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Full Length Research Paper

The influence of seed processing and drying techniques at varying maturity stages of *Solanum melongena* fruits on their germination and dormancy

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Studies were carried out to determine seed germination and dormancy of *Solanum melongena* cv. *Ngwa local large* and methods to overcome seed dormancy during seed maturation (midful seed=MS; full seed=FS; sign of ripening=SR; greenish red=GR and full red=FR). Seed germination was tested for fresh, dried and stored seeds processed by cut fruits and squeeze out seeds (Csq), dry; cut fruits, ferment, wash and dry seeds (CF) and dry seeds on whole fruit (DOF). Seeds reached physiological maturity (maximum dry weight) at the FR stage. Germination of the fresh seeds showed that all the developmental stages had acquired germination ability but were dormant. Fresh seeds harvested at FR and MS gave 29 and 24% germination, respectively. DOF improved seed germination percentage from 24 to 46 in MS and 29 to 50 in FR after one month of seed storage. Furthermore, the interaction effect indicated that DOF caused seeds to overcome dormancy by the third month of seeds in storage where FR and MS gave 90 and 73% seed germination, respectively. However, the main effect of FR could overcome dormancy to give 71% seed germination in five months of seed storage. This implied that the treatment (DOF) thus saved two months in overcoming dormancy as well as gave a higher germination percentage. Fruits from the crop species could be picked at MS and FR stages of development and seeds processed by DOF under the sun. This will overcome the seed dormancy in three months, improve germination and preserve the perishable genetic resources (seeds) from attack by *Quelea quelea* L. and *Lucinodes orbonalis Guen*.

Key words: Dormancy, seed drying, seed germination, seed processing and stage of seed harvest.

INTRODUCTION

As seeds develop in fruits they go through morphological, biochemical and physiological changes. Some of these changes are acquisition of germination ability, the development of desiccation tolerance and overcoming of seed dormancy (Samarah et al., 2004). Acquisition of ability to germinate in seeds has been reported to be attained at specific developmental stages in different crop species (Miles et al., 1988; Hamid et al., 1995; Samarah et al., 2004; Agbo and Obi, 2008). The ability of seeds to survive rapid or slow dehydration and to germinate following rehydration is a general definition used (Leprince et al., 1993). Dried, developing seeds that are not capable of germination following re-hydration are considered as "intolerant" of drying. Seeds are dormant when they fail to germinate under favourable environmental conditions and require to be exposed to some treatments to overcome the dormancy (Copeland and MacDonald, 1995). Seed dormancy is another important factor affecting germination of seeds harvested during maturation stages. Thus, the stage of seed maturity at harvest may affect seed dormancy and germination. This is most likely as some hormones in seeds have been shown to impair germination during maturation. For example, abscisic acid (ABA) had been shown to be involved in prevention of precocious seed development at a later stage of seed maturation (Romagosa et al., 2001). ABA has also been identified to play a major role in regulation of gene expression in seeds particularly the induction of several kinds of polypeptides (Skriver and Mundy, 1970) and the distribution of genes for certain reserves mobilizing enzymes

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(Jacobsen and Chandler, 1987). Yogeesha et al. (2006) had shown that a strong relationship exists between seed dormancy and ABA contents of seeds of *Solanum melongena* species. Free ABA is highest in developing seeds and is generally low or even undetectable in mature seeds (Black, 1991). High quality seeds are the result of good production practices which included: proper maintenance of genetic purity, proper timing and method of harvesting, appropriate processing during seed extraction, cleaning, drying and appropriate seed storage. Fasoyiro et al. (2005) indicated that the method of proces-sing seeds has large effect on the nutrient and antinutrients content of three varieties of pigeon pea (*Cajanus cajan*). Such nutrient composition of seeds largely affects the germination and dormancy of such seeds. Bonina and Cantliffe (2005) suggested that wet seeded fruit like *S. melongena* could be processed by cutting open the fruit and the seeds within scooped out, cleaned and dried.

S. melongena plant can be a fruit or fruit and leafy vegetable depending on the part(s) of the particular species in question that is consumed. *Ngwa* local has three distinct fruit sizes: large (fruit length and diameter = 5.0 and 5.1 cm); medium (fruit length and diameter = 4.5 and 4.0 cm) and small (fruit length and diameter = 4.10 and 3.30 cm). It is a fruit vegetable because the leaves are not consumed. The species is cultivated in large quantities in all parts of south-eastern Nigeria. The fruits are slightly bitter in taste and greenish in colour before full maturity. The green fruits are consumed fresh and served to visitors as cola in 'homes' and the red fully matured fruits are used to make stews. Seed production of *S. melongena* cv. *Ngwa local large* has received limited research emphasis. It has been observed in recent times that an important seed production constraint of *Ngwa local large* is the loss of fruits, and subsequently seeds to attack by insects and birds, which attack the fruit especially at the fully ripened stage. *Leucinodes orbonalis* Guen. (fruit borer) has been identified to be a major pest of *S. melongena* cv. *Ngwa local large* in parts of south-eastern Nigeria. It starts its attack from fruit setting stage and damage becomes pronounced from the month of August every year and continued till the end of the year. It, therefore, damages the fruit and seeds especially at the ripened stage to a devastating level leading to loss of seeds of important selections for continued production. Also, *Quelea quelea* L. birds damage the ripe fruits by feeding on them from the month of September. The two pests of the crop occur towards the time of seed processing period. Hence, it is necessary to find a way of averting the devastating effects they cause on seed production. Even though, these pests inflict serious damages on seeds of *S. melongena*, harvesting the fruits before they are fully matured may interfere with germination and storage of the seeds.

In Nigeria, the traditional way of processing *S. melongena* seeds are by drying them on the fruits and storing the fruits for the following year's planting. This method has been viewed as time consuming because the fruits are watery and takes long time to dry up. Alternative and faster methods of processing the seeds were adopted and tested along with the traditional method. The two methods adopted were cutting fruits and squeezing out the seeds and drying them and cutting the fruits into four parts, fermenting them for three days (for mucilage to be removed from seeds), washing the seeds and drying them. The seeds processed by the different methods were dried using three methods. The methods were sun drying, air-drying and dry pre-chilling. The processing or drying methods might reduce or negate the restraints imposed on the seeds due to external structure (seed coat and storage tissue) or internal factors (abscissic acid) (Bewley and Black, 1994) and improve germination at the appropriate development stage. The objective of this study was to determine the effect of maturity stage of fruit at harvest and method of seed processing on dormancy and germination of fresh, air-dried, sun dried and dry pre-chilled seeds of *S. melongena* cv. *Ngwa local large* over periods of time in storage.

MATERIALS AND METHODS

Seed processing

Seedlings of *Ngwa local large* cultivar were transplanted at University of Nigeria, Nsukka on 12 August, 2006. Nsukka is in the derived Savanna Agro-ecology. It is located on latitude 06°52' N, longitude 07°24' E and 447 m altitude. Rainfall is bimodal with an annual total of about 1500 mm. The soil texture is sandy clay loam. The seedlings were transplanted at a spacing of 80 x 60 cm. Poultry droppings were incorporated into the soil at the rate of 10 tons ha^{-1}. During seed development, three replicates of 100 fruits were picked at five developmental stages selected based on visual criteria, which included fruit colour and the area of the seeds filled with food material. The five developmental stages are described in Table 1.

The fruits were kept in tight plastic bags as they were picked and brought to the laboratory within one hour. In the fruit laboratory, six fruits per developmental stage were taken to measure fruits and seeds characteristics, including fruit weight, fruit length, fruit diameter, seed fresh weight and colour. Fifty seeds from another sample of fruits were immediately removed from the fruits, weighed and oven dried at 105°C for 24 h to determine seed dry weight and seed moisture content (MC) on a wet weight basis. Seed dry weight of the 50 seeds was recorded and the data were represented as (milligram) of dry weight per seed. Seed moisture content was calculated before drying and after at the other three periods of germination testing according to the ISTA rules (1985) as follows: the difference between the weight of wet seeds and oven-dry seeds was divided by the weight of the wet seeds. The remaining fruit were either immediately (fresh) used for measuring seed germination or the fruits were processed according to the three designed processing methods within 5 h after picking of fruits. The processing methods were: cut fruits and squeeze out seeds, and cut fruits and ferment for three days and dry seeds on the fruits for one month. Three methods were used to dry seeds from each of the three processing methods adopted. The drying methods were: air drying

Table 1. Description of the stages of seed development.

Stage of maturity	Harvest date (2006)	Description
Mid-full seed (MS)	6 October	Fruits were light green, some seeds were not fully filled, and light milky white in colour
Full seed (FS)	12 October	Fruits were green and attain maximum fruit size. More seeds are fully filled and milky white in colour
Sign of ripening (SR)	18 October	Fruits start to ripen from the stylar point. Seeds were fully filled and milky yellow in colour
Greenish red (GR)	23 October	Fruits were greenish red. Seeds were fully filled and milky yellow in colour
Full red (FR)	27 October	Fruits were fully red. Seeds were fully filled and light yellow in colour

Table 2. Fruit and seed measurements of *S. melongena* cv. *Ngwa local large* picked at five stages of development

Development stage	Fruit			Seed		
	Fresh weight (g fruit^{-1})	Length (cm fruit^{-1})	Diameter (cm fruit^{-1})	Fresh weight (mg seed^{-1})	Dry weight (mg seed^{-1})	Moisture content (%)
MS	37.08	3.80	3.77	1.47	0.27	82.30
FS	43.24	4.63	4.77	1.87	0.80	57.30
SR	43.45	4.83	4.80	2.27	1.27	43.70
GR	45.35	4.97	5.03	2.33	1.67	28.30
FR	47.45	5.00	5.03	2.53	1.93	23.70
LSD (P<0.05)	4.95	0..28	0.62	0.01	0.01	9..23

under shades at a maximum ambient temperature of 31.7°C and relative humidity of 65%, sun drying in a white house at a maximum temperature of 39°C and relative humidity of 59% and air dried seeds kept at 10°C for 10 days (dry pre-chilling). Drying of seeds by either air or sun was maintained until a moisture content of about 14% was obtained before the seeds were removed and either used for germination test or stored for future germination test.

Seed germination

Seed germination was determined on fresh seeds from two of the processing methods (cut fruits and squeeze out seed and cut fruits and ferment) that could give fresh seeds and after 4, 12 and 20 weeks of drying on each of the three processing and drying methods. Moisture content of the seeds was determined at each time of the germination test. For fresh seeds, they were removed from the picked fruits and plated within three hours. Thirty seeds were placed on two layers of filter papers and covered with a third layer in 9 cm petri-dishes and incubated at 31°C for 18 days. The petri-dishes were moistened with 6 ml of distilled water at the beginning of the test and water was applied to the petri-dishes as needed during the test period. Germination test was also carried out for the dried and stored seeds after 4, 12 and 20 weeks of drying. Seed germination (radicle protrusion through the testa) was evaluated on daily basis for 18 days to account for normal and abnormal seedlings, dead and dormant seeds and germination percentage. Normal seedlings are seedlings having a vigorous primary root or a set of secondary root system, intact hypocotyls and/or epicotyl without damage, at least one attached cotyledon and attached terminal buds (AOSA, 1986). Abnormal seedlings are those having the following defects: no primary root system with weak secondary roots, a lesion in the conducting tissue, those with one cotyledon missing and seedlings with damaged terminal buds (AOSA, 1986). Dormant seeds are imbibed seeds which remained firm and apparently viable at the end of the test period (ISTA, 1985). Dead seeds are those having decayed tissue at the end of the test (neither hard nor fresh and have not produced seedlings) and were determined by pressing the seeds by the finger (ISTA, 1985).

The statistical design was factorial experiment in completely randomized design (CRD) with three replications. The three factors were: fruit development stages (5 levels), seed processing and drying of seeds with three levels each. A total of forty-five (45) treatment combinations were obtained. Data collected on the seed attributes were subjected to analysis of variance following factorial in CRD format using Genstat 2.0, discovery edition (2005). Fisher's least significant difference (LSD) was used for mean comparisons among the stages of maturity and treatments, when the F-test for the effects was significant ($P < 0.05$).

RESULTS

Fruit and Seed measurements

Fruit and seed measurements of the cultivar picked at five different developmental stages are as shown in Table 2. There was significant increase in fruit fresh weight, length and diameter between mid full seed (MS) and other stages that is full seed (FS) to full red (FR). The

Table 3. Main effects of developmental stages and methods of processing on germination of fresh seeds of *Solanum melongena* harvested at five different stages of seed development.

Developmental Stage	CDP (days)	PG (%)	NS (%)	AbS (%)	Dead (%)	Dormant (%)
MS	2.33	23.60	7.20	16.40	20.00	56.40
FS	3.00	3.30	0.00	3.30	41.30	55.40
SR	2.33	1.70	0.60	1.10	3.90	94.40
GR	6.00	13.30	11.70	1.60	25.40	61.20
FR	5.83	29.40	28.90	0.50	10.60	60.00
LSD (0.05)	3.74	5.01	4.87	1.25	6.67	8.53
Processing						
CF	2.33	2.00	1.11	0.89	31.30	66.70
CSq	5.47	20.7	12.2	8.50	18.20	61.10
t (0.05)	2.37	3.17	3.08	0.79	4.22	5.40

CDP = Cumulative dormancy period, PG = percentage germination, NS = normal seedlings, AbS = abnormal seedlings, Dead = dead seeds, Dormant = dormant seeds.

stages from FS to FR had statistically similar fruit fresh weight, length and diameter. The fresh and dry weights of the seeds increased as fruits developed from MS to FR. On the other hand, the moisture content of the seeds decreased significantly ($P < 0.05$) with increasing stage of development. The FR had significantly ($P = 0.05$) higher seed dry weight and lower seed moisture content.

Seed germination

Seed germination (radicle protrusion) of fresh seeds of the five developmental stages processed by cutting fruits and fermenting (CF) for three days and cutting fruits and squeezing out seeds (CSq) are as shown in Table 3. The cumulative dormancy period was significantly ($P < 0.05$) lower in MS and sign of ripening (SR) stages. Greenish red (GR) had the longest CDP. On the other hand, full red (FR) had significantly ($P < 0.05$) higher germination percentage of 39.4 while SR showed lowest germination percentage. FR had the highest normal seedlings (NS) while MS stage had highest abnormal seedlings (ABS). FS and SR stages had significantly higher percentage of dead and dormant seeds whereas FR stage had significantly lower percentage of dead and dormant seeds. Cut fruits and squeeze out seeds (CSq) method of seed processing had significantly ($P < 0.05$) higher CDP, percentage germination (PG), NS and ABS while cut fruit and ferment (CF) method had significantly ($P < 0.05$) higher dead and dormant seeds. The main effects of stage of seed harvest on percentage of germinated and dormant seeds after processing and drying over the months of germination test are as shown in Figure 1. Drying the seeds slightly improved seed germination in all the stages of seed harvest by the first month of seed storage and germination test. Increased germination was recorded by the third and fifth months of seed storages. On the other hand, percentage of dormant seeds reduced with time in all the stages. FR had the least amount of dormant seeds while SR had the highest rate. However, interaction effects showed rapid improve-ment in germination in all the stages (Table 4). For example, rate of seed germination was improved at one month of seed storage when seeds harvested at MS, GR and FR were dried on the fruits under the sun. At the stages, and conditions of processing and drying, seed germination rates were 46, 59 and 50 percentages for MS, GR and FR respectively while rate of dormant seeds ranged from 43 to 40% for the stages. Interaction effects observed at three and five months of seed storage showed further enhancement of seed germination and reduction in dormancy (Tables 5 and 6). At three months of seed storage, germination rate was as high as 73% in MS processed by seeds dried on the fruits under the sun and 90 and 83% in FR processed by cut and squeeze out seeds and air dried and DOF under the sun, respectively. Under the two conditions, dormancy rates were as low as 23% for MS and 10 and 17% for FR. Furthermore, by the fifth month of seed storage, a minimum germination rate of 70% was recorded for all the stages when seeds were dried on the fruits under the sun. On the other hand, cut-ting fruits and squeezing out seeds and dried under the sun or air enhanced germination rate only in FR stage.

DISCUSSION

Fruit and seed development pattern in *Ngwa local large* showed that there is a significant difference in fruit fresh weight, length and diameter and seed fresh and dry weights and moisture content between MS and other stages of development. It also showed that the seeds reached physiological maturity at the FR stage when the seeds had maximum dry weight of 1.93 mg $seed^{-1}$ and

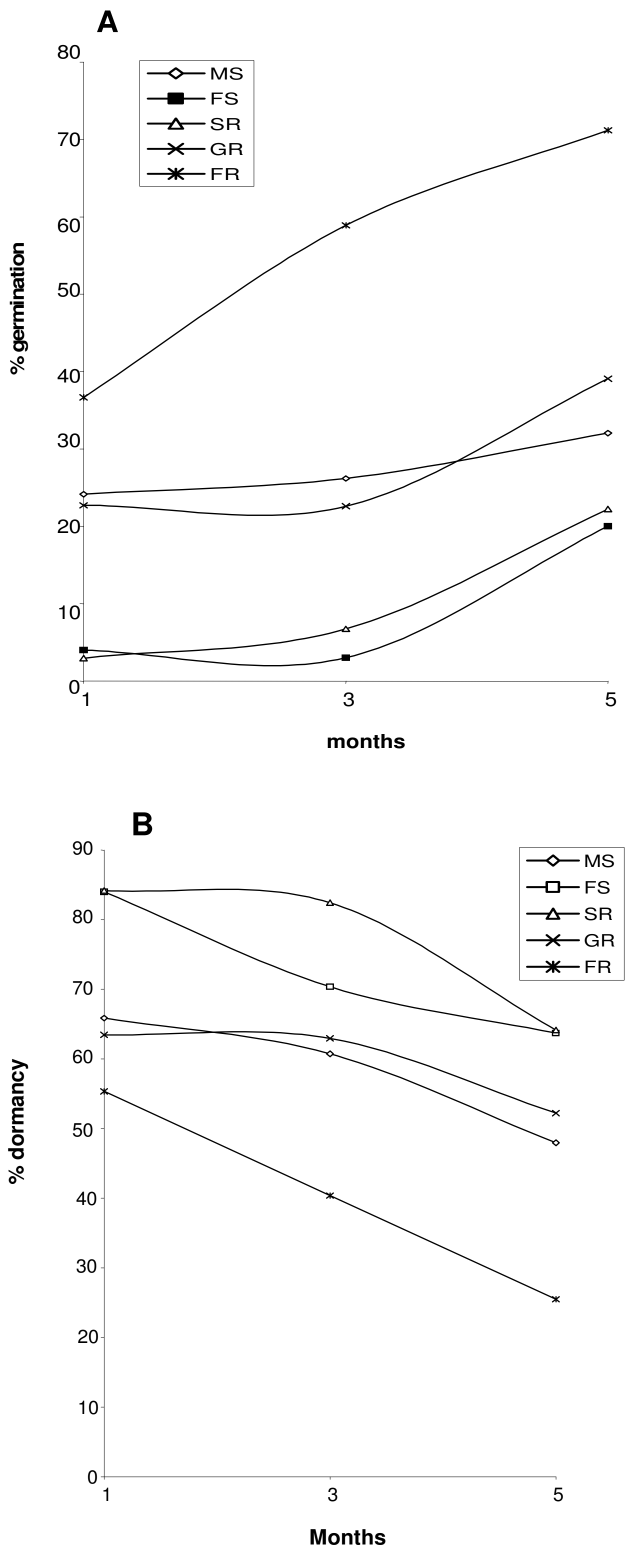

Figure 1. Main effects of stage of harvest on percentage germination (A) and dormancy (B) of the seeds after processing and drying over the five months of seed storage. MS = Mid full seed, FS = Full seed, SR = Sign of ripening, GR = Greenish red and FR = Full red.

least moisture content of 23.7%. The occurrence of physiological maturity at the full red stage was in agreement with other researchers in other crop species, showing that complete loss of green colour on the fruits was a positive indicator for physiological maturity (Samarah et al., 2004; Agbo and Obi, 2008). Miles et al. (1988) in his study indicated that seed moisture content can be used to standardize the time of harvest in studies of seed development and maturation.

The results of the seed germination revealed that all the developmental stages gave low and unreliable germination percentages. Thus the seeds have acquired germination ability from MS stage. The highest germination (29%) occurred at the physiologically matured stage (FR) and was followed by MS (24%). The stages FS, SR and GR had very low germination rates. The low germination rates within FS, SR and GR suggest the presence of inhibiting hormone(s) that hinders germination of seeds harvested at those stages. Presence of inhibiting hormones has been reported by (Yogeesha et al., 2006) in some cultivars of *S. melongena.* SR stage with the highest dormancy rate of 94% may be the stage of higher concentration of inhibiting hormone in the species as such hormones had been shown to decrease with seed maturity (Romagosa et al., 2001). Processing and drying methods imposed on the seeds enhanced their germination. After one month of drying the seeds harvested at MS stage and dried on the fruits under the sun a germination of 46% was obtained for the MS.

The appreciable improvement in germination of 24 to 46% in MS, and 29 to 50% in FR after one month of drying showed the impact of the processing and drying treatments on the seeds although they did not completely overcome dormancy. Samarah et al. (2004) had shown that desiccation of seeds of common vetch (*Vicia sativa* L.) which exhibits dormancy after harvest improves germination at the late maturity stage. The results of main effects of stage of maturity revealed that seeds from ripened fruits (FR) could overcome dormancy in an appreciable form by the fifth month of seed storage. However, the interaction effect indicated that drying seeds on the fruit under the sun caused seeds to overcome dormancy by the third month of seeds in storage where FR gave 80-90% and MS gave 73% seed germination. The processing and drying process thus saved two months as well as gave a higher germination rate. Seed germination rate increased after three and five months of processing and drying the seeds. The differences in germination rates under the different processing and drying methods indicated that the processing and drying methods affect seed germination. For example, drying seeds on the fruits, under the sun consistently gave higher germination rates even at immature stage (MS). This indicates the effectiveness of the traditional system of processing *S. melongena* seeds in Nigeria. Bonina and Cantliffe (2005) had earlier suggested cutting and scooping out of seeds

Table 4. Interaction between developmental stages, methods of drying and processing methods on germination of seeds of *Solanum melongena* after one month of drying.

Developmental stage	Processing method	Method of drying	CDP (day)	PG (%)	NS (%)	AbS (%)	Dead (%)	Dormant (%)	MC (%)
MS	CF	Air	0.00	0.00	0.00	0.00	17.78	82.22	16.37
MS	CF	Dry pre-chilled	0.00	0.00	0.00	0.00	29.56	70.44	15.53
MS	CF	Sun	0.00	0.00	0.00	0.00	19.11	80.89	15.53
MS	CSq	Air	0.00	0.00	0.00	0.00	15.00	85.00	16.07
MS	CSq	Dry pre-chilled	0.00	0.00	0.00	0.00	16.62	83.33	16.07
MS	CSq	Sun	5.67	2.22	1.11	1.11	15.56	82.22	15.53
MS	DoF	Air	8.67	37.50	37.50	0.00	13.33	49.17	15.20
MS	DoF	Dry pre-chilled	8.00	15.00	15.00	0.00	18.33	66.67	15.80
MS	DoF	Sun	4.33	45.56	44.44	1.11	11.11	43.33	14.00
FS	CF	Air	0.00	0.00	0.00	0.00	14.44	85.56	16.90
FS	CF	Dry pre-chilled	0.00	0.00	0.00	0.00	15.56	84.44	14.70
FS	CF	Sun	0.00	0.00	0.00	0.00	21.11	78.89	13.87
FS	CSq	Air	0.00	0.00	0.00	0.00	13.33	86.67	12.83
FS	CSq	Dry pre-chilled	0.00	0.00	0.00	0.00	16.62	83.33	13.10
FS	CSq	Sun	0.00	0.00	0.00	0.00	11.25	81.78	15.23
FS	DoF	Air	0.00	0.00	0.00	0.00	0.00	100.00	14.83
FS	DoF	dry pre-chilled	0.00	0.00	0.00	0.00	0.00	100.00	15.33
FS	DoF	Sun	0.00	0.00	0.00	0.00	17.78	82.22	14.70
SR	CF	Air	9.00	2.22	1.11	1.11	15.54	82.22	13.00
SR	CF	Dry pre-chilled	4.67	2.22	0.00	0.00	15.46	84.54	15.90
SR	CF	Sun	0.00	0.00	0.00	0.00	12.22	87.78	15.33
SR	CSq	Air	4.33	1.11	1.11	0.00	2.22	96.67	15.67
SR	CSq	Dry pre-chilled	0.00	0.00	0.00	0.00	14.45	85.55	15.33
SR	CSq	Sun	0.00	0.00	0.00	0.00	6.67	93.33	13.67
SR	DoF	Air	7.00	13.33	13.33	0.00	0.00	86.67	14.33
SR	DoF	Dry pre-chilled	0.00	0.00	0.00	0.00	0.00	100.00	13.97
SR	DoF	Sun	3.33	7.78	7.78	0.00	0.00	92.22	13.70
GR	CF	Air	9.33	4.45	1.11	3.33	3.33	92.22	13.53
GR	CF	Dry pre-chilled	5.00	2.22	2.22	0.00	20.00	77.78	12.10
GR	CF	Sun	10.33	6.67	5.56	1.11	10.00	83.33	13.33
GR	CSq	Air	6.33	47.78	45.56	2.22	5.56	46.67	15.33
GR	CSq	Dry pre-chilled	5.67	37.68	35.55	2.22	10.00	52.22	12.17
GR	CSq	Sun	6.33	23.33	21.11	2.22	15.56	61.11	12.67
GR	DoF	Air	12.00	23.33	23.33	0.00	16.67	60.00	14.63
GR	DoF	Dry pre-chilled	0.00	0.00	0.00	0.00	13.33	86.67	14.20
GR	DoF	Sun	9.00	58.89	57.78	1.11	0.00	41.11	14.87
FR	CF	Air	4.67	38.89	38.89	0.00	10.00	51.11	13.70
FR	CF	Dry pre-chilled	5.33	25.56	25.56	0.00	14.45	60.00	13.00
FR	CF	Sun	6.33	22.22	22.22	0.00	4.44	73.33	12.40
FR	CSq	Air	9.00	34.44	34.44	0.00	0.00	65.56	11.20
FR	CSq	Dry pre-chilled	7.33	41.11	41.11	1.11	0.47	58.89	12.00
FR	CSq	Sun	8.67	51.11	51.11	0.00	0.00	48.89	10.67
FR	DoF	Air	6.00	36.67	36.67	0.00	6.67	56.67	13.50
FR	DoF	Dry pre-chilled	7.33	30.33	30.00	0.00	10.00	60.00	13.50
FR	DoF	Sun	5.33	50.00	50.00	0.00	10.00	40.00	13.87
LSD (0.05)			3.899	10.57	20.87	0.00	11.386	14.114	-

CDP = Cumulative dormancy period, PG = percentage germination, NS = normal seedlings, AbS = abnormal seedlings, Dead = dead seeds, Dormant = dormant seeds; and MC = moisture content.

Table 5. Interaction between developmental stages, methods of drying and processing methods on germination of seeds of *Solanum melongena* after three months of storage.

Developmental stage	Processing method	Method of drying	CDP (day)	PG (%)	NS (%)	AbS (%)	Dead (%)	Dormant (%)	MC (%)
MS	CF	Air	0.00	0.00	0.00	0.00	15.67	84.33	10.00
MS	CF	Dry pre-chilled	0.00	0.00	0.00	0.00	23.33	76.67	8.02
MS	CF	Sun	0.00	0.00	0.00	0.00	10.00	90.00	8.12
MS	CSq	Air	0.00	0.00	0.00	0.00	16.00	84.00	9.33
MS	CSq	Dry pre-chilled	0.00	0.00	0.00	0.00	18.00	82.00	7.62
MS	CSq	Sun	0.00	0.00	0.00	0.00	16.00	84.00	7.81
MS	DoF	Air	6.33	60.00	60.00	0.00	13.33	26.67	14.33
MS	DoF	Dry pre-chilled	6.00	48.33	48.33	0.00	20.00	31.67	14.80
MS	DoF	Sun	5.67	73.33	66.67	6.67	3.33	23.33	11.00
FS	CF	Air	0.00	0.00	0.00	0.00	13.33	86.67	11.90
FS	CF	Dry pre-chilled	0.00	0.00	0.00	0.00	23.33	76.67	10.70
FS	CF	Sun	0.00	0.00	0.00	0.00	16.67	83.33	8.67
FS	CSq	Air	0.00	0.00	0.00	0.00	16.67	83.33	8.90
FS	CSq	Dry pre-chilled	0.00	0.00	0.00	0.00	20.00	80.00	8.00
FS	CSq	Sun	0.00	0.00	0.00	0.00	13.33	86.67	10.32
FS	DoF	Air	0.00	0.00	0.00	0.00	14.00	86.00	11.00
FS	DoF	Dry pre-chilled	0.00	0.00	0.00	0.00	13.33	86.67	11.22
FS	DoF	Sun	0.00	0.00	0.00	0.00	13.33	86.67	11.70
SR	CF	Air	0.00	0.00	0.00	0.00	3.33	96.67	9.00
SR	CF	Dry pre-chilled	0.00	0.00	0.00	0.00	13.33	86.67	10.42
SR	CF	Sun	0.00	0.00	0.00	0.00	6.67	93.33	10.32
SR	CSq	Air	8.00	6.67	6.67	0.00	16.67	76.67	10.00
SR	CSq	Dry pre-chilled	0.00	0.00	0.00	0.00	26.67	73.33	11.20
SR	CSq	Sun	0.00	0.00	0.00	0.00	3.33	96.67	9.33
SR	DoF	Air	0.00	0.00	0.00	0.00	16.67	83.33	12.33
SR	DoF	Dry pre-chilled	0.00	0.00	0.00	0.00	26.67	73.33	11.63
SR	DoF	Sun	0.00	0.00	0.00	0.00	10.00	90.00	8.12
GR	CF	Air	7.67	10.00	10.00	0.00	0.00	83.33	9.23
GR	CF	Dry pre-chilled	3.67	3.33	3.33	0.00	10.00	86.67	8.10
GR	CF	Sun	7.00	6.67	6.67	0.00	0.00	86.67	7.30
GR	CSq	Air	10.33	26.67	26.67	0.00	0.00	73.33	11.30
GR	CSq	Dry pre-chilled	8.33	16.67	16.67	0.00	10.00	73.33	10.14
GR	CSq	Sun	6.33	43.33	30.00	13.33	16.67	40.00	9.67
GR	DoF	Air	12.00	36.67	36.67	0.00	0.00	63.33	10.36
GR	DoF	Dry pre-chilled	8.33	16.67	16.67	0.00	10.00	73.33	9.23
GR	DoF	Sun	11.67	43.33	43.33	0.00	0.00	56.67	9.67
FR	CF	Air	5.67	23.33	23.33	0.00	0.00	76.67	8.00
FR	CF	Dry pre-chilled	10.67	20.00	20.00	0.00	10.00	70.00	8.15
FR	CF	Sun	7.67	46.67	46.67	0.00	0.00	46.67	8.00
FR	CSq	Air	10.67	90.00	90.00	0.00	6.67	10.00	8.00
FR	CSq	Dry pre-chilled	10.67	43.33	43.33	0.00	0.00	56.67	8.00
FR	CSq	Sun	8.00	83.33	83.33	0.00	0.00	16.67	7.33
FR	DoF	Air	11.67	76.67	76.67	0.00	0.00	23.33	8.50
FR	DoF	Dry pre-chilled	12.00	63.33	63.33	0.00	0.00	36.67	8.40
FR	DoF	Sun	11.33	83.33	83.33	0.00	0.00	16.67	9.83
LSD (0.05)			-	10.695	11.475	3.927	12.259	16.642	1.842

CDP = Cumulative dormancy period, PG = percentage germination, NS = normal seedlings, AbS = abnormal seedlings, Dead = dead seeds, Dormant = dormant seeds.

Table 6. Interaction between developmental stages, methods of drying and processing methods on germination of seeds of *Solanum melongena* after five months of storage.

Developmental stage	Processing method	Method of drying	CDP (days)	PG (%)	NS (%)	AbS (%)	Dead (%)	Dormant (%)	MC (%)
MS	CF	Air	0.00	0.00	0.00	0.00	10.67	89.33	8.000
MS	CF	Dry pre-chilled	0.00	0.00	0.00	0.00	20.33	79.67	6.667
MS	CF	Sun	0.00	0.00	0.00	0.00	10.00	90.00	6.667
MS	CSq	Air	0.00	0.00	0.00	0.00	10.00	90.00	7.333
MS	CSq	Dry pre-chilled	0.00	0.00	0.00	0.00	18.00	82.00	6.667
MS	CSq	Sun	0.00	0.00	0.00	0.00	16.00	84.00	6.667
MS	DoF	Air	10.00	66.67	66.67	0.00	0.00	33.33	12.000
MS	DoF	Dry pre-chilled	11.00	60.00	60.00	0.00	10.00	30.00	14.667
MS	DoF	Sun	8.33	71.67	71.67	0.00	0.00	28.33	9.333
FS	CF	Air	0.00	0.00	0.00	0.00	13.33	86.67	6.667
FS	CF	Dry pre-chilled	0.00	0.00	0.00	0.00	17.67	83.33	7.333
FS	CF	Sun	0.00	0.00	0.00	0.00	15.00	85.00	8.000
FS	CSq	Air	0.00	0.00	0.00	0.00	16.00	84.00	8.667
FS	CSq	Dry pre-chilled	0.00	0.00	0.00	0.00	16.67	83.33	6.667
FS	CSq	Sun	0.00	0.00	0.00	0.00	11.67	88.33	8.000
FS	DoF	Air	9.00	60.00	60.00	0.00	13.33	26.67	8.667
FS	DoF	Dry pre-chilled	9.33	50.00	50.00	0.00	13.33	36.67	8.667
FS	DoF	Sun	7.67	70.00	70.00	0.00	6.67	23.33	8.667
SR	CF	Air	0.00	0.00	0.00	0.00	16.67	83.33	6.667
SR	CF	Dry pre-chilled	0.00	0.00	0.00	0.00	13.17	86.83	5.833
SR	CF	Sun	0.00	0.00	0.00	0.00	12.50	87.50	6.167
SR	CSq	Air	8.00	16.67	16.67	0.00	13.83	69.50	6.833
SR	CSq	Dry pre-chilled	0.00	0.00	0.00	0.00	18.83	81.67	7.333
SR	CSq	Sun	7.00	10.00	10.00	0.00	12.33	77.67	7.167
SR	DoF	Air	7.67	58.33	58.33	0.00	11.67	30.00	10.333
SR	DoF	Dry pre-chilled	8.33	43.33	43.33	0.00	13.00	43.67	10.333
SR	DoF	Sun	7.00	71.67	71.67	0.00	5.00	23.33	6.667
GR	CF	Air	6.33	10.00	10.00	0.00	6.67	83.33	7.500
GR	CF	Dry pre-chilled	11.00	10.00	10.00	0.00	12.00	78.00	6.333
GR	CF	Sun	11.33	13.33	11.67	1.67	15.00	71.67	5.667
GR	CSq	Air	8.33	50.00	50.00	0.00	6.67	43.33	7.667
GR	CSq	Dry pre-chilled	9.33	26.67	26.67	0.00	0.00	73.33	6.333
GR	CSq	Sun	8.67	55.00	53.33	1.67	10.00	35.00	6.667
GR	DoF	Air	8.00	66.67	66.67	0.00	6.67	26.67	6.333
GR	DoF	Dry pre-chilled	9.67	50.00	50.00	0.00	10.00	40.00	6.167
GR	DoF	Sun	6.67	70.00	70.00	0.00	3.33	26.67	8.333
FR	CF	Air	7.67	31.67	31.67	0.00	0.00	68.33	6.500
FR	CF	Dry pre-chilled	8.00	33.33	32.50	0.83	11.67	55.00	7.167
FR	CF	Sun	8.33	56.67	56.67	0.00	10.00	33.33	6.167
FR	CSq	Air	8.00	75.00	75.00	0.00	0.00	25.00	7.667
FR	CSq	Dry pre-chilled	8.00	49.00	47.33	1.67	8.33	42.67	7.167
FR	CSq	Sun	8.33	88.33	88.33	0.00	0.00	11.67	7.167

Table 6. contd.

FR	DoF	Air	8.33	70.00	70.00	0.00	0.00	30.00	10.33
FR	DoF	Dry pre-chilled	9.33	65.00	65.00	0.00	0.00	35.00	5.833
FR	DoF	Sun	7.00	88.67	88.67	0.00	0.00	11.33	7.000
LSD (0.05)			2.26	12.31	12.04	-	13.25	16.74	1.637

CDP = Cumulative dormancy period, PG = percentage germination, NS = normal seedlings, AbS = abnormal seedlings, Dead = dead seeds; Dormant = dormant seeds, MC = moisture content

of *S. melongena* as a good option for processing of seeds in the species. However, in the present study, a similar processing method, CSq did not give reliable germination rates when compared with drying seeds on the fruit under the sun. On the other hand, fermenting seeds consistently gave high dead seeds and low germination rates even at the physiological maturity stage (FR). This indicates that seeds of the crop species do not tolerate fermentation process and agrees with the suggestion of previous report (Mayer and Potjakeoff, 1989) that seeds of many plants may lose viability when they are kept under water for any length of time. Highest germination rate was observed from FS and SR after five months of seed drying and storage suggesting presence of an inhibiting hormone(s) at the stages. This however, indicates that fruits of *Ngwa local large* should not be picked for seed processing at FS and SR as the processing and drying methods only made a significant impact on the seeds after five months. Five months may be too long as a waiting period before dormancy could be overcome and such seeds utilized for cropping. On the other hand, fruits can be picked at the MS and dried on the fruits under the sun as the processing method overcomes seed dormancy in MS for a reliable germination by the third month of seed drying and storage. Furthermore, seeds picked at MS will not be attacked by *Q. quelea* L. birds and *L. orbonalis* Guen. (which are major pests) because at MS, the fruits are not attractive to the birds and the larvae of *L. orbonalis* are not yet highly voracious in their feeding habit.

Conclusion

Ngwa local large seeds reached the physiological maturity (maximum dry weight) at the FR stage. Fruit colour changing to red was a good indicator that the species seeds had reached the physiological maturity. The germination of the fresh seeds showed that all the developed stages have acquired germination ability but are dormant. The level of dormancy was 94% in SR which was also the highest. Drying the seeds on the fruits under the sun improved seed germination from 24 to 46% in MS and 29 to 50% in FR thus helping in overcoming dormancy after one mouth of seed storage.

The result of the main effect of stage of maturity revealed that seeds from FR could overcome dormancy in an appreciable form by the fifth month of seed storage. However, the interaction effect indicated that drying seeds on the fruit under the sun caused seeds to overcome dormancy by the third month of seeds in storage where FR and MS gave 90 and 73% seed germination, respectively. The processing and drying process thus saved two months as well as gave a higher germination rate. Cutting fruits and squeezing out seeds helped in overcoming dormancy only at FR stage (physiological maturity). On the other hand, fermenting seeds consistently resulted in low germination rates and as high as 30% of dead seeds in MS after one month of drying the seeds. Fruits from the crop species could be picked at MS or FR stages of development for seed processing. Picking fruits at MS and drying the seeds on the fruit will help overcome the seed dormancy in three months and preserve the perishable genetic resource (seeds) from attack by *Q. quelea* L. and *L. orbonalis*.

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