

Full Length Research Paper

Comparative studies of seed priming and pelleting on percentage and meantime to germination of seeds of tomato (*Lycopersicon esculentum* Mill.)

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The effect of seed priming and pelleting on germination percentage and mean time to germination of local cultivars (cv.) of tomato (*Lycopersicon esculentum* Mill.) was studied in 2006 in Mauritius. Osmopriming with Polyethylene Glycol (PEG), at -1.25 MPa for 2 days resulted in significantly ($P < 0.01$) higher germination percentage (79.1%) than untreated control seed (62%) of the tomato cv. Sirius which is considered satisfactory for tomato. Besides, seeds primed for 2 days emerged earlier than seeds primed for 7 days. Acacia (*Acacia nilotica*) leaf powder which is locally affordable was used for the pelleting of the tomato seeds. The assay on seed pelleting proposed a formulation ratio (g/ml/ml) of seed: acacia powder: water of 10:3:22. Mean time to germination of the coated seeds was significantly different from that of the uncoated seed. However, meantime to germination significantly decreased in decoated seeds as compared to coated seeds. These results imply that seed coating presumably acts as a barrier that delays the emergence of tomato seedlings. Hence, pelleted seeds require decoating for enhanced germination and seedling emergence. This study concludes that seed priming and pelleting can be used to improve germination rate of seeds of locally grown tomato cultivars. These seed enhancement techniques can be adopted to standardize tomato transplant quality hence contributing to uniform crop stand in Mauritius.

Key words: Tomato, seed priming, pelleted seeds, seed germination percentage.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is the second most important vegetable in Mauritius (Evariste, 2003). Tomato grown in Mauritius includes local open-pollinated varieties Sirius, Calora, and MST 32/1. Besides, Epoch is the most famous imported hybrid variety. The north of the Island has remained the principal tomato-producing region followed by the South where tomatoes are grown all year round. Highest yields are obtained during cooler months of June to July, but peak production occurs in the months of November to January.

The average production is around 13000 tones and there is an increasing trend for producing salad tomatoes. Tomato prices in Mauritius show fluctuation due to yield variations across seasons.

Today's competitive agricultural development environ-

ment demands that growers produce high yield of good quality fruits to meet the market demand. A package of cultural practices for all year round production of tomatoes in sugarcane interrows has been devised and, determinant, heat and bacterial wilt resistant varieties have been developed. This also includes transplanting techniques with several advantages such as easy seedling management, uniform crop stand and up to one month reduction in crop cycle as compared to direct seeding.

The total yield and quality of transplanted crops depends on the transplant/seedling quality and performance. Presently, the cost of local seeds is as low as 25 Euros per Kg and planters waste seeds by sowing heavily. However, this practice cannot be done with costly imported hybrid varieties. As such, tomato hybrid variety Epoch costs up to 40 times as much for 1 kg. Subsequently, planters have adopted containerized systems of seedling production where two to three seeds are sown per container/cell to be more efficient and enhance

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the standard of tomato production. However, transplant quality is not of high standard because planters neglect the many factors that go along with seedling production.

Studies in Mauritius have revealed that inadequacy of good quality seed was the second biological problem after pest and diseases, which causes production to be irregular and inadequate (Govinden et al., 1997). Poor quality of seed can be addressed by seed priming which has been adapted in many developed countries to improve seed performance through increased seed vigor subsequent to enhanced percentage of seed germination and rates of seedling emergence (Argerich and Bradford, 1989; Abdulrahmani, 2007). The flowering dates are earlier (Gray et al., 1990) and more uniformity in stand establishment is observed leading to improved homogeneity at harvest and increased commercial yield (Haris, 2006).

As mentioned above, local planters usually sow tomato seeds heavily and do thinning later on to keep three plants (Govinden et al., 1999). This usually caters for losses due to poor quality of seeds of local tomato varieties and poor plant development in case of drought (Govinden et al., 1997; Govinden et al., 1999).

Seed priming and seed pelleting are physiological seed enhancement methods used on many horticulture crops to improve rate of seed germination and seedling performance so as to reduce seed wastage and facilitate the delivery of seeds (Taylor et al., 1998). Seed pelleting is applied to seeds to improve the outer structure into uniformly round seeds, which enable precision planting.

Both seed priming and seed pelleting can enhance seed quality, hence improving seedling value and reduce cost of transplant production. As there is an increased trend for earlier and all-year round production of tomatoes, the use of transplants will certainly increase. Tomato transplants could probably exist as a small industry where seedlings could be available all year round in sales outlets or self-service stores. Moreover, due to poor quality of local tomato cultivars, seed priming and pelleting may be used to address germination and seedling emergence problems that are the cause of low revenues of the planter during the transplant production phase. In this study, enhanced seed and transplant production techniques to improve quality of seedling were investigated. The effects of different seed priming techniques on germination potential of tomato seed were evaluated as well as the performance and requirements for the production of pelleted seeds of local tomato cultivars.

MATERIALS AND METHODS

Preparation of the osmotic pre-sowing treatments using PEG 6000 solutions

Experiments were conducted in the crop production laboratory of the University of Mauritius on tomato cultivar 'Sirius'. Pre-sowing treatment techniques combined the following conditions: untreated seed (control), osmoprimed seed and acacia leaf powder-pelleted

Table 1. Percentage of powder loaded by coated seeds

100 seed fresh weight of uncoated seeds	0.198
100 seed fresh weight of coated seeds	0.295
Powder loaded for 2 days soaking	0.097
% of powder loaded	32.839

seed. Four solution concentrations were tested and included osmotic (polyethylene glycol) PEG 6000 solutions of -0.75, -1.00, -1.25 and -1.50 MPa for two treatment application times of 2 and 7 days. Before priming seeds at these osmotic potentials, raw seeds were placed directly in the solutions to verify that there would be no radicle protrusion during treatment.

Osmotic solution was prepared by calculating the amount of PEG using the equation of Michel and Kaufmann (1973) and Taylor et al. (1998).

$$= [\text{PEG}]^2 [0.13T - 13.7] =$$

osmotic potential in MPa

[PEG] = concentration of PEG (gram per gram of water)

T = Temperature (°C)

Seeds were placed in 75 ml of aerated PEG solution for a priming duration of 7 days at $26 \pm 0.5^\circ\text{C}$. After treatment, primed seeds were washed under distilled water for 2 min and surface-dried with blotting papers. Seeds were left to dry in a ventilated area for 2 h until 6% moisture content was achieved.

Processing of Acacia (*Acacia nilotica*) leaf powder for pelleting tomato seeds

Leaves were collected from the acacia tree (*A. nilotica*), dried at 70°C for 2 h, ground to a fine powder and sieved (300 mesh standard kitchen sieve). Starting with a basic trial, 0.3 g tomato seeds were immersed in 100 ml mixture of acacia powder and water in a ratio (g/ml) of 1: 2 for 2 days. After treatment, seeds were sieved using 1 – 2 mm sieve and dried in open-air conditions ($25 \pm 2^\circ\text{C}$) for 2 days. The percentage powder loaded by 100 seeds and percentage of debris left after coating (purity test) was determined by weighing methods according to e-CFR, Canada (2003) (Table 1). The seed coating experiment is summarized in (Tables 2 and 3). Seeds of tomato cv. (MST/32) of less than 2 mm in size, acacia powder and water were mixed in a 100 ml beaker in the formulation of the different treatments (T10 to T50; T10 indicating that 10% powder is loaded by 100 seeds; T20 indicating 20% and so on). Uncoated seed was used as control. The seeds were left in the mixture for 2 days at $25 \pm 2^\circ\text{C}$, 60% relative humidity (RH). After treatment, seeds were sieved using 10 mm sieve and air-dried ($25 \pm 2^\circ\text{C}$) for 2 extra days.

Seed testing

To know whether acacia powder had an effect on the seed, one third of the coated seeds were set aside for de-coating. De-coating was done by rubbing the seeds to remove the powder film already loaded. The percentage of powder loaded by seeds (mg of coating in 1 seed and the % increase in weight of pelleted seed e.g 3 - 50 times [300 - 5000%]) and flowability of powder for each treatment were calculated on a fresh weight basis. Seed moisture content was determined as follows:

$$\frac{\text{Fresh weight of seed sample} - \text{Dry Weight of seed}}{\text{sample}} \times 100$$

The percentage of powder loaded by 100-coated seeds was 32.8%. Assuming the powder loaded (P) to be inversely proportional to the ratio of water (w) used for the mixture, the following equation was derived: $P = k/w$. (P = Powder loaded = 32.8; k= constant; w = ratio of water to be added to immersion mixture = 2). k was calculated and the final equation was as follows:

$$P = \frac{65.6}{w}$$

The above equation was used to estimate the amount of water to be added for getting effective pellets structure for different treatments (Table 2).

Table 2. Estimates of powder to be loaded by 100 tomato seeds.

Estimates of powder to be loaded by 100 seeds (%) (P)	Ratio (g/ml)	
	Acacia powder	Water
10	1	6.56
20	1	3.28
30	1	2.18
40	1	1.64
50	1	1.31

From Table 2, different formulations (treatments) were derived which gives the ratio of seed: water: acacia (x: z: y) powder needed to give pellet with 10 to 50% powder loaded (Table 3).

Table 3. Component Ratio for different pellet formation

Ratio of Immersion components	Formulation (ratio g/ml)				
	1	2	3	4	5
acacia powder (y)	1	1	1	1	1
Seeds (x)	0.3	0.3	0.3	0.3	0.3
Water (z)	6.56	3.28	2.18	1.64	1.31
Total Ratio	7.86	4.58	3.48	2.94	2.61

Using ratio of x: z: y for each formulation, treatments (T10 - T50) for a 100 ml mixture were derived (Table 4). For example, using formulation 1, treatment T10 was derived consisting of 12.72 g of acacia powder (y), 3.82 g of seeds (x) and 83.46 ml of water (z)

$$\text{calculated as follows: } y = \frac{1}{7.86} \times 100 = 12.76$$

$$x = \frac{0.3}{7.86} \times 100 = 3.82$$

$$z = \frac{6.56}{7.86} \times 100 = 83.46$$

Fungicide treatment

0.5 g of Metalaxyl (phenylamide used for seed dressing) fungicide was added to 100 g of coated material to control fungal growth (Ali et al., 1990; Table 4). For example, for treatment T10, the amount of metalaxyl (f) to be added was calculated as follows:

$$f = \frac{0.5}{100} \times 83.46 = 0.417$$

Statistical analysis

All the experiments were set up as a completely randomized design with three replicates. Data were analyzed using Analysis of Variance with mean separation by LSD Test. Germination percentage data was arc-sin transformed before analysis. Actual germination percentages are shown. Numbers are round off to 1 d.p.

RESULTS

Effect of osmotic priming with PEG 6000 treatment on seed germination potential

Tomato seeds cv. Sirius treated with a polythelene glycol (PEG) solution at -0.75 MPa for 2 days emerged significantly, (P < 0.05) earlier (2.5 days) (P = 0.06) than untreated seeds (3 days) (P = 0.02) (Table 5). When treated for 7 days seeds primed in an osmotic solution at -1.25 MPa gave faster emergence rate (4 days) than untreated seeds (4.8 days, P = 0.06). Mean germination time response to seed treatment (priming) averaged over priming duration was shorter than that recorded in the untreated seed (control). However, the response to 2 day priming was faster than that of the 7 day treatment (0.5 and 0.7 days difference from control respectively).

Germination percentage

Higher germination percentage (79%) was obtained when seeds were primed for 2 days in -1.25 MPa osmotic solution (P < 0.05). Data showed that priming improved germination percentage when seeds were treated for 2 days in contrast to a 7 day period that reduced germination percentage (Table 5). Germination percentage was lowest when seeds were primed in -1.50 MPa PEG solution for 7 days (67.5%) (P < 0.05) (Table 5).

The effect of pelleting seeds of tomato using Acacia (*A. nilotica*)

Mean time to germination of the coated seeds did not differ significantly when compared to uncoated seed with the exception of T20, where it took two more days for seeds to germinate (Table 6). When coated seed were compared to decoated ones, the mean time to germination greatly decreased in the latter group of seeds with significant differences in T50 and T40. These results suggest that coating presumably acts as a barrier that increases the mean time to germination in seed of tomato cv.

Table 4. Treatment formulations with fungicide for effective pellets formation.

Immersion components	Treatments				
	T10	T20	T30	T40	T50
acacia powder (g)	12.72	21.83	28.74	34.01	38.31
seeds (g)	3.82	6.55	8.62	10.20	11.49
water (ml)	83.46	71.62	62.64	55.78	50.19
Total mixture (ml)	100.00	100.00	100.00	100.00	100.00
Metalaxyl (g)	0.42	0.36	0.31	0.28	0.25

Table 5. Emergence rate and germination percentage of primed tomato seeds var. Sirius using different osmotic potentials and two priming durations.

Treatments (MPa)	Treatment Duration (application time) (days)			
	2		7	
	MTE (days)	Germination (%)	MTE (days)	Germination (%)
-0.75	2.5 ± 0.08*	71.5 ± 3.4ns	4.6 ± 0.02ns	76.0 ± 3.2ns
-1.00	2.5 ± 0.09ns	70.5 ± 5.7ns	4.9 ± 0.11ns	79.5 ± 2.9ns
-1.25	2.9 ± 0.26ns	79.1 ± 3.0**	4.0 ± 0.19**	77.5 ± 3.5ns
-1.50	2.7 ± 0.13ns	75.0 ± 1.5ns	4.8 ± 0.16ns	67.5 ± 3.5**
unprimed seeds	3.0 ± 0.17	62.0 ± 5.6	4.7 ± 0.13	84.0 ± 1.2

*Significantly different at 0.05%

** Significantly different at 0.01% ns: non-significant.

Table 6. Mean time to germination of coated and decoated tomato seeds produced from different formulations

Treatments	Mean time to germination			
	Coated seeds		Decoated seeds	
T50	5.47 ± 0.19	ns	4.44 ± 0	*
T40	6.25 ± 0.12	ns	4.34 ± 0.10	*
T30	6.21 ± 0.22	ns	4.95 ± 0.18	ns
T20	8.21 ± 0.65	**	5.82 ± 0.31	ns
T10	6.17 ± 0.32	ns	5.46 ± 0.19	ns
uncoated	6.10 ± 0.33	-	6.10 ± 0.32	-

Significant at 0.05 level

** Significant at 0.01 level

ns: Non-significant.

Table 7. Germination % for coated and decoated tomato seeds produced from different formulation

Treatment	% Germination			
	Coated		Decoated	
T50	74.00 ± 1.4	ns	78.00 ± 0	ns
T40	73.00 ± 2.1	ns	79.00 ± 0.7	ns
T30	74.00 ± 2.8	ns	83.00 ± 2.1	**
T20	63.00 ± 4.9	ns	75.00 ± 1.5	ns
T10	67.06 ± 2.2	ns	73.91 ± 6.1	ns
Control	67.00 ± 2.1	-	67.00 ± 2.1	-

** Significant at 0.05

level ns: Non-significant.

MST 32/1.

Pelleting tomato seeds with acacia powder did not tend to affect germination as coated seeds were compared to the uncoated seed control (Table 7). However T30 gave the best germination percentage. Higher germination percentages were recorded in decoated seeds than against coated seeds with a highly significant increase in germination percentage in decoated T30 seeds (Table 7).

DISCUSSION

Osmopriming

Seed priming started with Greek farmers who soaked cucumber seeds in milk or honey before sowing to increase germination and emergence (Parera and Cantliffe, 1994). Polyethylene Glycol (PEG 6000) is now

widely used for priming numerous agricultural and horticultural species due to high molecular weight and its inertia (Cantliffe, 1993). Aeration is often necessary during priming with PEG because oxygen solubility is 50% and mobility is 10%, depressing relative oxygen availability to the seeds by 5% (Mexal et al., 1975). This study demonstrates that osmopriming with PEG improves the vigor of tomato seeds as determined by a decrease in mean time to germination. Under all osmotic potential and priming durations, mean time to germination was lower in primed seeds by 1 day as compared to unprimed seeds as reported by Kant et al. (2003), De Castro et al. (2000), Cavallaro et al. (1994) and Leskovar and Sim Karssen et al. (1989) stated that in tomato seed, the mechanical resistance of the enclosing tissues decreases during osmotic priming, hence there is endosperm weakening. According to Gray et al. (1990) seed priming modifies the embryonic axis growth and subsequent seedling development. In the experiment, it was found that priming seeds at -1.25 MPa for 2 days increase germination rate by 27% as compared with the control (P (1987). In a study on wheat, maize, rice and sorghum, Basra (2002) and Badek (2005), stated that primed seeds emerged 1 - 3 days earlier than non-treated seeds and it quickly became apparent that these early gains led to a range of later benefits. Goobkin (1989) and Ozbingol (1999) also stated that PEG 6000 solution -treated tomato seeds germinate faster than untreated seeds. The treated seeds resulted in a more uniform and simultaneous germination. Bradford (1986) established that priming changes the germination mechanism in tomato seeds in that water uptake by primed seeds is more rapid than by unprimed seeds due to lower osmotic potential of primed seeds during imbibition or from improved hydraulic conductivity. < 01%). This positive response to osmopriming is consistent with the findings of Mauromical and Cavallaro (1997). The higher germination percentage could suggest that adequate metabolic activity had occurred in the seed at this osmotic potential and priming duration. Bino et al. (1992) indicate that DNA replication start at day 2 of the priming process. Coolbear and Grierson (1979) reported that higher germination rate was a result of higher levels of nucleic acid in primed seeds of tomato cultivars. They observed that increase in nucleic acid content in primed seeds was due to an enhanced ribonucleic acid (RNA) synthesis during and after priming treatment. It was suggested that the efficiency of priming was related to the accumulation of 4C nuclei in the radicle meristem (Gurusinghe et al., 1999). Similarly, Chiu (2006) and Ashraf (2005) also reported the effect of osmopriming on increasing the metabolic activity of treated seeds. Data in the present study suggest that when seeds are primed at -1.25 MPa for 2 days, radicle emergence is hindered but metabolic advancement occurs. Above an osmotic potential of -1.25 MPa and regardless of the priming duration, germination percentage was found to decrease. This could presumably be ascribed to higher osmotic potential, when seeds might not imbibe enough water to

reach the critical hydration level at which meta-bolic activity would occur. Vertucci and Farrant (1995) reported similar findings.

Our data indicated that priming seed for 7 days reduced germination percentage at all osmotic potentials as compared to control treatment, although osmopriming was found to improve germination rate and synchrony. Similarly, Argerich and Bradford (1989), Pill et al. (1997) and Mwale et al. (2003) reported that final germination percentage was unaffected when seeds were primed in some cases. In the present study, lowest germination rates were observed when seeds were primed at -1.50 MPa for 7 days (67.5%).

Seed pelleting

The rationale for seed pelleting is to take a seed that is light in density and turn it into a seed with a pellet around it that makes the seed heavier, more uniform and as perfectly round as possible. A planter will be able to plant that seed/pellet in the most accurate and precise way that is feasible. Creating a pellet is both a science and an art (Kubik, 2002). Most of the science comes when selecting the powder. It seems that acacia powder used as filler is very recent and no further literature concerning acacia powder has been obtained, mostly because seed pelleting materials and methods are 'trade secrets'. Acacia leaf powder was chosen as filler for tomato seed pelleting because it is locally available and has been recommended by Nargis et al. (1999), where tomato seeds were pelleted at 300 g/kg of seeds. Through this trial, acacia leaf powder is assumed to act as both a nutrient supplier and a delivery system for recent protection materials to protect seeds against soil and seed borne pathogen. Similarly, immersing seeds in macronutrient solutions has claimed to increase the seedling growth of sugar beets and grain yield and nutrient uptake of cereal (Scott, 1989; Woomer, 2003). The present study showed that although no binder was used-the only binding agent being water-, acacia powder could be used for pelleting seed of tomato because of the adherence nature of this material onto the seed coat. The main disadvantage in the use of acacia powder was the development of fungal mould on the seed that had to be treated with fungicide (Metalaxyl). Along the same line, Lobl et al. (1979) warned about the care required in the use of organic material for pelleting seeds as there might be a risk of rapid microbial invasion of the pellet when planted in soil. The use of fungicides as components of seed pelleting materials has also been recommended by Huijbregts (1995).

Although T30 and T40 coated seeds produced the best pellet, it took coated seeds longer to germinate as compared to uncoated seeds. This could be due to the compact coat that was produced around the coated seeds which could presumably create a mechanical barrier to the protrusion of the radicle. These results correlate with those of Halsey and White (1980) and Petch (1991) on carrot where seed coating slowed germination. Durant

and Loads (1986) also found that a clay pellet applied to seeds of sugar beet retarded and reduced emergence. Delay in germination could also be due to limited availability of oxygen to the embryo of seed coated with acacia leaf powder. Sach et al. (1981) reported similar findings in their study, where seeds of sweet pepper were coated with clay and sand. In the reported study, oxygen releasing salts including barium oxide and sodium borate were included in the treatment formulation. It is worth mentioning that T30 and T40 coated seeds gave higher germination percentage (76 and 73% respectively) than uncoated seeds (67%), meaning that germination process is not affected by the pellet size or structure. The increase in germination may be due to the availability of nutrients in the acacia powder. Pelleting of seeds with nutrients in pelleting material raised the yield of tomatoes through accelerated growth and development (Konstantinov, 1983). Moreover, during germination tests, it was observed that pelleted seeds gave seedlings with deeper green and larger leaves as compared to unpeeled seeds.

However, decoated seeds required less time to germinate as compared to coated or uncoated seeds. Moreover the germination percentage was significantly ($P < 0.05$) higher in decoated seeds for T30 (*3% for decoated as opposed to 76% for coated) (Table 7). These results suggest that acacia powder may have a negative effect on germination when used as coating. The performance of pelleted seed may be negatively affected as a result of chemical transformation caused by the applied fungicide or many other factors as reported by Scott (1989) and Petch (1991).

Conclusion

This study has shown that osmopriming and seed pelleting techniques may be used to enhance seed of local tomato cultivars as a result of their positive effects on germination and seedling performance. Seed priming with polyethylene glycol (PEG 6000) osmotic solutions was found to enhance seed germination rate and hasten mean time to germination, both of which are seed vigor indexes. Subsequently, it was proposed that seeds of local tomato cultivars could be primed using solutions of osmotic potential in the range of -0.75 to -1.25 MPa for 2 days at $26 \pm 0.5^{\circ}\text{C}$ and under photosynthetically active radiation conditions. For earlier emergence rate and uniformity of stand, -0.75 MPa was recommended. Moreover, using lower osmotic potential implies using less PEG, hence reducing the cost of the priming treatment. For enhanced germination percentage, an osmotic potential of -1.25 MPa may be more appropriate. This study suggests a ratio of 10:3:22 in the formulation of acacia powder: seed: water for tomato seed pelleting. However, decoating appears essential for enhanced germination rate and seedling performance.

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