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ONION GENOTYPE SKILLS IN DIFFERENT PLANTING SYSTEMS

Gabriel Mascarenhas Maciel[1], Guilherme Repeza Marquez[1], Ariel Santivañez Aguilar[1], Igor Forigo Beloti[1]*, Igor Matheus Alves[1], Maurício Pivetta Momesso[1]

[1]Universidade Federal de Uberlândia (UFU) campus Monte Carmelo. Km 1, LMG-746, CEP: 38500-00, Monte Carmelo-MG, Brazil. Tel: 55-34-3810-1010

*Autor para correspondência: Igor Forigo Beloti, agroifb@gmail.com

ABSTRACT: Currently, planting onion through seedling production is predominant in the state of Rio Grande do Sul. Thus, the present work aimed to evaluate the agronomic potential of new onion genotypes as a function of the planting system for this region. Eleven genotypes were evaluated, as follows: "commercial genotypes" Bola Precoce, Mulata, Sprint, Suprema and "pre-commercial genotypes" TE 201, TE 209, TE 216, TE 230, TE 242, TE 316 and TE 329, submitted to four planting systems: seedling production, seedling production with leaf pruning before transplanting, no-tillage manually planted at the definitive site and seedling production in trays. Treatments were arranged in an 11 x 4 factorial scheme (eleven genotypes and four planting systems). Although little practiced, the no-till system for onion cultivation for the northwestern region of Rio Grande do Sul can potentially be explored. Genotypes that best adapted to this system were: Bola Precoce, Suprema, Sprint, Mulata and TE 201. Comparatively, "commercial" genotypes showed an increase of 10.81 t ha^{-1} in relation to "pre-commercial" genotypes in the no-till system, proving the efficiency of this system.

KEYWORDS: *Allium cepa*; onion cultivation; no-till; transplant

APTIDÕES DE GENÓTIPOS DE CEBOLA EM DIFERENTES SISTEMAS DE PLANTIO

RESUMO: Atualmente predomina-se no estado do Rio Grande do Sul, o plantio de cebola através de mudas produzidas em sementeiras. Deste modo, o presente trabalho objetivou avaliar o potencial agronômico de novas variedades de cebola em função do sistema de plantio para esta região. Foram avaliados onze genótipos, sendo: "genótipos comerciais" Bola Precoce, Mulata, *Sprint*, Suprema e "genótipos pré-comercias" TE 201, TE 209, TE 216, TE 230, TE 242, TE 316 e TE 329, submetidos a quatro sistemas de plantio: produção de mudas em sementeira, produção de mudas em sementeira com poda das folhas antes do transplantio, plantio direto no local definitivo e produção de mudas em bandejas. Os tratamentos foram arranjados em esquema fatorial 11 x 4, (onze genótipos e quatro sistemas de plantio). Apesar de pouco praticado, o sistema de plantio direto na cultura da cebola para a região noroeste do Rio Grande do Sul, pode ser potencialmente explorado. Os genótipos que melhor se adaptaram a este sistema foram: Bola Precoce, Suprema, Sprint, Mulata e TE 201. Comparativamente os genótipos "comerciais" apresentaram acréscimo de 10,81 t. ha^{-1} em relação aos genótipos "pré-comerciais", no sistema de plantio direto, comprovando a eficiência deste sistema.

PALAVRAS CHAVE: *Allium cepa* L.; cultivo de cebola; plantio direto; transplantio

INTRODUCTION

Among vegetables grown in Brazil, onion (*Allium cepa* L.) is the third most important in both job creation and volume produced. In the 2017 harvest, 57 thousand hectares of onion were cultivated in Brazil, reaching a total production of 1600 t, with average yield of 28.06 t ha^{-1}. Most of this production is concentrated in the southern region, which accounts for approximately 50% of national production, with Rio Grande do Sul being the fifth largest producer with 10.4% (Agrianual, 2017).

The expression of the agronomic potential of a genotype is known to be related both to its local adaptation and management practices. Thus, it is sought through management practices to provide conditions that enhance agronomic expression in order to combine productive aspects related to the real conditions of the producer. Among production techniques, onion crop can be established by no-tillage, seed bulbs, seedlings produced in trays and seedlings of bare roots (Fontes e Silva, 2002). In the search for cultivars adapted to different planting systems, considering also the effect of genotype-environment interaction for this crop, it is necessary to identify adapted and productive genotypes (Faria et al., 2012).

Traditionally cultivated from seedlings and in conventional planting system, onion cultivation has been facing production problems, mainly regarding labor for planting and soil and water conservation. In contrast, this method results in satisfactory yields (Filgueira, 2008).

In recent years, there has been increasing interest from producers and technicians for the adoption of new onion cultivation alternatives in the state of Rio Grande do Sul, especially regarding the no-till system, which is still incipient in this region. In this planting system, the presence of plant cover provides increased water infiltration in the soil, increasing water storage capacity and reducing evaporation (Teófilo et al., 2012), resulting in better water use efficiency (Tivelli et al., 2010).

Studies in the state of Rio Grande do Sul aiming to evaluate the behavior of new onion varieties and different planting systems are scarce. Moreover, the cultivation of this vegetable in Brazil has been increasingly demonstrating the suitability of certain genotypes for specific regions. Thus, the present work aimed to evaluate the suitability of new onion varieties as a function of the planting system for the northwestern region of Rio Grande do Sul.

MATERIAL AND METHODS

The experiment was conducted from May to December 2016 in northwestern Rio Grande do Sul, in the municipality of Bozano, located at "28 ° 23 '16" S and 53 ° 54' 53 "W, and altitude of 328 m a.s.l. According to the Köppen system, the climate is classified as Cfa (humid subtropical without typical drought). The average temperature (° C), rainfall (mm) and relative humidity (%) occurred during the experimental period can be seen, respectively, in Figures 1 and 2. The chemical and physical characteristics of soil in the experimental area are shown in Table 1.

Figure 1. Average temperature (°C) and rainfall (mm) occurred during the experimental period. Bozano, 2016.

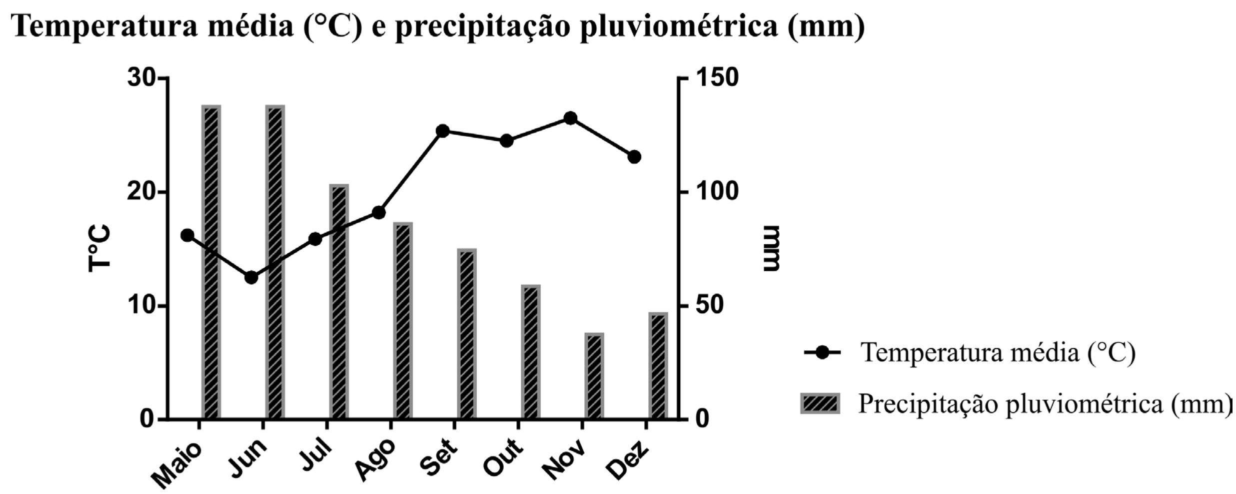

Figure 2. Relative humidity (%) during the experimental period. Bozano, 2016.

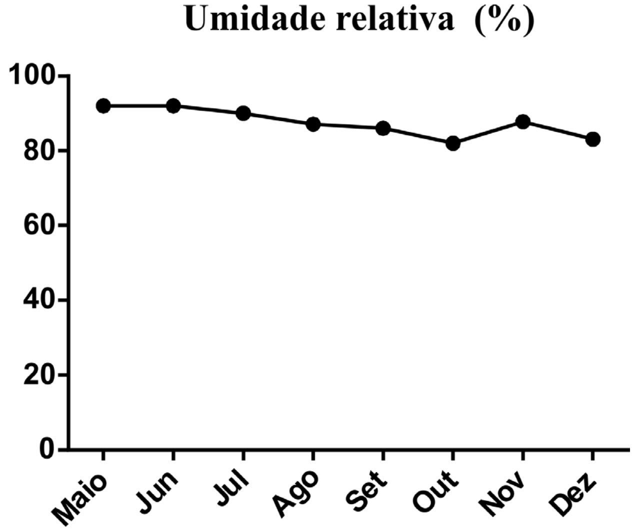

Table 1. Chemical and physical characteristics of the soil used to conduct the experiment

pH (H_2O)	P avaliable	K	Cu	Zn	Mn	Ca	Mg	Al^{3+}	H+Al	MO	CTC (pH 7,0)	Clay	t	V
	mg.dm^{-3}					cmolc.dm^{-3}				kg.dm^{-3}		%		
6.0	5.0	352.0	8.1	6.4	37.3	14.7	6.6	0.1	7.7	3.7	29.9	30	0.4	74.1

All experimental area was previously prepared before sowing and transplanting, equitably for all treatments. Treatments were arranged in a factorial scheme (11 x 4), with eleven genotypes and four planting systems (Table 2). The eleven OP (Open pollination) genotypes used were: "commercial genotypes" Bola Precoce, Mulata, Sprint, Suprema and "pre-commercial genotypes" TE 201, TE 209, TE 216, TE 230, TE 242, TE 316 and TE 329. All genotypes were submitted to four planting systems as follows: Seedling production and subsequent transplanting at 75 days after sowing (PMS), which is predominantly used by onion producers in the state of Rio Grande do Sul (Filgueira, 2008), seedling production, seedling with leaf pruning before and after transplanting at 75 days after sowing (PMP), no-tillage manually performed at the definitive site (PD) and seedling production in polystyrene trays containing 200 cells and subsequent seedling transplantation at 47 days after sowing (PMB).

Table 2. Description of evaluated genotypes

ID	Genotypes	Description of genotypes
T1	Bola Precoce	Commercial variety of 'baía' type with globular shape.
T2	Mulata	Commercial variety of 'crioula' type with globular shape.
T3	Sprint	Commercial variety of 'baía' type with globular shape
T4	Suprema	Commercial variety of 'baía' type with globular shape.
T5	TE 201	Pre-commercial 'baía' type obtained after 4 selection cycles on Sprint variety
T6	TE 209	Pre-commercial 'baía' type obtained after 4 selection cycles on Mulata variety
T7	TE 216	Pre-commercial 'baía' type obtained after 6 selection cycles on Sprint variety
T8	TE 230	Pre-commercial 'baía' type obtained after 4 selection cycles on Sprint variety
T9	TE 242	Pre-commercial 'baía' type obtained after 7 selection cycles on Sprint variety
T10	TE 316	Pre-commercial 'baía' type obtained after 4 selection cycles on Bola Precoce variety
T11	TE 329	Pre-commercial 'baía' type obtained after 4 selection cycles on Suprema variety
	Contrasts	**Description of the contrasts of interest**
C1	[(T1+T2+T3+T4)/4] - T5+T6+T7+T8+T9+T10+T11)/7	Commercial Genotypes vs. pre-commercial genotypes
C2	T1 – (T5+T6+T7+T8+T9+T10+T11)/7	Bola Precoce *vs.* pre-commercial genotypes
C3	T2 – (T5+T6+T7+T8+T9+T10+T11)/7	Mulata *vs.* pre-commercial genotypes
C4	T3 – (T5+T6+T7+T8+T9+T10+T11)/7	Sprint *vs.* pre-commercial genotypes
C5	T4 – (T5+T6+T7+T8+T9+T10+T11)/7	Suprema *vs.* pre-commercial genotypes

The seedbed used for sowing seeds was located in an open environment. Previously, the soil was prepared with a rotary hoe and fertilizer in the 05-20-20 formula (90 g.m^{-2} of the seedbed) was incorporated. Seeds were placed in 1.0 cm deep furrows spaced 10.0 cm apart. The sowing density was 5.0 g.m^{-2}. Crop treatments included sprinkler irrigation as needed and manual weeding. In the tray seedling (PMB) production system, the seedling phase was carried out under protected greenhouse cultivation covered with 150 micron polyethylene plastic film, and 200 cell polystyrene trays were used. Trays were filled with commercial coconut fiber substrate. Two seeds per cell were used and pruning after emergence leaving one seedling per cell.

The sowing of the eleven onion genotypes (Table 2) as a function of the four production systems occurred on the same day (05/12/2016). Three replicates were performed, totaling 132 plots (4.0 m^2 per plot). Each plot consisted of four rows of 2.5 m in length, being represented by 125 plants per plot. Spacing of 40.0 cm between rows and 8.0 cm between plants was adopted, equivalent to 312,500 plants. ha^{-1}. Cultural treatments were performed as recommended for onion culture (Filgueira, 2008).

Harvesting was manually performed according to the phenological stage of plants, when they presented above 70% top collapse. After collapsing, occurring at 140-150 days after transplantation (DAT), 50 plants were randomly taken as sample in the two central lines in each plot. After harvesting, bulbs underwent a "curing" process for a period of 15 days. After this period, yield was evaluated in t.ha^{-1} according to the planting systems.

The experiment was designed in a randomized block design (factorial scheme) using the following statistical model: Yij = μ + bj + factor A + factor B + A x B + eijk interaction. Analysis of variance was performed using the SISVAR statistical application for each character evaluated (Ferreira, 2011). Means were compared by the Tukey test (P> 0.05). Estimates of contrasts of interest were also obtained by applying the Scheffé test (P> 0.01) (Table 2).

RESULTS AND DISCUSSION

There was a significant effect among evaluated genotypes and planting systems. The same was true for the interaction between genotypes vs. planting system (significant, P> 0.01). In fact, the different planting systems influenced the expression of the agronomic potential among the different genotypes evaluated in northwestern Rio Grande do Sul (Table 3).

Table 3. Analysis of variance for onion genotype yield

Source of Variation	DF	MS
Genotypes	10	467.64 **
Production Systems	3	850.53 **
Genotypes vs. Planting Systems	30	56.45 **
Block	2	1.80 *
Error	88	2.31
Total Corrected	131	
CV (%)	8.3	

**, * = significant p = 0.01 and p = 0.05 respectively by the Scheffé test

In the present study, adopting the no-tillage system (PD), commercial genotypes Bola Precoce, Mulata, Sprint and Suprema (55.15; 51.86; 54,0; 55,48 t ha^{-1}, respectively) stood out. The good performance of pre-commercial TE 201 genotype should be highlighted, which did not differ significantly from commercial genotypes by the Tukey test (P> 0.05), showing productivity of 51.57 t ha^{-1} (Table 4).

Table 4. Comparison of averages for onion genotype yield (t ha^{-1}) as a function of no-tillage system (PD), seedling production in trays (PMB), seedling production for later pruning (PMP), seedling production with no pruning (PMS) and contrasts of interest

ID	Genotypes	Production of bulbs (t.ha^{1}) $^{(x)}$			
		Planting system			
		PD	PMB	PMP	PMS
T1	Bola Precoce	55,15 Aa	39,65 Cbcd	48,65 Bb	54,54 Aab
T2	Mulata	51,86 Aab	26,54 Cf	34,76 Bd	50,57 Abcd
T3	Sprint	54,00 Aa	41,90 Cbc	48,75 Bb	50,11 Bcd
T4	Suprema	55,48 Aa	37,29 Cde	48,84 Bb	55,92 Aa
T5	TE 201	51,77 Bab	42,64 Cb	55,18 Aa	53,70 ABabc
T6	TE 209	37,92 Ae	34,53 Be	37,48 BCd	38,44 Aef
T7	TE 216	46,53 Bcd	39,16 Cbcd	34,91 Dd	54,41 Aab
T8	TE 230	34,37 Ae	38,31 ABcde	35,47 Bd	41,13 Ae
T9	TE 242	44,58 Ad	39,14 B bcd	43,64 Ac	46,55 Ad
T10	TE 316	49,39 Bbc	47,90 Ba	42,68 Cc	55,27 Aa
T11	TE 329	33,58 Af	29,01 Bf	27,76 Be	36,33 Af
	CV (%)	8,67	7,70	9,44	12,71

	Estimation of contrasts $^{(y)}$				
	Contrasts of Interest	PD	PMB	PMP	PMS
C1	[(T1+T2+T3+T4)/4] - (T5+T6+T7+T8+T9+T10+T11)/7	10,81 **	-2,33 ns	5,66 **	6,23 **
C2	T1 – (T5+T6+T7+T8+T9+T10+T11)/7	11,84 **	0,98 ns	9,06 **	7,98 **
C3	T2 – (T5+T6+T7+T8+T9+T10+T11)/7	8,55 **	-12,13 **	-4,82 **	4,02 **
C4	T3 – (T5+T6+T7+T8+T9+T10+T11)/7	10,69 **	3,23 ns	9,16 **	3,56 **
C5	T4 – (T5+T6+T7+T8+T9+T10+T11)/7	12,17 **	-1,38 ns	9,25 **	9,37 **

[(x) Means followed by the same lowercase letter in columns and uppercase in rows do not differ from each other by the Tukey's test at 5% probability (p = 0.05)]

(y) **, *, ns = significant p = 0.01, p = 0.05 and not significant, respectively, by the Scheffé test

Several studies conducted in the state of Santa Catarina found that the no-tillage system provided increased bulb production (Camargo, 2011). Despite the suitability of genotypes so far confirmed in this study in northwestern state of Rio Grande do Sul, the no-tillage system in onion culture is little practiced, despite all its agronomic benefits (Amado et al., 1992; Panachuki et al., 2011; Souza et al., 2013). The low performance of the other pre-commercial genotypes in relation to commercial genotypes was reinforced by values obtained in contrast C1 (commercial genotypes vs. pre-commercial genotypes), C2 (Bola Precoce vs. pre-commercial genotypes), C3 (Mulata vs. pre-commercial genotypes), C4 (Sprint vs. pre-commercial genotypes) and C5 (Suprema vs. pre-commercial genotypes) (Table 4).

Regarding the comparison among genotypes as a function of the tray seedling production system (PMB), only pre-commercial TE 316 genotype stood out, producing 47.90 t ha^{-1}, a value considered significant by the Tukey test (P> 0 .05). In fact, by adopting the tray seedling production system, the producer needs less demand for seeds for planting, allowing lower risk due to possible weather variations that may occur during seedling formation (PMS), since seedlings in trays are produced for a period in a protected environment (Vincenzo and Neto, 2003). Still in the tray seedling production system (PMB), only C3 contrast (Mulata vs. pre-commercial genotypes) had significant effects (P> 0.01), demonstrating that despite the poor agronomic performance of most genotypes except for TE 316 genotype, pre-commercial genotypes presented better agronomic potential in the tray seedling production system (PMB), compared to commercial Mulata genotype (Table 4).

In the seedling production system performing leaf pruning (PMP) before transplanting, significantly affects among genotypes were observed by the Tukey test (P> 0.05) (Table 4). For this planting system (PMP), only pre-commercial TE 201 genotype differed from the other pre-commercial genotypes (TE 209, TE 230, TE 242 and TE 329), including commercial genotypes (Bola Precoce, Mulata, Sprint, Suprema), showing productivity of 55.18 t ha^{-1}. Despite the high individual agronomic potential of TE 201 genotype in the pruned seedling system (PMP), the group of pre-commercial genotypes produced 5.66 t ha^{-1} less than the group of commercial genotypes, which were more productive as presented by the C1 value (commercial vs. pre-commercial genotypes), which value was significant at 1% probability. This result represents a 12.51% difference in productivity from the average of commercial genotypes.

For this system (PMP) the group of pre-commercial genotypes stood out only in relation to commercial Mulata genotype, producing 4.82 t ha^{-1} more per hectare, as presented by C3 (Mulata vs. pre-commercial genotypes) (Table 4). This represents a 12.17% difference in productivity from the average of the group of pre-commercial genotypes. The group of pre-commercial genotypes was not potentially more productive in relation to commercial genotypes: Bola Precoce, Sprint and Suprema, according to the significant values presented by contrasts C2 (Bola Precoce vs. Pre-Commercial Genotypes), C4 (Sprint vs. Pre-commercial Genotypes) and C5 (Supreme vs. pre-commercial genotypes), with 9.06; 9.16 and 9.25 t ha^{-1} respectively (Table 4). This represents, respectively, 22.88; 23.14 and 23.36% difference from the average of the group of commercial genotypes.

Despite the agronomic potential expressed by TE 201 genotype, it is essential to take into account the economic, environmental and agronomic aspects when adopting the conventional system. Several studies have shown the lower efficiency of conventional planting with respect to soil conservation, nutrient leaching, nutrient percolation and soil (Cividanes, 2002; Szajdak et al., 2003; Souza et al., 2013).

Regarding the performance of genotypes in the seedling production system without pruning (PMS), which is the system most adopted in the state of Rio Grande do Sul (Filgueira, 2008), it could be observed that two commercial genotypes stood out (Bola Precoce and Suprema) and three pre-commercial genotypes (TE 201, TE 216 and TE 316), which differed from the other genotypes evaluated. The similar performance of pre-commercial TE 201, TE 216 and TE 316 genotypes in relation to commercial Bola Precoce and Sprint genotypes is highlighted. In all contrasts, C1 (commercial genotypes vs. pre-commercial genotypes), C2 (Bola Precoce vs. pre-commercial genotypes), C3 (Mulata vs. pre-commercial genotypes), C4 (Sprint vs. pre-commercial genotypes) and C5 (Suprema vs. pre-commercial genotypes) had significant effect at 1% probability (Table 4).

These results confirm the better performance of the group of commercial genotypes compared to the group of pre-commercial genotypes. However, the individual potential of pre-commercial TE 201, TE 216 and TE 316 genotypes was similar to that of commercial genotypes (Bola Precoce and Suprema), not differing by the Tukey test at 5% probability (Table 4). As in the conventional onion planting system using PMS or PMP methods, several aspects should be considered, mainly related to environmental, agronomic, economic and labor factors (Cividanes, 2002; Szajdak et al., 2003; Tivelli et al., 2010) and the benefits of the PD system on onion culture (Amado et al., 1992; Panachuki et al., 2011; Souza et al., 2013).

Regarding the genotype vs. planting system interaction, no genotype stood out in the four planting systems [seedling production followed by transplanting at 75 days after sowing (PMS), seedling production, leaf pruning of seedlings before transplanting and subsequent transplanting at 75 days after sowing (PMP), no-tillage manually performed at the definitive site (PD) and seedling production in 200-cell trays and subsequent seedling transplantation at 47 days after sowing (PMB)]. However, genotypes were mostly adapted in two production systems, expressing better their agronomic potential (seedling production system and subsequent transplanting at 75 days after sowing and no-tillage manually performed at the definitive site). It is noteworthy that in both production systems, commercial Bola Precoce, Mulata and Suprema genotypes and pre-commercial TE-209, TE-230, TE-242 and TE 329 genotypes stood out.

The higher potential of the no-tillage system can be explained by the higher mass production, which increases the protection of the soil surface against the impact of raindrops, consequently reducing soil, water and nutrient loss by runoff (Panachuki et al., 2011), and also by nutrient cycling, since decaying residues on the soil surface release nutrients (Pacheco et al., 2011) and some of them can be absorbed by the onion throughout its cycle.

Similarly, to the PMS system, predominantly adopted in Rio Grande do Sul (Filgueira, 2008), all genotypes stood out, except for commercial Sprint genotype. Alternatively, to the PMS system, onion cultivation has been carried out under no-tillage system (Kieling et al., 2009). The PMS system uses practices such as plowing and tillage for soil preparation, which alter the size and composition of the seed bank, modifying the vegetative flora of the surface.

This system generates wear and negative impacts on the soil, such as compaction, erosion, loss of water and topsoil, as well as reduction of organic matter contents (Souza et al., 2013). Despite the productive potential of the PMS system in the state of Rio Grande do Sul, it is worth highlighting all the benefits that the PD system can provide for onion culture (Amado et al., 1992; Panachuki et al., 2011; Souza et al., 2013).

Therefore, the no-tillage system for onion cultivation in northwestern Rio Grande do Sul can be potentially explored. This system allows reduction of production costs due to the use of mechanization and consequently lower use of labor. In addition, it provides increased water infiltration into the soil, increasing water storage capacity and reducing evaporation. The genotypes best adapted for this system were: Bola Precoce, Suprema, Sprint, Mulata and TE 201.

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