Effect of moisture contents and storage temperature citrus seeds biology essay

King et al. (1981) determined that the longevity of various citrus seeds improved as the storage temperature and moisture contents of seeds were decreased. The lemon, lime and sour orange dried up to 5 % moisture contents and stored at -20 °C suffered no significant decline in viability within the storage period of seven months for lime, lemon and sour orange respectively.

Nayer (1981) examined that seeds were extracted from Duncan grapefruit, pineapple, sweet orange, Troyer citrange and rough lemon fruits and these seeds were treated with different fungicides. These seeds were then stored moist, surface dried after 1-16 days of drying at room temperature. All four citrus cultivars showed delayed germination due to drying at different regimes for different durations. With Duncan grapefruit, seed stored moist was 80 % germination twenty days before surface dry seed and some were killed by two days drying. At the other extreme, rough lemon seed survived 16 days drying with out loss of viability and germination delay was not grater after 16 days than after 1-2 days drying.

Saraswathy et al. (1997) studied three tropical fruit species believed to recalcitrant seed storage behavior, Mangosteen (Garcinia mangostana L.), rambai (Baccaurea motleyana Muell.- Arg.) and jelentik (Baccaurea polyneura Hook. f.). Their seeds showed no dormancy and they germinated more easily and more quickly. At the time of harvest, the moisture contents (fresh weight basis) were 53. 54, 51. 20 and 44. 90 % for G. mangostana, B. motleyana and B. polyneura respectively. G. mangostana seeds lost their viability when their moisture contents fell to about 24 % while B. motleyana seeds lost their viability below 35. 5 % moisture contents. However, for B.

polyneura the seeds could be dried to low moisture content with high survival percentage. The viability was still high when the rates of moisture contents were reduced to 13. 46 %. At this moisture content, the germination percentage was 91. 76 % and it was found that the seeds survived cryopreservation with 8. 3 % viability. They also vary greatly in their size. Seeds of G. mangostana are larger than Baccaurea seeds and thus, more sensitive to the desiccation tolerance. Seeds and embryonic axis structure may play a very important role in desiccation sensitivity. Fu et al. (1994) reported that the desiccation tolerance in two species with recalcitrant seeds: Clausena lansium (Lour) and Litchi chinensis (Sonn.) was studied. They resulted that the mature seeds were less sensitive to desiccation than the fully mature ones while the embryonic axis of the same stage were more tolerant of desiccation than whole seeds.

Aslantus and Pirlak, (2002) reported that the germination capacity of strawberry pollen increased in low temperature. However, germination percentage of 4°C and fresh pollen was almost in first week. Pollens that were stored at 4 °C showed low 53. 40 % germination percentage in early weeks but the rate of germination was further decreased quickly and up to 48 weeks the rate of germination percentage was 20. 10 %. Conclusively the range of temperature and humidity are the major influencing factors in pollen behavior of different conditions. Pollens that were stored at -60°C showed better results and these pollens showed 60 % viability after storing for 48 weeks. The most successful factor for pollen conservation is the storage temperatures and moisture contents of material, lowering of both temperature and humidity tends to increase the period of viability.

Ganeshan (1986) studied the cryopreservation of papaya pollens in liquid nitrogen (-196 °C) and found that the pollen cryopreserved for 485 days retained their viability and germination percentage as high as fresh pollens were germinated in vitro. Pollens stored for 300 days could effect normal fertilization, producing fruit and seed set on a par with controls, indicating no major loss of fertility. Pollen samples exhibited high tolerance to direct freezing at ultra low temperatures un-controlled thawing to ambient temperature and re-freezing back to cryogenic temperatures, when viability was determined after storage. This method of preservation would be more profitable for breeders and gene banks involved in conserving genetic recourses.

Normah and Serimala (1995) reported that citrus aurantifolia seeds can be successfully cryopreserved at -196 °C after desiccating them to a moisture content of 12. 93 % (50% viability) while seeds of C. halimii presented only 25 % viability after cryopreservation at moisture contents of 9. 5 %. The Seeds of C. hystrix are highly sensitive to desiccation as they failed to germinate when the moisture contents were reduced to 27 % and thus did not survive cryopreservation. The embryonic axes of the three Citrus species gave higher percentage of survival after cryopreservation. Survival rate was 100 % in C. aurantifolia and C. halimii embryonic axes with moisture contents of 9-11 % and 16. 6 % respectively. With C. hystrix axes, the highest survival rate obtained that was 60 % at a moisture content of 11. 04 %. The cryopreservation methods were further employed for the embryonic axis of C. hystrix. There was no improvement in the survival percentage obtained.

Khalil (1999) observed that unstratified seeds of Troyer citrange, (C. volkameriana) lime cultivars Balady and Rashidi and sour orange were extracted during January. (1) Seed fresh weight (2) Seedling emergence and vigor as affected by seed weight, seed density and soaking in IBA. The comprehensible differences were observed in seed weight and uniformity and the range of its distribution. They also determined that the large and high density seeds were associated with high rates of emergence of seedling.

Radhamani et al. (1991) stated that the seed coats usually acted as a mechanical barrier for the germination of the seeds which was improved by removing it in all the seven citrus species tested namely limes, lemons, mandarins, sweet orange, sour orange and pummelos. The surface characteristics of the seed coat were examined using SEM and surface structure differed in the various species under study. A correlation between the thickness of seed coat and their rate of germination was found in these species.

Chilembwe et al. (1992) reported that commercially processed seed of different citrus cultivars. The seeds were used as the effect of hydration and priming on the rate of germination. Seeds which were soaked in aerated water showed increased germination rates and emergence rates compared with that of un- soaked seeds. The soaking of seeds at 35 °C temperature enhanced these differences rather than at 25 °C. Priming seeds in solution of PEG 6, 000 was not successful as germination and emergence percentage were lower than soaking in distilled water.

Polat and Kaska (1992) studied the impacts of stratification at 4 °C for 30 days on germinations for the seeds of Loquat cultivars Gold Nugget and Tanaka. Stratification markedly increased the rate of germination percentage of seeds, resulting in 98. 75 % germination. Un-stratified but chilled seeds demonstrated 68. 75 % germination, while untreated and controlled seeds show 63. 75 % germination. Stratified seeds germinated more rapidly than the seeds which were untreated.

Kadam et al. (1994) reported that viability and rate of germination percentage of ciotrus limonia seeds were examined during the storage period for up to six weeks in the open air or in polythene bags at room temperature (90 % RH) and storage temperature 10 °C (45 % RH). Both were declined during the storage periods but this decrease was least for seeds stored at 10 °C +45 % RH.

Dument and Berjak (1995) described that the recalcitrant seeds were generally larger and show much curtailed longevity even if stored hydrated. They also determined minimum water content tolerated by embryos of five recalcitrant species and their subsequent survival after cryopreservation.

Roberts et al. (1999) reported that the citrus seeds have practically recalcitrant seed storage behavior, because they are highly sensitive to desiccation (cryogenic) temperature condition. Usually it was desirable for long term storage conservation of seeds. More recently, it has proved that citrus seeds have not been considered to be truly recalcitrant, as they can tolerate desiccation to some extent. However, their tolerance is limited and varies from species to species and variety to variety. Citrus seeds are some

what intermediate between orthodox and recalcitrant seeds and can be named as “ non orthodox”.

Hong and Ellis (1995) stated that there are differences in seed storage behavior among species particularly within the genus. Seeds of C. Robusta and C. libercia were tested for germination following desiccation and storage for up to one year at -20°C with 5-13 % (robusta) or 5-14 % (liberica) moisture content. Viability was lost more quickly during storage conditions the lowest the temperature below 15 °C and the lowest moisture content 11. 3 %. Seeds of C. liberica were more sensitive to desiccation. Only the 6 % surviving rate was obtained to desiccation with 13. 5 % moisture content. It is concluded that C. libercia showed recalcitrant seed storage behavior but that C. robusta shows an intermediate seed storage behavior. Evidence is variation in seed storage behavior with in the genus Citrus and the intermediate category is discrete rather than a continuum between orthodox and recalcitrant.

Effect of Plant Growth Regulators on Citrus Seed Germination

Burger and Hackett (1982) observed that Valencia orange seeds did not germinate when the fruits were harvested during the early November, while seed from November harvested fruit stored at 3-4 °C for 21 days germination was 100 %. An equivalent germination response was obtained when seeds from fruits were extracted in April. They were also examined when treatment of IBA reduced about 50% germination in seeds from non cold treated fruits.

Burger (1983) reported that germination of sour orange seeds air dried for more than 1 day was delayed and the rates of germination were decreased. A naphthalene-acetic acid soaked seeds reversed the effect of drying and resulted in taller seedling with stem dry weight. But stratification and a water soak did not reverse the undesirable effect of air drying.

Edwards and Mumford (1983) informed that the seeds of citrus aurantium were stored in a range of different substances including fruit juices, phenols, growth regulators, and a kind of fungicides and solutions of high osmotic potential. The effects of these substances on germination at 200 °C and on viability of seeds stored at 40 °C over long periods were examined. Low temperature 4 °C alone was more effective and more valuable than any of the substances in preventing germination or growth in storage and had no adverse effect on germination percentage. The survival rate of imbibed seeds at 4°C was best in 10-2 M NAA. The germination imbibitions at 25 °C were incomplete with all the substances, and there was significant loss of viability.

Ramos et al. (1997) reported that the immature fruits contain larger number of seeds than mature fruits. The seeds were removed from immature fruits, 10 to 12 weeks after anthesis of Citrus sunki and disinfected with 1 % NaOCl for 20 minutes before placing on Murashige and skoog medium. After 40 days at 25 °C with a 16-h photoperiod at 3, 000 lux, showed that the highest germination percentage rates (8 %) corresponded to an NAA concentration of 0. 68 mg/L. The concentration of benzyladenine in this trial was inadequate to stimulate satisfactory development of the immature seeds of cv. Sunki.

Kalita et al. (2002) determined the effect of plant growth regulators (PGRs) gibberellic acid, IBA, IAA and NAA at different concentrations (200, 400, 600 and 800 ppm) on citrus reticulate seed germination. Plant growth regulators (PGR) treated seeds required only fewer days for germination than distilled water treated seeds (control). Treatment with 600ppm IBA recorded the shortest time (19 days) required for germination. This was statically at par with 800ppm IAA, 600 and 800ppm GA3 (21, 20 and 21 days respectively). Treatment with 800ppm NAA recorded the highest germination percentage (86. 6 %) which was statistically at par with 600ppm IBA (80 %). The control treatment recorded the lowest germination percentage (33. 33 %). The highest leaf number (7) was recorded upon treatment with 800ppm IBA. The control treatment recorded the lowest leaf number as compared to the PGR treated seeds.

Parsad and Rekha (1991) observed that the seeds of three strains of Rangpur lime and acid lime were irradiated at the amount of 6-2KR and germination rates were compared with that of the control one. A significant decreased in germination rates were occurred with increasing the exposure of 50-60 % at the semi lethal dose level. The radiation sensitivity was of chief importance in the mutations program.

Rao and Singh (1992) reported that hydration-dehydration treatments with tanic acid and benzoic acid increased the percentage of the germination in black gram and green gram, while compared with water soaked and dry seeds. Dhillion et al. (1993) examined that hybrid seeds from 6 citrus cultivars crosses, dried and sown in polythene bags filled with a mixture of farm yard manures (FYM) and sand during the month of August. Seeds of

seven combinations failed to germination. The highest seed germination percentage (74. 4 %) was gained with the Ludhiana selection + Lime Attari cross.

Leonel et al. (1994) accounted that seeds extracted from mature and ripe fruits on 5th May, washed in running tap water and then dried under shade for a week, stored at 4-5 °C until 16 September. Then these seeds were soaked in water in various solutions of growth regulators for 24 hrs. The seeds were germinated at 25 °C under white light on filter paper moistened with distilled water. The germination was evaluated after every two days. Data was calculated and tabulated on the number of germinated seeds, germination percentage, average germination time and average rate. The differences were observed between different treatments but germination was highest (97 %) following treatments with phenylmethylaminopurine at 20mg/L.

Raju and Sivaprakasam (1994) deliberated that the effects of the treatments with fungicides, bactericides, hot water on the viability of cabbage cultivars. September seeds were judged promptly after treatment and after storage under ambient condition for 3 or 6 months. Seeds treated with carbendazim at the rate of 2g/Kg, hot water at 50°C for 30 min or thiram at the rate of 2g/Kg had higher germination percentage (mean values for the 3 assessments of > 80 %) than the control (71 %).

Normah et al. (1997) observed that desiccation sensitivity of seeds of mangosteen (Garcinia mangostana), rambai (Baccaurea motleyana) and jelentik (Garcinia polyneura). These were known as tropical fruits species

believed to have recalcitrant seed storage behavior. The seeds showed no dormancy, they germinated easily. At the time of harvesting, the moisture contents were 53. 54, 51. 20 and 44. 90 %. The seeds of Mangosteen (G. mangostana) lost their viability when their moisture contents fell to about 24 % while B. motleyana seeds lost viability below 35. 5 % moisture contents. However, for B. polyneura seeds could be dried to low moisture contents with highest survival rate. The viability was still high when the moisture contents were reduced to 13. 46 %. At this moisture content, the germination percentage was 91. 76 % and it was found that the seeds survived cryopreservation with 8. 3 % viability. For B. polyneura axes, the los of viability when their moisture contents fell to about 36 %, while for B. polyneura axes viability was reduced to 33. 67 % when the moisture is 27. 30 %. So it was concluded that the seeds vary in degree of desiccation sensitivity.

Dussert (1999) determined the seed desiccation sensitivity in nine species of the genus Coffea by measuring seed viability after equilibration and various saturated salt solutions. The results showed that Coffea is a suitable material for studying desiccation sensitivity.

Leonel and Rodrigues (1999) reported that the citrus limonia seeds were extracted from ripe fruits, washed with tap water, air dried and then these seeds were stored at 4 °C for 12 days. After storage these seeds were then treated for 24 hrs with KNO3 0. 1 % at the rate of different concentrations. The evaluations were observed and conducted at 5 days interval, starting 15 days after sowing. The statistical analysis showed that the growth regulator

treatment did not enhance seed germination and those treatments with KNO3 at 0. 1 % and 0. 2 % inhibited the germination of seeds

Tokeshi et al. (1999) reported that the supply of energy of seeds decreases during the germination periods. The survival percentage of the seedlings probability increases if the germination period of seeds is reduced. The potential of seedling survival is called vigor which can be determined from the speed of emergence. The effective micro organisms (EM) have plant growth regulator action like Naphthalene acetic acid. The speed of emergence was evaluated in tangerine cv. Coleoptra seeds treated with metalaxyl for 30 minute before sowing. The speed of emergence of the EM treatment was superior to the control one. The growth promoter effect of EM was best during the initial four days of emergence of the seedlings. In comparison of 40 days old seedlings, the EM treated seeds produced larger plants than that of the control treatment.

Hong et al. (2000) stated that the viability of Norway maple seeds collected 21 days before mass maturity (68 % moisture content) and at mass maturity (65 % moisture contents). Their viability was reduced from 52-85 % to 7 % if dried rapidly to 4-5 % moisture contents.

Effect of storage on seed moisture contents

King and Roberts, (1979) stated that viability of citrus seeds is greatly affected by drying for different time periods, viability being decreased when the moisture contents were reduced to some extent. Citrus seeds have been usually classified as recalcitrant seeds as some species loss their viability when the moisture contents are reduced below 10 %. Recalcitrant seeds

normally originated from certain moist areas where the seeds are not exposed to drying before germination. In their natural habitat, conditions are often favorable for instantaneous germination and the seeds do not require long term storage conservation.

Richards, (1952) reported that the seeds of musk lime (C. macrocarpa) lost their viability at different storage regimes, at high temperature and at the low moisture contents in a few days. Teng and Hor, (1976) reported that the seeds of country lime (C. aurantifolia) lost their viability and moisture contents after 7 days when they were stored at 20-25°C. Mungomery et al. (1966) determined that the viability of citrus seeds can be maintained in storage regimes when the moisture content is high and the range of temperature is 5-10 °C.

Barton, (1943) reported that sour orange (C. aurantium) seeds deteriorated in a short time at the moisture contents of 80 % and a temperature of 5 °C, but rough lemon (C. limonia) seeds were still viable at the moisture contents of 56 % and at a temperature of 5 °C after 500 days. The seeds of C. grandis were viable at the moisture contents below 10 % (Hanjo and Nakagawa, 1978) and the seeds of grapefruit (C. paradise) and mandarin (C. reticulate) were viable after 80 days stored at 14. 1 % and 10 % moisture contents respectively at a temperature of 4. 5 °C (Mallareddy, et al., 1977).

Mumford and Grout, (1979) indicated that citrus seeds can be stored in dry condition for different time periods. Recently experiments have shown that C. limon seeds remained viable for 20 days stored at a moisture content of 1.

2 % at room temperature, provided that the testas were removed from the seeds before drying.

The advantages of storing dry seeds are significant in practical terms since a very little space is occupied by the dry seeds and they are easier to handle and maintain free from micro- organisms, but there is insufficient evidence to data to suggest that all citrus species can be stored in this way.

Cameron and Soost, (1969) reported the fact that the seeds responded differently to dry storage when their seed coats were removed. The seed coat may be an important factor in seed preservation. It is known that the seed coat generally is one of the major and important factors that generally influenced seed germination. Citrus seed coats can be easily distinguished into three layers, the mucilage, the testa and the tegmen. The outer seed coat or testa is tough and is covered by mucilage. The tegmen is a thin and papery layer of seed. Their roles are not still well understood. Removing the testa usually accelerate the germination of the seeds. In their natural habitat, these layers are likely to protect from the dehydration until environmental conditions are favorable for better germination of citrus seeds (King and Roberts., 1979).

Hortmann et al. (2001) reported that the rate of germination of the Seed is greatly influenced by many factors, which include type of substrate, environmental factors such as oxygen, water and temperature and for some plant species, light.

Effect of Desiccation on Citrus Seeds

Wood et al. (2000) concluded that desiccation results in the induction of dormancy rather than reducing the seed viability and showed that heat shock (4 hours at 36°C) followed by low temperature (26C°C) could be used to break the dormancy.

Wood et al. (2000) determined the effect of desiccation and temperature on germination capability of Papaya seeds. More than 50 % of freshly isolated cleaned but un-dried seeds germinated at 26 °C. However, desiccation to approximately 20 % relative humidity reduced the rate of germination percentage at this temperature to less than 10 %. A substantial increase in the rate of germination at alternating temperature (33/19°C) indicated that desiccation induces seed dormancy rather than viability loss.

Doijode (1998) reported that the seeds of Kaghzi lime with 6. 6 % moisture contents were packed in aluminoum foil laminated pouches under partial vacuum and then these packets were filled with nitrogen and carbon dioxide. These packet were stored at -20, 5, 15 °C and ambient (16-35 °C) temperature. There was no germination of seeds which were stored under ambient temperature after 6 months of storage while their viability was retained for 24 months in low temperature. Seed viability was initially affected due to desiccation injury.

Pritchard et al. (2004) reported that the first challenge for the long term conservation of seeds of desiccation sensitive species is to determine their response to desiccation tolerance. This can be achieved either by the routine processing of seeds for long term conservation and identifying species more

actively by specific, targeted screening that fail to survive or by fully characterizing the response to dehydration of individual species (Hong and Ellis, 1996). Using these approaches, approximately 540 species with desiccation sensitive seeds have been identified (Flynn et al, 2004), although it has been estimated that this trait could be present in an approximately 8 % (20000 species) of the world flowering plants (Dickie and Pritchard, 2002). As it is unlikely that all of these species will ever be identified through experimental determination, a second approach to desiccation tolerance investigation is needed that identifies reliable and robust correlate of seed desiccation, leading to the development of a predictive frame work for seed storage responses.

A number of studies have determined potential correlation of seed desiccation sensitivity, including seed mass (Hong and Ellis, 1998; Dickie and Pritchard, 2002; Pritchard et al., 2004), seed shape(Tompsett, 1984, 1987; Hong and Ellis, 1997, seed moisture content at shedding (Hong and Ellis, 1998), seed germination rates, seed allocation to physical defence (Pritchard et al., 2004; Daws et al., 2005) and both gross and local scale habitate variables (Hong and Ellis, 1998; Dussert et al., 2000; Tweddle et al., 2003; Pritchard et al., 2004; Daws et al., 2005).

Rate of dehydration greatly effects desiccation tolerance of recalcitrant seeds. This effect is presumably related to two different stress factors: direct mechanical or physical stress factor because of the loss of the water physiochemical damage of tissues as a result of metabolic alterations during drying. Liang and Sung (2002) determined a new theoretic approach to represent these two types of stresses and investigated how seed tissues

responded differently to two stress vector, using the model of cocoa (Theobroma cacao) and ginkgo (Ginkgo biloba) embryonic tissues dehydrated under various drying conditions. Cumulative desiccation stress increased sharply under slow drying conditions, which was also detrimental to embryonic tissues. This quantitative analysis of the stress time response relationship helps to understand the physiological basis for the existence of an optimal dehydration rate, with which maximum desiccation could be achieved.

Hong et al. (2001) determined that storage behavior and longevity of seeds of lemon (C. limon) and sweet orange (C. sinensis) following desiccation between 14 and 4 % moisture contents. They also observed the hermetic air dry storage for up to 914 days at temperature between 15 and -20 °C up to 6 days in liquid nitrogen (-196 °C). The results conformed that both the species showed intermediate storage behavior that is between Orthodox and recalcitrant. Air dry storage environment require care to obtain maximum longevity of seeds. The seeds of sweet orange were highly sensitive to desiccation tolerance and less than 25 % of seeds were survived more than 210 days at 5 °C and 8. 7 % moisture contents. The most advantageous air drying environment for the medium storage of the longer lived lemon seeds was 5°C and 7. 5 % moisture contents.

Fu et al. (1994) reported that desiccation tolerance of Clausena lansium (Lour.) seeds was highest at 67 days after anthesis (DAA). When they tolerated air- drying for 9 days: 74 DAA was measured as physiological maturity and their full viability was only maintained for up to 3 days of drying. Over ripened seeds (88 DAA) had the lowest desiccation tolerance. In

Litchi chinesis (Sonn.) the desiccation sensitivity of seeds at 98 DAA (fully mature) was higher than that at 84 and 91 DAA (less mature).

Role of Seed Drying Methods on Citrus Seed Behavior:

Saipari et al. (1998) determined the effect of air and silica drying on seed germination percentage and viability, field emergence, seedling growth and water absorption patterns in citrus species. P. trifoliate was the most sensitive to seed drying while C. grandis and C. karna were fairly tolerant to seed drying. Seed viability scored on the basis of tetrazolium staining was slightly higher but paralleled the germination percentage in laboratory and seedling emergence.

There have not been appropriate methods for drying of seeds. The drying of seeds has major effect on the quality of the seed. Pachy et al. (2003) designed an experiment to determine proper drying techniques in order to improve the seed quality of citrus seeds. There were three drying methods namely sun drying, 40°C hot air oven and using silica gel as the moisture absorbent. Initial seed moisture content were determined and recorded. Seed samples were quickly dried until it reached to the moisture contents of 20, 15, 10, and 5 % respectively. Standard germination tests, vigor tests by accelerated aging technique, viability tests by tetrazolium chloride test were used. It was observed that drying with silica gel result 57 % germination rate, 92 % in viability test and 38 % in vigor test. Hot air oven drying method provided 47 % in germination, 90 % in viability test and 29 % in vigor test. The result of two previous methods can maintain the viability of citrus seeds but can not sprout may be due to chemical inhabitant of seeds. While the sun drying method result poorest quality of the seeds which were 30 % in

germination rate, 85 % in viability and 19 % in seed vigor. The use of sun drying system has provided highest temperature which generally makes them unsuitable for small scale drying harvested seed crops. Silica gel can reduce the relative humidity below 40 % and then removed the seed moisture contents. Therefore, drying with seed moisture absorbent was the best result and sun drying was the poorest method of drying seeds.

Sangakara, (1995) reported that the drying citrus seeds under shade and ambient temperatures maintained germ- inability to greater extent than when the seeds are desiccated in ovens.

Silica gel drying method was first used by the Pritchard et al. (2004) for safe and effective dehydration of seeds. Six or seven aliquots of seeds were placed in polythene bags with an equal mass of freshly regenerated silica gel desiccants. The bags were then placed in an incubator at 26 °C and periodic reweighing of the seeds, separated from the silica gel, allowed target masses and hence the moisture contents to be obtained. Maximum drying times varied from 6 d, for Sclerocarya birrea, to 35 d for Syzygium cumini depended on the time required for the seeds to reach3-7 % moisture contents.

Edwards and Mumford (1985) dried up the seeds of sour orange in streams of air and some of its constituent’s gasses which were O2, N2 and CO2 at 25-40 °C. The seeds lost their moisture contents at different rates in the different gasses at the same temperature and showed marked variation in the rates of germination. The intact seeds dried at a rate of 30 % moisture loss per 100 hrs in a rapid air current showed the best viability.

Chemical composition of Citrus seed

Prill et al. (1949) determined the effect of chemical compounds and organic acids on the germination of the seeds and growth of seedlings. Evenari, (1949) mentioned that fruit juice of C. aurantium, C. limon, C. maxima and C. nobilis contain a substance that inhibit the germination of the seed of citrus. The effect of these acids and chemical compounds on the germination of citrus seeds and the effect of a sudden change in their concentrations on the physiology of seed has not been explored.

Cohen, (1956) and Monselise (1959) provided the evidence for the existence of the inhibitors in the seed coat of citrus seeds. They showed that when the seeds of citrus were soaked in water, the resulting solutions inhibited the germination of weed seeds and suggested that this effect might be caused by the presence of inhibitor substances in the seed coat of citrus such as phenolic contents.

Van buren, (1970) reported that the chemical compounds like protein, fats, sugars, phenolics, enzymes are widely distributed in plant, particularly in fruits. The amount of these compounds per fruit usually decreased as the size of the fruit increased. Among these compounds phenolics are the major inhibitors for the germination of seeds after ABA.

Ulrich, (1970) reported that when citrus seeds are removed from the fruits there was a remarkable change in their environment because the pulp and juice of the fruit are very rich in organic acids and chemical compounds like protein, fats, sugar and lipids. These compounds are usually dissolved in the

water either free or in combination with salts, esters or glycosides. In lemon juice the citric acid is 60-90 % of the total soluble sugars (Wolf, 1958).

Devlin, (1975) determined the effect of dehydration on the seed coat that has not been still investigated, and it is possible that the viability of the seed is reduced during drying due to change in the nature of the seed coat which in turn effect the embry