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Utilization of mandacaru extract, polyvinyl acetate-based glue, and cassava gum as cementing agents for pelletizing creole maize seeds with rock dust

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Abstract

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The objective of this study was to evaluate the effects of different adherent agents, specifically mandacaru extract, polyvinyl acetate-based glue, and cassava gum, on the pelleting process of creole maize seeds with rock powder. Pelleting serves as a valuable method to enhance the seeds' worth and contribute to an increased market value. Creole seeds, commonly produced in family farming, possess inherent resistance and wide genetic variability, which have been inherited from their ancestors. The research was conducted at the Plant Propagation Laboratory, affiliated with the Campus of Engineering and Agricultural Sciences at the Federal University of Alagoas. Rock dust (MB-4) was used as the coating material for the seeds. The following parameters were evaluated: water content, weight of one thousand seeds, initial germination count, germination rate, germination speed index, average germination time, germination uncertainty, root and shoot length, and dry mass. Among the adherent agents tested, cassava gum exhibited the highest efficiency for pelletizing maize seeds with rock dust.

Keywords: germination; genetic variability; vigor

Introduction

Maize is cultivated worldwide and holds significant commercial value as a grain crop due to its high productivity and adaptability to adverse environmental conditions. It has been utilized for various purposes since ancient times, providing products for human and animal consumption (Silveira et al., 2015).

Albuquerque et al. (2008) emphasize that maize cultivation stands out as a productive agronomic activity, particularly for small and medium-sized farmers, as it offers a product with high added value and a favorable return on capital per cultivated area. Maize is considered a highly nutritious food, rich in fiber, vitamins, and minerals, making its production, consumption, and sale highly profitable. Small-scale farmers play a crucial role in its productivity, with their planting and production directly benefiting the population (Crisostomo et al., 2018).

Paterniani (2000) suggests that creole maize varieties demonstrate better tolerance to environmental variations and higher resistance to pathogens due to their adaptation to local conditions. These "creole" populations are valuable genetic resources for improvement programs, as they exhibit high potential for adaptation to specific environmental conditions and offer genetic variability that can be explored in the search for genes conferring tolerance and resistance to biotic and abiotic factors. Melo et al. (2020) highlight that the use of native varieties that are locally adapted not only yields environmental benefits but also helps maintain the genetic diversity of the species, which can serve as a source for further improvement.

Seed pelletizing is a widely adopted technology that enhances seed value and contributes to a competitive market (Santos, 2016). This process involves the application of a dry, inert, fine-grained material, along with a cementing material known as adhesive or adherent, to the seed surface. Rock dust is an option for seed treatment, possessing characteristics such as a multielemental composition and slow solubilization, which make it suitable for alternative production systems and environments prone to nutrient leaching, particularly tropical soils (Van Straten, 2009).

Given the limited information available on the pelletization of native seeds, this study aims to evaluate the effects of four adhering agents: water, mandacaru extract, polyvinyl acetate-based glue and cassava gum on the corn seed pelletization process. Creole with rock dust.

Material and Methods

The study was conducted at the Plant Propagation Laboratory, located at the Campus of Engineering and Agricultural Sciences (CECA) of the Federal University of Alagoas (UFAL) in Rio Largo, AL, Brazil. The creole maize seeds used in the experiment were from the Jabotão cultivar (harvested in 2019).

Four different cementing agents were employed: 1 - water, 2 - mandacaru extract, 3 - polyvinyl acetate-based glue, and 4 - cassava gum. The seeds were placed inside a plastic bottle and the respective cementing agent was added. The bottle was gently shaken to ensure uniform coating. Subsequently, the seeds were coated by covering them with the cementing agent and then placed in a plastic tray containing rock powder (MB-4). The tray was lightly shaken to ensure proper coverage of the seeds. Excess rock dust was removed by sieving at the end of the process. The weight of one thousand seeds (PMS) and water content were measured to evaluate any changes after treatment.

Next, the treated seeds were placed on germitest paper, rolled up, and moistened with distilled water at an amount equivalent to 2.5 times their weight. The rolls were then placed in a Biochemical Oxygen Demand (B.O.D.) chamber at a temperature of 30°C for germination. Seeds that produced normal seedlings, with all essential structures intact, were considered germinated, indicating their potential to continue developing into normal plants under favorable conditions (Brasil, 2009). Daily counts of germinated seeds were conducted for seven days at the same time each day.

The water content of the seeds was determined using the oven method at 105 ± 3ºC for 24 h, following the guidelines specified in the Rules for Seed Analysis (Brasil, 2009). This determination was carried out when the tests were initiated, using four samples per treatment. Additionally, the weight of one thousand seeds was determined by weighing eight repetitions of 100 units, according to the RSA (Brasil, 2009): TSW = SW x 100/N, where TSW represents the weight of one thousand seeds (g), SW is the sample weight (g), and N is the total number of seeds.The variables analyzed were:

a) Germination: $gi = (\Sigma ki = 1ni/N) \times 100$, where ni is the number of germinated seeds/seedlings emerged in time *i* and N is the total number of seeds placed to germinate (Carvalho et al., 2005).

b) First germination count: It was carried out jointly with the germination test, computing the percentage of normal seedlings obtained from the fourth day after the installation of the tests.

c) Germination Speed Index: G1/N1 + G2/N2 + ... + Gn/Nn, where GSI = G1, G2 and Gn = number of germinated seeds computed in the first, second and last count and N1, N2 and Nn = number of days from sowing to the first, second and last count (Maguire, 1962).

d) Average germination time: $t = \Sigma ki = 1(niti)/\Sigma ki = 1ni$, where ti: time from the beginning of the experiment to the *i* nth observation (days or hours); ni: number of seeds germinated in time *i* (number corresponding to the *i* nth observation); *k*: last day of germination (Czabator, 1962).

e) Uncertainty index: $U = -\Sigma ki = 1Filog2Fi \asymp Fi = ni/\Sigma ki = 1ni$, where Fi: relative frequency of germination; ni: number of seeds germinated in time *i* (number corresponding to the *i* nth observation); *k*: last day of germination (Labouriau, 1983).

f) Length of the root and aerial part of the seedlings: At the end of the germination test, the hypocotyl and the primary root of the normal seedlings of each subsample were measured with the aid of a graduated ruler and the results expressed in centimeters per seedling (Melo, 2011).

g) Dry mass of the root and aerial part of the seedlings: After the end of the germination test, the normal seedlings of each repetition were separated into aerial part and root and packed in paper bags, then placed in a forced ventilation oven at 80°C for a period of 24 h. After this time, the samples were placed in desiccators with activated silica gel and weighed on an analytical balance with a precision of 0.0001 g, and the result expressed in g/seedlings (Nakawaga, 1999).

The experimental design employed was completely randomized (CRD), with four replications of 25 seeds per treatment. The data were subjected to analysis of variance (ANOVA), and means were compared using the Tukey test. If necessary, the Dunnett test was also performed at a significance level of 5%. The statistical analyses were conducted using the SISVAR 5.6 software (Ferreira, 2011).

Results and Discussion

In terms of the weight of one thousand seeds (TSW) (Table 1), it was observed that the coating with the proposed adherent agents resulted in increased TSW values for all treatments, except for the seeds coated with water alone. Regarding the water content (WC) (Table 1), the seeds showed similar results that were not statistically different from each other. This indicates that the adherent agents used in the coating process did not retain moisture, and the laboratory environment temperature of 35°C was sufficient for drying during the coating process. In contrast to our findings, Lagôa et al. (2012) reported significantly lower water content values (WC) in pelleted corn seeds compared to non-coated ones.

Table 1. Weight of a thousand seeds (TSW) and Water content (WC) of Creole corn seeds (Jabotão) subjected to adherent agents for pelleting with rock dust

Treatments	TSW, g	WC, %
Water	299.0 bz	12.0 az
Mandacaru	328.1 ay	11.7 az
Glue (PVA)	325.2 ay	11.8 az
Cassava gum	328.1 ay	12.1 az
	TSW = 298 z	WC = 12 z
CV, %	11.00	9.19

Means followed by the same lowercase letter in the column do not differ at 5% probability by Tukey's test.
Means followed by the same letter (z, y), between TSW and WC (control - no bonding agents + rock dust), do not differ significantly at 5% probability by Dunnett's test.

There were no statistically significant differences observed among the treatments for the first germination count (FGC), germination (G), and germination speed index (GSI) (Table 2). This finding aligns with the research conducted by Melo et al. (2020), which demonstrated that pelleting does not reduce the percentage of seed germination, irrespective of the material used, making it a reliable parameter for assessing the success of the process. Additionally, Peske & Novembre (2011) obtained similar results in their study involving millet seeds coated with different adherent materials, corroborating the findings of the present research.

Table 2. First germination count (FGC), germination (G) and germination speed index (GSI) of Creole corn seeds (Jabotão) submitted to adherent agents for pelleting with rock dust

Treatments	FGC, %	G, %	GSI
Water	99 a	99 a	6.187 a
Mandacaru	96 a	98 a	6.025 a
Glue (PVA)	96 a	99 a	6.100 a
Cassava gum	100 a	100 a	6.250 a
CV, %	2.44	5.98	2.97

Means followed by the same lowercase letter in the column do not differ at 5% probability by Tukey's test.

Upon evaluating the results of mean time (MT) and uncertainty (U) of germination in Creole maize seeds (Jabotão) (Table 3), it was confirmed that cassava gum demonstrated superior performance compared to the other treatments, displaying significant statistical differences. The delayed radicle emergence can be attributed to the presence of materials used in the coating process, which create a physical obstacle that the seed must overcome. However, certain materials facilitate better diffusion of gases and water between the seed and the external environment (Nascimento et al., 2009). In this study, cassava gum exhibited the lowest MT, indicating its ability to enhance the germination process. Interestingly, the results for germination speed index (GSI) were contrary to expectations. The treatments yielding the highest GSI values were associated with the lowest MT values, indicating a faster germination process achieved with the cassava gum treatment.

Table 3. Mean time (MT) and uncertainty (U) of germination of Creole maize seeds (Jabotão) submitted to adherent agents for pelleting with rock dust

Treatments	MT, dias	U, bit
Water	4.34 b	0.162 b
Mandacaru	4.51 b	0.181 b
Glue (PVA)	4.48 b	0.188 b
Cassava gum	4.00 a	0.112 a
CV, %	5.88	9.57

Means followed by the same lowercase letter in the column do not differ at 5% probability by Tukey's test.

Regarding the initial development of the seedlings, as evaluated by the length and dry mass of the primary root and shoot (Table 4), it was observed that the highest averages were achieved when cassava gum was used, exhibiting statistically significant differences from the other treatments. The application of cassava gum as the adherent agent for pelleting likely facilitated the germination process by efficiently degrading the reserves present in the seeds. This, in turn, promoted the growth of the root and shoot, leading to the accumulation of dry mass. It is worth noting that, at this stage, the entire development of seedlings relies on the chemical composition of the seeds (Marcos Filho, 2015).

Table 4. Root length (RL) and shoot length (SL) of seedlings from Creole maize seeds (Jabotão) subjected to adherent agents for pelleting with rock dust

Treatments	RL, cm	SL, cm	RDM, g	DMAP, g
Water	9.60 b	8.37 b	0.817 b	1.048 b
Mandacaru	10.11 b	9.00 b	0.902 b	0.889 b
Glue (PVA)	10.15 b	9.22 b	1.017 b	1.003 b
Cassava gum	12.20 a	10.00 a	1.595 a	1.478 a
CV, %	7.98	6.82	8.65	4.99

Means followed by the same lowercase letter in the column do not differ at 5% probability by Tukey's test.

Conclusions

Cassava gum stands out as the most efficient adhering agent for pelletizing corn seeds with rock dust.

Pelleting gave all seeds a uniform size and shape, which significantly reduces flaws, resulting in better seed distribution and faster sowing.

It is a simple and cheap process, this technique protects the seed against external factors.

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