objective of this study is to evaluate the agronomic performance of thirteen local ecotypes under lowland rice-growing conditions in Lower Casamance

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Materials and Methods

Study area

The study was conducted at the Senegalese Institute of Agricultural Research (ISRA) station of Djibelor, locatedbetween 12°33′39″ N and 16°18′25″ W, along the Cap Skirring road in the commune of Niaguis, Ziguinchor district(Figure 1 : location of the study area (Sonko, 2022).). The soil is a tropical ferruginous type with a sandy texture and a low organic matter content (less than 1%) ((Loyer etal., 1986)..

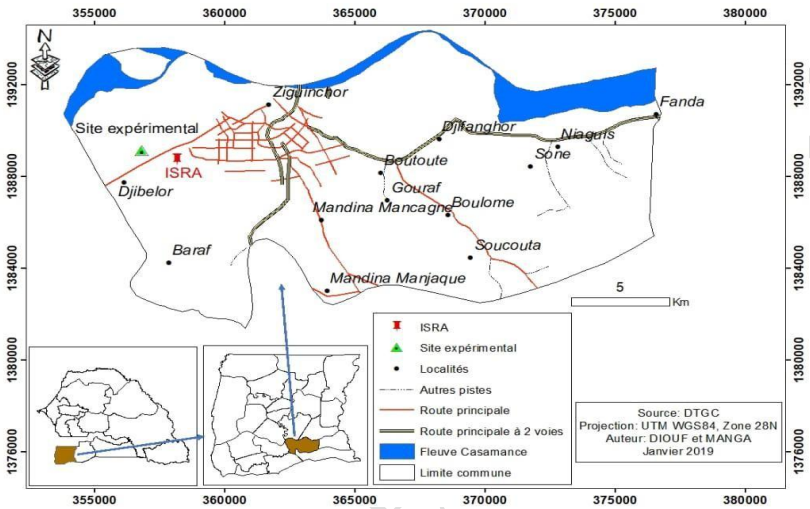


Figure 1 : location of the study area (Sonko, 2022).

The area is influenced by a southern coastal Sudanian climate (Sagna, 2005). It is characterized by two seasons: a dry season lasting 7 to 8 months, extending from November to May, and a rainy season lasting 4 to 5 months (from June to October). In 2024, total rainfall (1.645 mm) was higher than the annual average for the 1991–2020 period (1.373 mm). (Figure 2: variation of rainfall in 2024 compared with the climatic normal for the 1991–2020 period (CRA/Djibelor rainfall station).).

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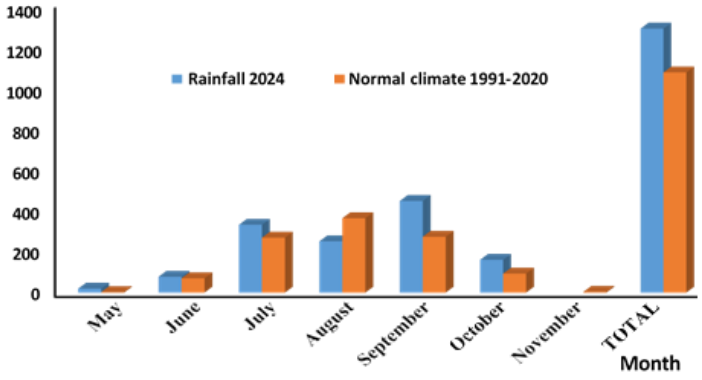


Figure 2: variation of rainfall in 2024 compared with the climatic normal for the 1991–2020 period (CRA/Djibelor rainfall station).

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Quantity(mm)

Plant material

A set of 14 varieties including thirteen (13) local rice ecotypes (V1 Diary; V2 Bilkissa; V3 Soumbane; V4 Bonty-Kolda; V5 Fouleme; V6 Diangue; V7 Bonty-Oukout; V8 Niji; V9 Oukout; V10 Lori; V11 Yangolale; V12 Agathia; V13 Alisor) and one improved variety (V14 ISRIZ 8) were tested.

Experimental design

The varieties were arranged in a randomized complete block design with 04 replicates. Each block is composed of 14elementary plots corresponding to the 14 treatments. The experimental plot was 9 m². The spacing between plots and between blocks was 1 meter and 2 meter, respectively.

Trial management

Seedlings were transplanted at 2 plants per hill, with a spacing of 20 cm between rows and 20 cm between hills. Compost was applied as a basal fertilizer at rate of 5 tons per hectare. The foliar organic fertilizer Green OK was applied 7, 28, and 50 days after transplanting, at the rate of 5 ml of product diluted in 16 liters of water. Two weedings were performed on the 15th and 40th days after transplanting.To prevent from insect pests, plant based biopesticide from Neem (*Azadirachta indica*) extracts was applied40 days after transplanting.

Measured parameters

Measurements focused on growth parameters (plant height at maturity, number of tillers per m²),phenological parameters (dates of 50% flowering and 80% physiological maturity), yield and components (panicle lenght, grain yield, weight, 1.000-grain weight, number of grains per panicle, and grain sterility rate).

Statistical analysis

Analyses of variance was performed using XLSTAT software, version 2016. Tukey's test was used to compare means at the 5% significance level.

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Results and Discussion

Plant growth and development

Plant height varied significantly ($p < 0.0001$) among varieties (Figure 3: Plant height among the tested varieties). Higher heights ofplant wererecorded for local varieties Diary (149.5 cm), Fouleme (144.9 cm), Niji (144.7 cm), and Yangolaye (144.2 cm). The ecotypes Bilkissa (110.7 cm) and Bonty-Kolda (112.5 cm) developed lower heights of plants.Differences in plant height among the varieties may be explained by both environmental and genetic factors. Plant height is an important agronomic trait in the selection of high-yielding varieties because it directly influences lodging resistance. Consequently, plant height at maturity constitutes a key criterion for farmers when selecting rice varieties (Kone, 2010). Furthermore, the varieties Bilkissa and Bonty were identified as the shortest genotypes, in contrast to the findings of Bioversity International et al. (2007), who described them as having medium to tall plant height.

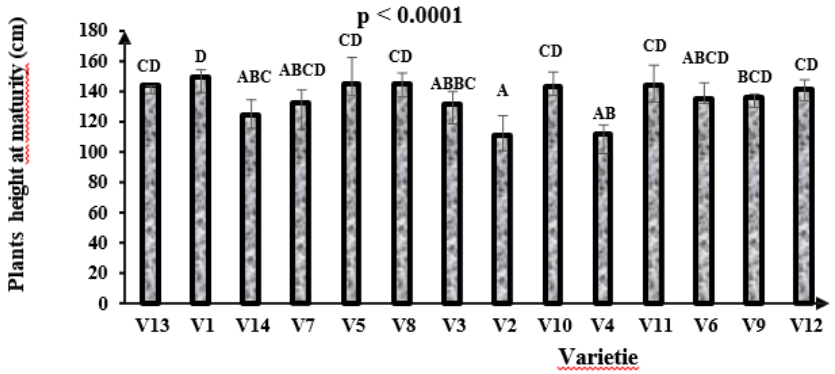


Figure 3: Plant height among the tested varieties

Legend:V1(Diary),V2(Bilkissa),V3 (Soumbane),V4(Bonty-kolda),V5(Fouleme),V6(Diangue),V7 (Bonty-oukout), V8 (Niji), V9 (Oukout), V10 (Lori), V11 (Yangolale), V12 (Agathia), V13 (Alisor), et V14 (Isriz 8)

Tillering capacity varied significantly ($p = 0.001$) among varieties (Figure 4:Number of tiller among tested varieties). The highest number of tiller was observed in the variety Oukout (380 tillers/m²). The ecotypes Lori (251 tillers/m²) and Niji (237 tillers/m²) showed statistically similar in number of tiller. In contrast, the lowest number of tiller was recorded for the variety Bonty Oukout (125 tillers/m²). In addition, some local ecotypes produced a greater number of tillers than the improved variety. This observation is consistent with the findings of ADRAO et al. (2003) and Mbaye (2019), who reported that the number of tillers per plant may vary

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from 4 to 38

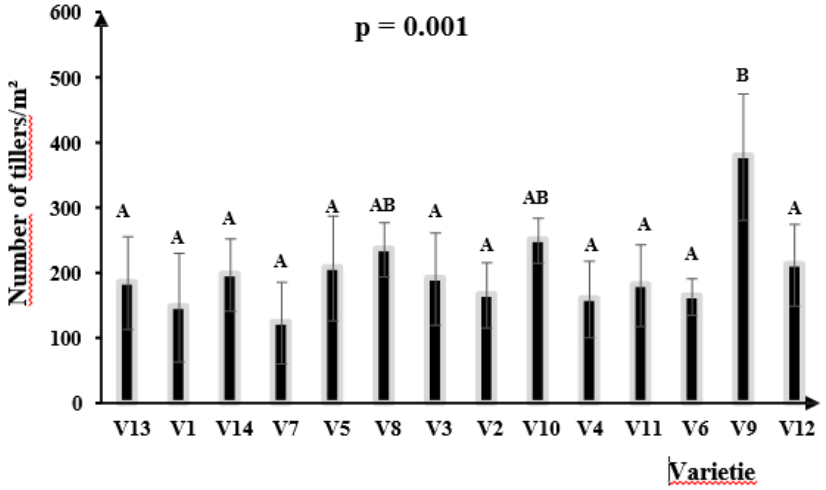


Figure 4:Number of tiller among tested varieties

Legend:V1(Diary),V2(Bilkissa),V3 (Soumbane),V4(Bonty-kolda),V5(Fouleme),V6(Diangue),V7 (Bonty-oukout), V8 (Niji), V9 (Oukout), V10 (Lori), V11 (Yangolale), V12 (Agathia), V13 (Alisor), et V14 (Isriz 8)

Plant flowering 50% ($p < 0.0001$) and physiological maturity **(**$p < 0.0001$**)**were highly significantly different between varieties (Figure 5: flowering (A) and maturity (B)stages among tested varieties). The improved variety ISRIZ 8 (85 days; 115 days) and the ecotypes Bilkissa (90 days; 116 days) and Bonty Kolda (92 days; 116 days) exhibited the earliest flowering and physiological maturity. The variety Diary reached the maturity later (139 days) than other varieties. Early flowering observed in the ecotypes Bilkissa, Bonty, and Lori, as well as in the improved variety ISRIZ 8, has also been reported by Sanni et al. (2016) and Faye et al. (2017). Early flowering enables these varieties to complete their growth cycle before the end of the rainy season (Sanni et al., 2011). This characteristic is essential for determining optimal sowing dates and reducing risks associated with temperature fluctuations, which may increase spikelet sterility. Moreover, flowering duration is useful for classifying varieties into short-, medium-, or long-cycle groups. Traditional varieties such as Bilkissa, Bonty, and Lori, which require a longer period from sowing to maturity under aerobic conditions, likely experienced delayed growth due to water stress and temperature changes occurring at the end of the crop cycle. These findings differ from those reported by Nguetta et al. (2010), who indicated that conventional upland rice varieties generally reach maturity within approximately 150 to 170 days. Similarly, Bassene et al. (2015) reported that the sowing-to-physiological maturity period for Brazilian and lowland NERICA varieties ranged from 80 to 90 days.

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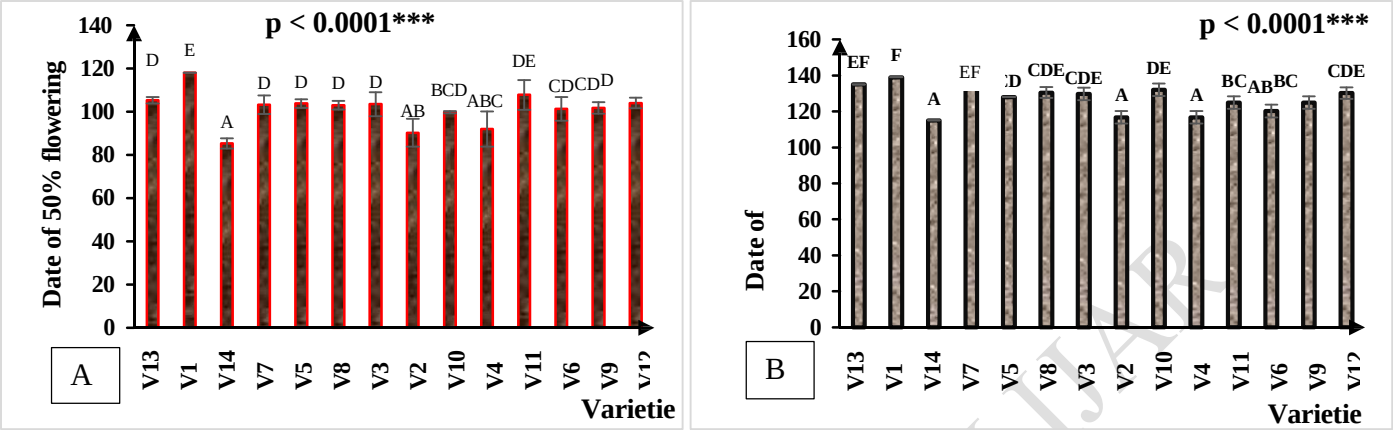


Figure 5: flowering (A) and maturity (B)stages among tested varieties

Legend:V1(Diary),V2(Bilkissa),V3 (Soumbane),V4(Bonty-kolda),V5(Fouleme),V6(Diangue),V7 (Bonty-oukout), V8 (Niji), V9 (Oukout), V10 (Lori), V11 (Yangolale), V12 (Agathia), V13 (Alisor), et V14 (Isriz 8)

Yield and components

The length of panicles varied significantly **(**p = 0.00012**)**between different varieties (Figure 6 :Panicle length among tested varieties.). Lori exhibited the longest panicles (28.3 cm), followed by Niji and Yangolaye. In contrast, the shortest panicle length was recorded with the ecotype Diary (19.0 cm).The local ecotypes exhibited the longest panicles, exceeding 25 cm in length, which is in agreement with the observations of Sanni et al. (2016) and Kouakou et al. (2016) on upland rice cultivated in the Sudanian–Sahelian zone, as well as with the findings of Faty (2020) on lowland rice in Middle Casamance.

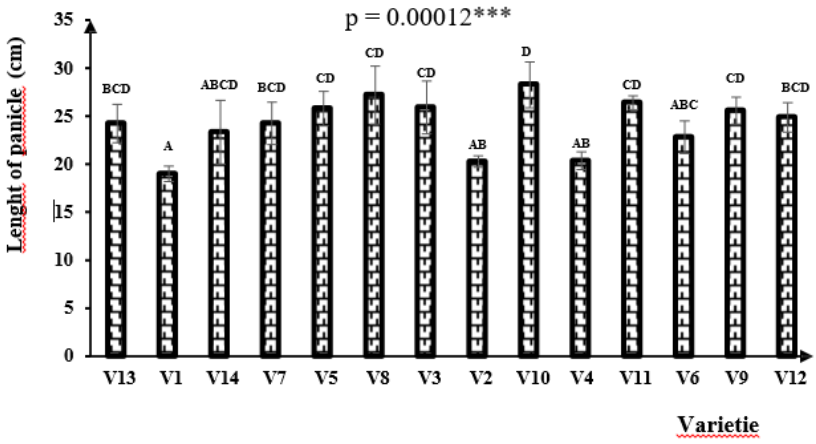


Figure 6 :Panicle length among tested varieties.

Legend: V1(Diary),V2(Bilkissa),V3 (Soumbane),V4(Bonty-kolda),V5(Fouleme),V6(Diangue),V7

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(Bonty-oukout), V8 (Niji), V9 (Oukout), V10 (Lori), V11 (Yangolale), V12 (Agathia), V13 (Alisor), et V14 (Isriz 8). Mean with same letters a not statistically different.

A highly significant difference were observed among varieties for grain yield **(**p = 0.0003**),** number of grains per panicle(p < 0.0001)and1000grains weight(p < 0.0001).In contrast, no significant difference was observed for the grain sterility rate(Table 1: Yieldand components among different tested varieties).The grain yield varied between 2209 and 4809 kg/ha and was significantly higher for Oukout (4895 ± 483 kg/ha) followed by Agathia (4691 ± 677 kg/ha). Bilkissa (2209 ± 1.111 kg/ha), Diangue (2278 ± 574 kg/ha) and Bonty-Oukout (2.456 ± 1103 kg/ha) recorded the lowest grain yield.The number of grains per panicle was significantly higher in Agathia (158 ± 44) and Niji (151 ± 33) in contrast to ISRIZ 8 (71 ± 18) whichrecorded the lowest number. For the 1000 grain weight, the highest values were recorded on Niji (28.2 ± 1.2 g) and Lori (28.3 ± 1.0 g), while Bilkissa (18.7 ± 1.0 g) exhibited the lowest value.The grain sterility rate were higheron ISRIZ 8 (13.6 ± 3.8%) and Diangue (13.1 ± 5.9%). the variety Lorirecorded the lowest sterility rate (6.4 ± 1.9%). The local varieties Oukout, Lori, Niji, Agathia, and Soumbane produced higher grain yields than the improved variety ISRIZ 8. Similar results were reported by ADRAO et al. (2011) and Faty (2020), with local varieties achieving yields exceeding 3 t ha^{-1}. In addition, Manzelli et al. (2019) documented yields ranging from 0.4 to 6 t ha^{-1} for traditional varieties in Middle Casamance. In the groundnut basin of Senegal, Kanfany et al. (2017) found that the grain yields of improved upland rice varieties were comparable to those obtained in the present study. The relatively low yield performance of ISRIZ 8, compared with its maximum potential yield of 8 t ha^{-1}, may be attributed to a high sterility rate and insufficient grain production. Kouakou et al. (2016) demonstrated that grain yield is strongly influenced by spikelet sterility rate and thousand-grain weight.

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204 Table 1: Yieldand components among different tested varieties

Varieties	Grain yield(kg/ha)	Number grain of panicle	1000 grainsWeight (g)	Grainsterility rate(%)
Agathia	4691 ± 677BC	158 ± 44C	27.4±2.0C	10.7 ±5.2A
Niji	4060 ± 472ABC	151± 33BC	28.2 ±1.2C	11.7 ±4.3A
Lori	4275 ± 401ABC	140±26BC	28.3 ± 1.0C	6.4±1.9A
Fouleme	4003 ±448,787ABC	143± 41BC	25.0 ± 3.3C	10.7 ±3.5A
Soumbane	3437 ±844ABC	143±40BC	26.9 ± 0.7 C	11.2 ±5.5A
Yangolaye	3240 ±1506ABC	133±25ABC	26.4 ±2.3C	9.6 ± 3.3A
Oukout	4895 ± 483C	86±17AB	25,3 ± 2.1C	10.3 ±6.7A
Alisor	2701 ± 1104AB	145±15BC	24.2 ± 1.1BC	8.9 ±3.6A
Bonty-Oukout	2456 ± 1103A	118 ±11ABC	26.5 ± 1.6C	9.9 ±6.4A
Diary	3304 ± 358ABC	91 ±14AB	24.8 ±1.4C	8.0 ±2.7A
Isriz 8	3376 ± 606ABC	71±18A	25.0 ±1.4C	13.6±3.8A
Diangue	2278 ±574 A	98 ±7ABC	24.8 ±1.0C	13.1± 5.9A
Bonty-Kolda	2866 ± 1335ABC	105±16ABC	19.9 ±1.3AB	10.2 ± 6.2A
Bilkissa	2209 ± 1111A	127±16ABC	18.7 ±1.0A	7.7 ±1.6A
General mean	3414 ± 1136	122.5± 35.0	25.1± 3.1	10.2±4.5
P.value	0.0003***	<0.0001***	<0.0001***	0.726ns

205 Means sharing the same superscript letter are not significantly different at the 5% level according to Tukey's
206 test. ns: not significant; *: significant; **: highly significant; ***: very highly significant.
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Conclusion

The evaluation of the agronomic performance of traditional rice varieties in Lower Casamance showed that ecotypes Oukout (4895 ± 483 kg/ha), Agathia (4691 ± 677 kg/ha), Lori (4275 ± 401 kg/ha), and Niji (4060 ± 472 kg/ha) were the most productive in terms of grain yield. The improved variety ISRIZ 8 (85 days) and the ecotypes Bilkissa (90 days) and Bonty-Kolda (92 days) exhibited early flowering. Thus, local varieties shown interesting characteristics such as a better resilience to climatic variations. Within the framework of phytogenetic resource conservation strategies and the achievement of food sovereignty, these varieties can therefore play an important role in breeding programs.

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