EFFECT OF SEED DESICCTION AND STORAGE ON SEED VIGOUR AND GERMINATION IN FOUR SPECIES OF INDIGENOUS FRUIT TREES

BY

LUDOVICK OBED NDENFOO URONU

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT ON THE REQUREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FORESTRY OF SOKOINE UNIVERSITY OF AGRICULTURE.

MOROGORO, TANZANIA

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ABSTRACT

A study was conducted for *Cordyla africana* Lour, *C. densiflora* Milne.Redh., *Strychnos cocculoides* Baker and *S. spinosa* Lam., in the laboratory, to investigate desiccation tolerance and storage conditions that will maintain high seed vigour and germination. Three experiments were conducted: Initial, desiccation sensitivity and storage trials. For initial and desiccation trial, a Randomized Complete Block Design with four replications was used. For storage trial, a 5 x 4 x 3 factorial experiment with four replications was conducted. Factor one was moisture contents at five levels: *C. africana* (50, 38, 25, 13 and 8%); *C. densiflora* (54, 41, 27, 14 and 10%); S. *cocculoides* (43, 32, 22, 11 and 5%) and *S. spinosa* (41, 31, 21, 10 and 5%). Factor two was storage temperature at four levels, -20, 4, 16 and 25^0 C and factor three was packaging materials at three levels, polyethylene bags cotton cloth bags and aluminum foil bags. Germination test was conducted after every 2, 4, 8 and 20 weeks. Assessment were done for, daily germination percent, final germination percent, radicle elongation, germination value and germination energy percent. Seed of *C. africana* and *C. densiflora* were found to be sensitive to desiccation, seed vigour and viability were substantially reduced after desiccation from 50 to 13% and from 54 to 14% respectively. For *S. cocculoides* and *S. spinosa* seed viability and vigour were not sensitive to desiccation. Storage conditions significantly influenced seed viability and vigour after two weeks of storage. Seeds of *C. africana* and *C. densiflora* maintained high final cumulative germination of 90 and 95% and higher radicle elongation of 19 and 42 mm respectively, for seeds stored with their initial moisture content at 16^0C in cotton cloth bags. Germination value and germination energy followed the same trend. For *S. cocculoides* and *S. spinosa* seeds were not significantly affected by storage. It is concluded that, Seeds of *C. africana* and *C. densiflora* are recalcitrant and those of *S. cocculoides* and *S. spinosa* are intermediate. It is recommended that seeds of *C. africana* and *C. densiflora* should be stored with moisture content between 25 and 50% and 27 and 54% in cotton cloth bag at 16^0 C respectively, for period no exceeding eight weeks. Seeds of *S. cocculoides* and *S. spinosa* can be stored for up to 20 weeks in polyethylene bags, with moisture content between 5 and 40% at temperatures of $\geq$ 4^0C but not exceeding 25^0C. Further study should be conducted to determine rates of cell membrane disruption during desiccation.

DECLARATION

I, LUDOVICK OBED NDENFOO URONU, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and has not been submitted for a degree award at any other University.

Signature..................................

Date.....21-11-2002.....

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DEDICATION

This work is dedicated to my beloved parents Obed Ndenfoo Uronu and Anna Obed Uronu who scarified a lot toward laying down the firm foundation of my education

TABLE OF CONTENTS

Page

Page

Page

Page

Page

Page

Page

Page

SYMBOLS

≈	Approximately
^0C	Degree Centigrade
^0E	Degree East
^0F	Degree Fahrenheit
^0S	Degree South
Σ	Summation
=	Equal to
<	Less than
>	Greater than
+	Plus
-	Minus
±	Plus or minus
%	Percent
&	And

LIST OF TABLES

Page

Page

Page

Page

LIST OF FIGURES

Page

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AAS	African Academy of Sciences
ANAFE	African Network for Agroforesty Education
ANOVA	Analysis of Variance
AOSA	Association of Official Seed Analysts
a.s.l.	Above sea level
ATP	Adenosine triphosphate
cm	Centimetre
DNA	Deoxy ribonucleic acid
E	East
et al.	And other
etc	And many more
e.g.	For example
FAO	Food and Agriculture Organization
g	Gramme
GADA	Glutamic acid decarboxylase activity
GLM	General Linear Model
ha	Hectre
ht	Height
i.e.	That is
ICRAF	International Center for Research in Agroforestry
IPGRI	International Plant Genetic Resources Institute

ISTA	International Seed Testing Association
Kg	Kilogramme
Km	Kilometre
m	Metre
mg	Milligramme
mm	Millimitre
NORAD	Norwegian Agency for Development Cooperation
NTSP	National Tree Seed Programme
Pr	Probability level
RNA	Ribonucleic acid
R^2	Coefficient of determination
S	South
SAS	Statistical Analysis Systems
SE	Standard error
SPP	species
SUA	Sokoine University of Agriculture
Yr	Year
Var	Variety

SYMBOLS

≈	Approximately
^0C	Degree Centigrade
^0E	Degree East
^0F	Degree Fahrenheit
^0S	Degree South
Σ	Summation
=	Equal to
<	Less than
>	Greater than
+	Plus
-	Minus
±	Plus or minus
%	Percent
&	And

CHAPTER 1

1. INTRODUCTION

1.1 Back ground

Rural population in Tanzania just like other developing countries derives a significant part of their food and energy requirement from wild fruits. These fruits play a greater role as food sources and thus improves nutritional status and provide cash derived from the sale of fresh fruits or processed products (Saka and Msothi, 1994). They also make a significant contribution by providing a supplement to a largely starch diets based on subsistence crops and when other means fails local inhabitants can often rely for survival on the presence of these forest species (FAO, 1983; Palgrave, 1992).

In Tanzania, most wild fruit trees occur naturally in natural forest and miombo woodland environments, which are subjected to constant pressure from other land uses such as continuous clearing of land for agriculture, overgrazing and annual forest fires, which threatens extinction of many indigenous fruits trees/shrub species (Wood, 1966; Mnzava, 1980). Harvesting of fruit trees for other purposes leaves behind genetically poor materials leading to genetic erosion. In addition, for most indigenous tree species natural regeneration is inadequate. Consequently, many indigenous fruit trees are becoming scarce in natural forests and woodlands. It is therefore crucial to promote regeneration of these species especially by employing artificial regeneration techniques. Thus, there is an urgent need for their domestication. *Cordyla* species i.e. *C. africana* Lour. and *C. densiflora* Milne-Redh. and *Strychnos* species i.e. *S. cocculoides* Baker, and *S. spinosa* Lam are among such species. According to Mbuya *et al.* (1994), FAO (1983) and Palgrave (1992). These species regenerate naturally by seed, coppice and root suckers but natural regeneration is inadequate.

Domestication of indigenous fruit tree species is hindered by among other things lack of inadequate seed handling and appropriate technology on the storability of seeds. According to Nkang *et al.* (2000) seeds of many tropical species do not undergo maturational drying and cannot be maintained in anything other than short-term storage. Due to their high moisture content they germinate soon after they are shed. Knowledge of seed storage behavior is therefore a pre-requisite of ex-situ plant biodiversity conservation by seed storage. In addition, domestication of wild fruit trees requires among other things, sufficient supply of viable seed at the right time. However in some species fruit setting is irregular and thus storage of seed becomes a necessity. The environment under which seed is stored is an important factor in determining the period that seed can be stored and maintain an acceptable level of germination and vigour. As pointed out by Lewis *et al.* (1998) it is generally accepted that storability may be improved by controlling the storage environment.

Roberts (1973) and Chin and Roberts (1980) classified species in two categories one being recalcitrant and the other orthodox. Recalcitrant species are those species whose seeds cannot survive drying below relatively high initial moisture content and cannot be successfully stored for longer periods. Whereas orthodox species are those species, which can survive drying below relatively low initial moisture content and can be successfully stored for long periods. Bewley and Black (1994) and Ouedraogo (1996) introduced a third concept of intermediate species, with intermediate characteristics between recalcitrance and orthodox, in which seeds survive desiccation but become damaged during dry storage at low temperature.

There is very scanty information on storage behavior of the seeds of C. *africana*, C. *densiflora*, S. *cocculoides* and *S. spinosa*. Msanga (1998) reported these species to be recalcitrant and that they cannot retain viability for longer period under normal conditions. The seed of these species have relatively high initial moisture contents and are suspected to be recalcitrant or intermediate between recalcitrant and orthodox.

Little research has been done on germination, desiccation tolerance and storage of indigenous fruit trees (Msanga *et al.* 1999 a, b). Information provided by FAO (1983) on 40 food and fruit bearing forest species of Tanzania did not cover desiccation tolerance and storage of recalcitrant seed of indigenous fruit trees. Consequently there is no information on the appropriate storage condition i.e. optimum storage temperature, moisture content and packaging materials for *C. africana, C. densiflora, S. cocculoides* and *S. spinosa* although very little information is provided by Msanga (1998) on storage of *Cordlya africana* and *C. densiflora.*

1.2 General objective

The general objective of this study was to investigate desiccation tolerance and storage conditions (temperature, moisture content and packaging material) that will maintain high germination and seed vigour for *Cordyla africana, C. densiflora, Strychnos cocculoides* and *S. spinosa.*

1.3 The specific objectives were:

For the four species to determine:

- Optimum seed desiccation tolerance.
- Appropriate storage conditions i.e. temperature and moisture content that will give high germination and seed with high vigour.
- Appropriate storage containers that will maintain high viability of seeds.

1.4 Working hypothesis

During the study, following hypotheses were tested:

- For each species, desiccation has no significant effect on seed germination and seed vigour.
- For each species, storage conditions i.e. moisture content and temperature have no significant effect on seed germination and seed vigour.
- For each species, storage containers have no significant effect on germination and seed vigour.

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CHAPTER 2

2. LITERATURE REVIEW

2.1 Species description, distribution and regeneration

2.1.1 *Cordyla africana*

Cordyla aficana is also known as Wild mango in English and Mroma in Kiswahili belongs to the family Papilionoideae. It is a large spreading deciduous tree up to 25m in height with rounded crown (Palgrave, 1988; Ruffo *et al.*, 2002). It has grayish-brown and rough thick and grooved bark. The leaves are alternate, compound with 11 to 28 pairs of leaflets plus a terminal leaflet, each one oblong to 2.5 cm, dark green with a short hair stalk. The fruit of *C. africana* is very unusual large pod resembling a semi-leafy drupe, more or less spherical about 4 cm long and 3 cm broad, beaked at the tip, yellow when ripe, with fine green streaks. It contains soft pulp and one or two seeds. (Palgrave, 1988; Msanga, 1998; Ruffo *et al.*, 2002). About five kilograms of fruits produces one kilogram of seeds. The seed is large and fleshy, 3 cm long and 2 cm broad, with rounded ends. The seed coat is thin, light green and streaked by strands of ducts resembling a network of fibers. One kilogram contains about 100 of freshly harvested seeds (Msanga, 1998).

Cordyla africana occurs from low altitudes in hot areas up to 1000 m above sea level, especially in riverrine fringes or forests and also in swamp forests from Kenya, Mozambique, Malawi, Zambia to South Africa. In Tanzania it is widespread especially in Kilimanjaro, Kilosa, Lindi and on Zanzibar Island (Ruffo *et al.*, 1994).

The species regenerate naturally from the seed and coppice. According to Palgave (1988), its regeneration is inadequate. Phenology of *C. africana* according to personal experience is that it flowers in February, June, and August. Fruiting is between November and January.

The fruit of *C. africana* is very testy and is eaten both raw and cooked. It has very high vitamin C content. The brown and hard heartwood is used for heavy construction building, sleepers, bridge timber, wooden spoons, and also for making drums. The tree also exudes a gum resin. It is also used to provide shade around homesteads and is suitable for avenue planting (Mbuya *et al.*, 1994; Ruffo *et al.*, 2002).

2.1.2 *Cordyla densiflora*

Cordyla densiflora locally known as Mkwata belongs to the family Papilionoideae. It is a deciduous tree up to 10 m high. It has often short, much branched to a rounded, bushy spreading crown. According to Msanga (1998) the fruit of *C. densiflora* is a large fleshy pod, almost egg-shaped, about 5 cm long and 3 cm wide, beaked at the tip, and yellowish-green when ripe, with fine reddish-green streaks. It contains soft pulp and one seed. About five kilograms of fruits produces one kilogram of freshly harvested seeds. The seed is large and fleshy, about 3-5 cm long and 3 cm wide. The seed coat is light green, thin and streaked by strands of ducts resembling a network of fibres. One kilogram contains about 90 of freshly harvested seeds (Msanga, 1998). The bark is smooth pale grey to pale brown. The leaves are compound, odd pinnate 9-21 cm long, with 5-9 pairs of alternate leaflets plus one at the tip, often small, oval 2-5.5 cm long, tip rounded or notched, pale grey-green, no hairs or few often small curly hairs below especially along the midrib, base rounded.

Cordyla densiflora grows between 800 to 1200 m above sea level. It occurs naturally in deciduous woodland, bush land and in commifora thickets. Where it grows the dominants tree species include, *Acacia nigrescens* Oliv., *A. Senegal* (L.) Will.d, *A. tortilis* (Forssk.) Hyne, *Adansonia digitata* L., *Albizia amara* (Roxb.) Boiv., *A. Harvey* E.Fourn., *Commifora africana* (A.Rich.) Engl., *C. ugogoensis* Engl., *Delonix elata* (L.) Gamble, *Entandrophragma bussei* Engl., *Euphorbia candelobram* L., *Lonchocarpus capassa* Rolfe, and *Xeroderris stuhlmanii* (Mendonca & E.C.Sousa)Taub. (Brenan 1967). In Tanzania it is known to grow naturally in semi arid areas in Iringa and Dodoma regions and the species is endemic in Tanzania.

Cordyla densiflora regenerates naturally from seed and coppice (FAO, 1983). However according to observation made by FAO (1983) only samplings to mature trees were noted to be present and there were no trace of seedlings. This can be attributed to disturbances such as grazing, annual wild fires and also due to drought. In its natural habitat it has been observed that, there are about 8 to 20 stems per hectare (FAO, 1983).

Phenology of *C. densiflora* is that it flowers between May and October (FAO, 1983). However, Brenan and Greenway (1949) observed that it flowers in February, June and August. This implies that the flowering takes place towards the end of the rainy season, extending into the dry season. The fruit ripening takes place between October and February, during the rainy season. It can therefore be concluded that it takes about six months from fertilization of the flower to the ripening of the fruit (FAO, 1983).

The fruit pulp of *C. densiflora* is edible and rich in vitamin C and therefore nutritious fruits can also be sold to increase economic status. Tree stems are used for building poles, traditional stools, grain mortars and live fences and the species provides good shading.

2.1.3 *Strychnos cocculoides*

Strychnos cocculoides known as Monkey orange and corky bark in English and Mpera mwitu and Monga in Kiswahili, belongs to the family Loganiaceae. It is a semi-deciduous shrub or a small tree 3-8 m high. The branches often have recurved stipular spines, sometimes ending in a straight spine, leaves ovate or elliptic, base cunneate to round, shine above dull below with 5 veins from the base, twigs have spines. The fruit of *S. cocculoides* is large, round and hard woody berry about 7 cm in diameter, dark green sparkled with white when young, becoming yellow when ripe yellow or orange lenticeliate (Beentje, 1994; Ruffo *et al.*, 2002). According to Msanga (1998), the fruit contain 25 to 30 seeds embedded in pulp. Seed is flat round about 2 cm in diameter, and creamy white. One kilogram contains about 1800 of freshly harvested seed.

The species occur in areas with annual rainfall between 500 – 1500 mm. It has wide distribution in Zambezian regional centre of endemism, which is mainly dominated by miombo woodland type of vegetation. In Tanzania the species is widely distributed from sea level up to more than 2000m above sea level (FAO, 1983; Mbuya *at el.*, 1994; Ruffo *et al.*, 2002).

Strychnos cocculoides regenerates naturally by seed, coppice and root suckers. However natural regeneration is inadequate and in its natural occurrence there are about 4 stems/ha of diameter between 15 – 29 cm and about 15 – 20 stems/ha with diameter above 15 cm (FAO, 1983). *Strychnos cocculoides* flowers from September to November and fruiting is from April to August. On the other hand *S. cocculoides* flowers between March to August, and fruiting is from October to January (Palgrave, 1988). However it has been also observed to flower from October to February, during the rain season while fruiting takes place from July and December, during the dry season, (FAO, 1983). Therefore it takes about 8 months from flower fertilization to fruit ripening

The fruit of *S. cocculoides* has pulp which is edible and with pleasant taste (Katende *et al.*, 1999). According to Ndabikunze *et al.* (1999) the species contains 135.3Mg/100g of vitamin C, 36.883Mg/100g of reducing sugar, 0.6% of protein and 1.32% of fat. As reported by Watt and Breyer-Brandwijk (1962) the species yields

0.85% of reddish fixed oil. The wood is suitable for tool handle. Breyer-Brandwijk (1962) suggested that roots may be chewed for treatment of eczema (skin disease). The species is also alleged to cure gonorrhoea.

2.1.4 *Strychnos spinosa*

Strychnos spinosa Lam. known as spiny monkey orange in English and Mpapa in Kiswahili belongs to the family Loganiceae. It is a shrub or a small tree up to 7m in height. Branches are often with pairs of straight or curved spines, and it has smooth whitish bark. Leaves oval; to circular, to 5 cm long, they have three veins from the base, leathery, glossy green above, wedge-shaped to the base, to 10 cm long. The fruit of *S. spinosa* is spherical berry, woody-shelled up to 12 cm in diameter, deep yellow to yellow-brown when mature, not lenticelliate resembling an orange (Beentje, 1994). The fruit contains many flat seeds with hard coat within juicy rather acid pulp. The seed is flat round about 2 cm in diameter, and creamy white. One kilogram contains about 1800 of freshly harvested seeds.

The *species* occur in areas with annual rainfall between 500 – 1500 mm. It has wide distribution in Zambezian regional centre of endemism, which is mainly dominated by miombo woodland type of vegetation. It occurs in areas up to more than 2000m above sea level (Palgrave, 1988). According to Morgan (1972), the species grow on black to dark-grey clays (grumosolic soils), dark to ready loamy sands (latosolic soils) and yellow-red loamy sands. The species grow naturally in *Brachystegia-Isoberlinia* woodland and *Brachystegia* mixed forests and in deciduous woodlands

(Brenan and Greenway 1949, Bruce and Lewis 1960). The common associated species included *Afzelia quanzensis* Welw., *Brachystegia boehmiii* Taub., *B. spiciformis* Benth., *Combretum collinum* Fresen, *C. molle* G.Don, *C. zeyheri* Sond., *Julbernadia globiflora* (Benth.) Troupin, *Pericopsis angolensis* (Bak.) Van Meeuwn, *Terminalia sericea* DC., *Vitex ferruginea* Schum. and *V. mombassae* Vatke. It grows well in areas with temperatures ranging from 14^{0}C to 25^{0}C

Strychnos spinosa regenerates naturally by seed, coppice and root suckers. However natural regeneration is inadequate and there is no established data on the number of stem per hacter. The ripe fruit pulp of *S. spinosa* is edible. According to Palgrave (1988) roots or green fruits are used as an antidote to snake bite while the roots alone provide an emetic and also a remedy for fevers and inflamed eyes. The shell of dried fruits is used to make sound boxes for musical instruments and wood is suitable for fuel.

2.2 Seed viability, germination and vigour

2.2.1 Seed viability

According to David and Dornbos (1994), seed viability, germination and vigour each describe different aspects of the quality of seed population. Seed viability is the capacity of seed to germinate under favourable conditions provided that any dormancy in the seed is broken before testing germinability. Consequently viability and germination can be considered to have dual meanings, the specific ones are physiologically and technically oriented. To the seed technologist, seed viability refers to the capability of seed to germinate and produce a "normal" seedling (David and Dornbos, 1994). Physiologically, viability refers only to whether or not a seed contains any tissues that are metabolically active, possessing energy reserves and enzymes capable of sustaining live plant cells.

The other major aspect in connection to seed viability is the fact that there are majority of species which their seeds can retain viability and store well when dried to low moisture content, these seeds are categorised as orthodox. However some seeds cannot be dried to very low moisture content and must retain a relatively high moisture content during storage in order to maintain maximum viability, these are known as recalcitrant (Bewly and Black, 1994).

For seed quality assessment, the standard germination test is the principal and accepted criterion for seed viability (Hampton and Coolbear, 1990). As pointed out by Copeland and McDonald (1995), in the standard germination test seeds are germinated in favourable conditions and this may correctly predict field performance under optimum field conditions.

2.2.2 Seed germination

2.2.2.1 Generally

Seed germination is the emergence and development from the seed embryo, of those essential structures, which are indicative of the seed's capacity to produce a normal plant under favorable conditions. (Justice, 1974; ISTA, 1993). It is now generally accepted that seed germination is the most important than all quality measurements of the seeds (Bonner, 1974). Consequently the main aim of laboratory germination is to estimate the maximum number of seeds that can germinate in optimum conditions. In the laboratory, the environmental conditions which includes moisture, temperature, aeration and light.

2.2.2.2 External factors affecting germination

2.2.2.2.1 Favorable conditions for germination

For seed to germinate, it should be provided with environmental conditions favourable to germination process. Mayer and Polykoff-mayber (1989) listed adequate supply of moisture, suitable temperature and composition of gases as well as light for certain seeds to be among the conditions required for germination.

The quantitative and qualitative requirement of these environmental factors varies according to species (Berrie, 1984). Water is basic requirement for seed germination for enzymatic activation and for break down, translocation and use of food reserve. Temperature plays a major role in seed germination by controlling and regulating the seed metabolic activities. Optimum temperature for seed germination varies from one species to another. Light may induce or promote germination, especially for seed, which respond positive to light (photoblastic). However, in some cases seeds might fail to germinate even after provision of favorable conditions for germination. This is caused by among other thing seed dormancy.

2.2.2.2.2 Seed dormancy

Seed dormancy as defined by Taylorson and Hendricks (1977) is physiological state in which viable seeds fail to germinate when exposed to suitable condition for germination. Seed dormancy can be categorised into three groups. Exogenous or seed coat dormancy, endogenous or embryo dormancy and combined dormancy.

Seed coat imposed dormancy is broken by making the seed coat permeable to water (Tietema, 1992). Embryo dormancy is often caused by the presence of inhibitors, sometimes the embryo is still immature when the seed is released from the tree. However in majority of seeds, dormancy is coat-imposed. When this is the case, the structure around the embryo can inhibit germination in different ways such as by inhibiting water intake, inhibiting oxygen or carbon dioxide exchange, containing chemical inhibitors exercising a mechanical constraint.

Seeds of *C. africana* and *C. densiflora* do not exhibit dormancy problems (Msanga, 1998). Although *S. cocculoides* and *S. spinosa* are reported to have a hard seed coat which inhibit germination (FAO, 1983; Palgrave, 1992; Mbuya *et al.* 1994), the hard seed coat can be softened by soaking the seed in cold water for 12 hours to improve germination (Mbuya *et al.*, 1994). The problem of seed dormancy is therefore of less interest in this study.

2.2.2.3 Stages of seed germination

Germination consists of three overlapping processes:

- Absorption of water, mainly by imbibition, causing a swelling of the seed and eventually splitting of the seed coat.
- On imbibition, metabolism quickly recommences leading to increase in enzymatic activity, increased respiration and assimilation. This informs the fundamental cellular activity (RNA and protein synthesis), to signals the use of stored food and translocation to growth regions (Bewly and black, 1994).
- Cell enlargement and divisions resulting in emergence of radicle and plumule (Kugman *et al.* 1968 in Willan, 1985).

The process of germination is achieved by elongation of radicle, which expands and penetrates the surrounding structures marking the completion of germination. (Bewly and black, 1994). In most seeds the radicle of the embryo is close to the micropile, where absorption of water is easier and quicker than through the seed coat. As the radicle swells, it exerts pressure on the seed coat, which commonly splits first at this point to free the radicle. This gives rise to the primary root, which grows, down into the soil and soon produces lateral roots. (Willan, 1985).

Subsequent stages after radicle elongation and outbreaks depend on whether the species exhibits epigeal germination. For example in *S. cocculoides* and *S. spinosa* the hypocotyl elongates and the cotyledons are lifted above the ground. For these two species, a white radicle protrudes at the scar end and develops into a vigorous taproot. The seed coat is carried up by the hypocotyl on the cotyledons (Msanga, 1998). The leafy cotyledons changes colour from white to green. Furthermore the germination of these two species according to preliminary results indicated that germination for these species is very good, since fresh seeds can attain up to 90 and 95% (Uronu, 2000).

Cordyla africana and *C. densiflora* exhibits hypogeal germination. In this stage the hypocotyl is undeveloped and cotyledons remain on or in the ground. According to Msanga (1998) the seed coat splits at the scar point and the radicle protrudes. The epicotyl splits the two cotyledons apart and elongates, while the cotyledons remain within the seed coat, buried in the germination medium. It has been observed that germination of fresh seed of these species is very good and uniform under favorable conditions, they can attain up to 90% and 80% for *C. africana* and *C. densiflora* respectively (Msanga, 1998).

2.2.3 Seed vigour

The other important aspect is the seed vigour. Seed vigour as defined by McDonald, (1980) is the quality of seed responsible for rapid and uniform germination, extended storability, good field emergence and ability to perform well over a wide range of edaphoclimatic conditions. According to Base (1994), storability factor is very important aspect of seed vigour and in absence of data on field performance, may serve as a very useful index of vigour. Therefore vigour test, which detects differences between the viability and seed vigour under conditions of deterioration and stress, can be therefore very good indicator of the field performance of seed lots, which have experienced deterioration and consequently becomes helpful in making decision on the use of seed and storage options (Fay *et al.* 1993).

Vigour is differentiated from germination ability in several ways. Definition of vigour identifies the desire to measure uniform and rapid seedling emergence, thereby focusing attention on seeds with stronger germination potential. According to David and Dornbos (1994), vigour also focuses on emergence potential in a variety of field conditions, both optimum and less optimum, thereby gaining greater relevance to typical agronomic conditions.

2.2.3.1 Classification of vigour tests

Vigour tests can be categorized into two categories, the first one is single test which is based on some aspect of germination behavior, it attempts to develop physiological or biochemical indices of vigour like germination energy, defined as the germination percentage when the mean daily germination (cumulative germination percentage divided by the time elapsed since sowing date) reaches peak and germination value, which is a composite value, that combines both germination speed and total germination and provides an objective means of evaluating the results of germination test. Germination value is determined using a formula by Djanshir and Poubeik (1976). The second test is multiple testing, which is classified into three main groups namely, seedling growth and evaluation test, stress test and biochemical tests (Hampton and Coolbear, 1990; Vieira *et al.*, 1999). Detailed procedures for these tests are presented in the vigour-testing handbook (AOSA, 1983), however short description is provided below:

2.2.3.1.1 Seedling growth and evaluation tests

Seedling growth and evaluation tests include first the seedling vigour classification and it also measures seedling growth rate and speed of germination tests. The seedling growth rate has received somewhat stronger acceptance than the other two since seedling dry weight represents a logical and relevant estimate of the rapid and uniform emergence desired by growers and avoids more subjective ratings (Larsen *et al.*, 1998). It has been also revealed that seedling growth rate provide an accurate prediction of field performance with pepper (*Capsicum annuum* L. *Var. annuum*) (Trawatha, *et al.*, 1990).

2.2.3.1.2 Stress Tests

Stress tests include accelerated ageing, cold and conductivity. Of these the cold test has received extremely wide usage and acceptance with many crop types by seed companies and associations alike, because of its relevance to typical production environment soils. A short description of these tests, summarised from AOSA (1983) is provided below.

Accelerated ageing

- This is a physiological stress test done by using high temperatures and relative humidity that permit controlled deterioration of the seed.
- Accelerated ageing tests may detect physiological differences among seed lots that cannot be identified by the standard germination test.

The cold test

- The cold test is another physiological stress tests.
- This test determines the potential of seed to germinate under unfavorable conditions.

The conductivity test

Conductivity test is a valuable seed test for many crops (Hampton and TeKrony, 1995). Low quality seeds have poor membrane structure that allows the out ward diffusion of ions during imbibition that are detected by monitoring the electrolytes present in steeper water (Simon and Mills, 1983). The main processes involved are summarised below:

- Conductivity test serves as an indicator of cellular electrolyte and solute leakage.
- As the seed dry at maturity, cellular membranes within the seed undergo changes.
- Upon rehydration, these membranes, in the process of becoming intact, allow amino and organic acids and various ions to escape.
- The premise of this vigour test lies in the rapid reorganization of cellular membranes in high vigour seed during imbibition, thus preventing excessive electrolyte leakage.
- Due to the loss of electrolytes through disorganized membranes of low vigour seeds, conductivity readings are higher for low vigour seed lots than high vigour lots as the seeds are rehydrated.

2.2.3.1.3 Biochemical Tests

A biochemical test includes, the tetrazolium, conductivity, respiration, glutamic acid decarboxylase activity (GADA), and adenosine triphosphate (ATP) content tests. The common test that has received wide usage is the tetrazolium test. However tetrazolium test is not very much in use due to the fact that it is very strenuous, it require large amount of time to evaluate seed samples and it is also difficulty to relate zones of damage to germinability and vigour (David and Dornbos, 1994).

Today, two vigour tests (conductivity and accelerated ageing) are considered sufficiently standardized to be recommended appropriate vigour tests (Humpton and TeKrony, 1995). In conclusion the choice of vigour test therefore, should take into consideration type of species, resource and time available to conduct the test. As stipulated by Aastrup *et al.*, (1989) the mean germination time can also be used as an indicator of vigour levels. It is also supported by Schmidt (2000) that speed of germination is an expression of seed vigour. It is anticipated that high-vigour seeds germinate faster than low-vigour seeds under any conditions. This is the main criterion used to evaluate seed vigour for *C. africana, C. densiflora, S. cocculoides* and *S. spinosa* in the current study.

2.3 Seed storage

2.3.1 Generally

Seed storage may be defined as the preservation of viable seeds from the time of collection until they are required for sowing (Holmes and Buszewicz, 1958 in Willan, 1985). When seed for afforestation can be sown immediately after collection, no storage is needed.

2.3.2 Importance of seed storage

It is difficult to imagine how we would sustain ourselves if it were not possible to store seeds from one season to the next. Proper seed storage aims at maintaining the viability of the seed at the highest possible level (Stubsgard, 1992). Seeds samples storage is used to store seeds for future use, as in the case e.g. for gene resource conservation, and storage of species in bulk quantities, especially those which have irregular fruiting (periodicity) like most of tropical species whose fruit set is irregular (Poulsen, 1993; Nkang *et al.* 2000) and timing of favorable, time and conditions for germination (Willan, 1985).

2.3.3 Storage periods and methods of storage

2.3.3.1 Storage periods

Storage of seed for less than one year is applicable for those species, which have poor storability e.g. recalcitrant species like *Syzygium cuminii* (L.) Skeels, *S.guineense* (Willd.) DC., *Sorindeia madagascariensis* Thouars DC. and *Uacapa kirkiana* Mull.Arg. (Msanga *et al.* 1999a,b, 2000). Furthermore, it is also feasible especially when both seed production and afforestation are regular annual events, or when local collections are undertaken by a nursery for its own use, or when the availability of storage facilities are so poor that the seeds are expected to lose their germination capacity within the year. (Willan, 1985).

2.3.3.1.2 One to five years

Seed storage for one to five years is applicable to those species, whose seed can be stored (orthodox), and when the species has irregular fruiting (periodicity) and in case there is large storage facilities which are so good that is economically more feasible to undertake collections only in years with good crop (Willan, 1985; Bewley and Back, 1994).

2.3.3.1.3 Long-term storage

Long-term seed storage is useful for future use as in case for gene resource conservation. Seed should be capable of being stored e.g. orthodox like most of the legumes for example *Acacia spp.* which at approximately 5% moisture content and 18^{0}C (Willan, 1985).

2.3.3.2 Methods of storage

Several economically important crop, timber, and fruit species of the tropics are the backbone of developing countries. Crops like rubber (*Havea brasiliensis*) Cocoa (*Theobroma cacao* L.) and coconuts (*Cocos nucifera* L.) and fruits such as mango (*Mangifera indica* L.), Durian (*Durio zibethinus* Murry), Jack fruit (*Artocarpus heterophyla* Lam) are some of the major plant species that produce recalcitrant seeds.

The conservation of recalcitrant seeds is hindered by the lack of knowledge on their storage requirements as compared to orthodox seeds. The typical recalcitrant seeds are short-lived with a life span of a few days to a few weeks, and are very sensitive to desiccation and low temperatures. As such it is very difficult or rather impossible, to store them for germplasm conservation.

2.3.3.2 Main types of methods of seed storage

The storage techniques currently being used for recalcitrant seeds can be grouped into four main types:

- Moist or imbibed storage
- Partial desiccation technique
- Controlled atmosphere storage
- Cryogenic storage

(a) Moist or imbibed storage

Unlike orthodox seeds, recalcitrant species have to be kept moist or with high moisture content. Recalcitrant seeds have been known to survive when kept in moist conditions, such as in moist media. Study by King and Roberts (1982) revealed that seeds of cocoa immersed in water for a month resulted in 60 percent germination. Whereas for most species, low temperature of 7^0C is used to prevent early germination.

(b) Partial Desiccation Technique

The moisture content of recalcitrant seeds at maturity is in the range of 30 to 70%. Some species are killed when their moisture content is lowered to 25% while others can be dried to a lower moisture level. Hence instead of keeping them moist, attempts have been made to partially dry them, i.e. surface drying. This can be done in association with a fungicidal treatment. Observation made by Hor *et al.* (1984) revealed that seeds of cocoa processed by partial drying to 35 percent and dusted with 0.2 percent (w/w), benlatethiram mixture and packed in batches of 500 seeds in thin (0.15 mm), perforated plastic bags conditioned room remained viable for over six months with over 50 percent germination

(c) Controlled Atmosphere storage

Over the years experts have experimented with storing seeds in various gases but there is not yet a single successful method for practical application.

(d) Cryogenic storage

To survive at a very low storage temperature, reduced moisture in seeds is a pre-requisite. Usually when seeds have a very low moisture content, they will not suffer from freezing injury even at -196^0C (Stanwood and Bass, 1978). Although the most promising method of germplasm conservation for recalcitrant species is storage in liquid nitrogen (Roberts *et al.*, 1984), unfortunately so far there is no report of successful storage of recalcitrant seeds using this methods. It is not very practical to store such large seeds in cryogenic tanks or containers. Chin (1994) revealed that large seeds tend to explode, leading to physical damage to seeds and many other types of large seeds tend to crack and suffer from mechanical damage.

2.3.4 Factors affecting longevity in storage

2.3.4.1 Seed condition

Longevity of seed in storage depends on seed maturity, parental and annual effects, freedom from mechanical damage, freedom from physical deterioration, freedom from fungi and insects, initial variability, ageing of seed and storage conditions. (Willan, 1985; Bewley and Black, 1994).

2.3.4.2 Moisture content

Moisture content is measured as the weight of water as a percentage of the total weight of the seed i.e. fresh weight of seed minus dry weight of seed over fresh weight of seed expressed in percentage (ISTA, 1993).

Controlling the moisture content of the seed in storage is the most efficient and easiest way to prolong the mean viability period. As a rule of thumb for orthodox species, the mean viability period doubles each time the moisture content is lowered by 1% between 14 and 5 percent. (Willan, 1985). As a general rule when the moisture content is high (>30%) non-dormant seeds may germinate, whereas for 18 to 30% moisture content rapid deterioration by microorganisms can occur. Seeds stored at moisture content between 18 to 20% will respire as a consequence in poor ventilation the generated heat will kill them (Bewly and Black, 1994). Likewise Poulsen (1993) suggested that storage at high moisture contents could be compensated by reducing the storage temperature.

The effect of moisture content depends somewhat on the oil content of the seed. According to (Bewley and Back, 1994), relative moisture content of proteins and carbohydrates are higher in seeds with oil (since there is no free water in the oil), compared to seeds without oil at the same moisture content.

It have been noted that some species are very tolerant to desiccation, although the attributes of what makes some embryo tolerant and other non-tolerant are not certain (Osborne, 2000). Certainly a functional DNA repairs is requirement for survival (Boubriak *et al.*, 1997). Consequently during desiccation all embryos do not die in the same way.

2.3.4.3 Temperature

Temperature, like moisture content, is negatively correlated with seed longevity; the lower the temperature the lower the rate of respiration and thus the longer the life span of the seed in storage (Willan, 1985). A rise in temperature increases the rate of chemical and biochemical processes. At very high temperatures beyond the usual physiological range, inactivation of enzymes and disruption of the structure of bioorganelles takes place (Basu, 1994).

According to Bewley and Back (1994), choice of storage temperature varies considerably according to species and the period for which the seed is to be stored. As stipulated by Bewley and Back (1994), for orthodox species, for each 10^0F (5.6^0C), decrease in seed temperature, the storage life is doubled. Likewise as revealed by Bonner (1990), recalcitrant seeds particularly those found in tropical zones, are sensitive to temperatures below 10 to 15^0C.

2.3.4.4 Storage atmosphere

The most obvious method of reducing the rate of aerobic respiration is to exclude oxygen from the atmosphere surrounding the seeds. Whereas the complete exclusion of oxygen from the storage atmosphere appears to be beneficial for most dry orthodox seeds, there is evidence that some oxygen is necessary for recalcitrant seeds (Willan, 1985).

2.3.4.5 Storage containers

Some form of container is necessary for most seed storage, to facilitate access to, and handling of, individual seed lot while keeping them separate, to make the best possible use of storage space, to provide protection against animal and insect pest and, for some seeds, to prevent passage of moisture and gases between the enclosed and the outside atmosphere (Willan, 1985),

According to Bewley and Back (1994), many types of containers have been used for tree seeds, which can be conveniently divided into: Materials freely permeable to moisture and gases (cotton bags, paper bags, cardboard and fiberboard). Materials completely impermeable, when sealed, to moisture and gases (tin or aluminum cans and drums, glass jars, plastic vials and laminated aluminum packages). Materials resistant, but not completely impermeable to moisture (polyethylene and other plastic films and aluminum foils). Selection of type of storage container depends on storage conditions (Schmid, 2000) for higher moisture content (more than 10%) cloth (cotton, hessian) bags that allow some ventilation are the most suitable (Schmid, 2000) whereas orthodox seed with low moisture content is preferably stored in airtight containers.

2.4 Recalcitrant, orthodox and intermediate seed species

2.4.1 Recalcitrant seeds

Recalcitrant seeds are generally very large in comparison to orthodox seeds. They exist under a moist ecological forest – type environment. They are also very heavy, with 1000-seed weight often exceeding 500g (Chin *et al.*, 1984). This is also attributed to their high moisture content (ranging from 30 to 70%) at time of shedding from the parent plant. There is also a great deal of variation in moisture content between individual seeds with a high coefficient of variation of about 7-13% compared to 2 to 3% in orthodox seeds (Chin *et al.*, 1984).

It is well known that recalcitrant seeds are shed by the plant when they are still high in water content. They are usually borne in perennial species which, during the evolution process, adopted a reproduction strategy adapted to wet and warm regions (Roberts and King, 1980). Recalcitrant seeds continue to hydrate until the end of development and maturation (Finch-Savage *et al.*, 1992). Due to their moisture content, recalcitrant seeds present capacity to germinate immediately after seed natural dispersion, without the need of exogenic additional hydration (Farrat *et al.*, 1992). The other important aspect of recalcitrant seeds is degree by which seed tolerate dehydration, according to Berjak and Pammenter (2001, it is a function of how rapidly water can be lost, less time available for metabolic-linked damage, and the lower content that can be attained without lethal injury.

Water content is a decisive factor of the behaviour of recalcitrant seeds during the storage. In those seeds, the sub-cellular water is strongly associated to the macromolecule cellular surfaces assuming, partially, the stability of membranes and macromolecules. The loss of structural water during the drying process would cause the alteration of metabolic systems and membranes, resulting in the beginning of the deterioration process (Farrat *et al.*, 1988).

Recalcitrant seeds have their viability reduced when the water content reaches values inferior to those considered critical, when it is the same or inferior to those considered lethal, there is total loss of viability (Pritchard, 1991; Hong and Ellis, 1998 and Martins *et al.*, 2000). The sensibility of the recalcitrant seeds to desiccation depends on the species, being the critical and lethal water content relatively high, i.e. from 27 to 38% respectively. (Andrade and Pereira, 1997) and from 12 to 22% (Priestley and Williams, 1985; Andrade and Pereira, 1997).

According to Bonner (1990) recalcitrant seeds, particularly those found in tropical zones are sensitive to temperatures below 10 to 15^{0}C. Likewise loss of viability during the desiccation phase due to slow drying or development of a germination constraint may also occur (Probert and Longley, 1989). Therefore the use of different rates of desiccation (King and Roberts, 1980) and dehydration and rehydration of seeds at a range of temperatures (Kovach and Bradford, 1992 and Kovach *et al.*, 1993) have been suggested as useful approaches in the study of recalcitrant seeds.

However some studies have indicated that critical and lethal values within a species varied with speed and temperature of seed dehydration (Farrant *et al.*, 1985; Pritchard, 1991). Other studies however have indicated that viability loss was independent of the drying method utilized (Finch-Savage, 1992; Pritchard *et al.*, 1995 and Bonner, 1996). Furthermore in another study it has been observed that deterioration resulting from the drying seeds affects both germination and vigour (Becwar *et al.*, 1982).

It should be noted, however, that various degrees of recalcitrant are known, as a function of relative desiccation tolerance and low temperature sensitivity. Berjak and

Pammenter (1994) suggested that recalcitrance is not an absolute phenomenon and that there is a continuum of seed behaviour from orthodox to recalcitrant. grading from that characterized by extreme desiccation tolerance, through a decreasing ability to withstand dehydration stress. Consequently, Probert and Longley (1989) attempted to characterise the relationship between water content and recalcitrant seed viability. They observed critical water content to mean water content below which seed viability decreases significantly and 'lethal water content' to mean water content associated with the breakdown of seed metabolic processes and the loss of viability.

According to Finch-Savage (1996), the water content to which seeds can be dried without viability loss depends on the degree of recalcitrance and is related, among other factors, to membrane integrity and metabolic activity that lead to free radical attack. It usually varies from 25 to 70%. It has been established that more rapid drying of tropical seeds permits survival to lower water contents than does slower drying (Bilia *et al.*, 1999)

There is very scanty information on appropriate storage conditions for *C. africana, C. densiflora, S. cocculoides* and *S. spinosa*. Mbuya *et al.* (1994) pointed out that the seed of *S. spinosa* has hard seed coat and suggested that the seed can be stored. However they did not specify storage conditions. On the other hand, Msanga (1998) pointed out that seeds of *C. africana* and C. *densiflora* cannot tolerate desiccation below 25% moisture content, he noted further that the species can be stored up to four weeks at room temperature without a significant loss of viability.

Preliminary results showed performance of some species with recalcitrant and intermediate seeds at different desiccation and storage conditions have been reported by the International Plant Genetic Resources Institute (IPGRI, 1998; 1999). According to Thomsen (1998) the germination of seeds of *Hancornia speciosa* B.A.Gomes with initial moisture content of 51% dropped from 100 to 0% after desiccation from 51 to 3.8% while those desiccated to 32% germination dropped to 32%. Another study with the same species whose seeds were desiccated to 48, 44, 41, 33, 27, 12, 6 and 5% moisture content gave germination of 95, 92, 86, 82, 82, 80 and 54 % respectively. Its seed did not tolerate desiccation below 12% moisture content.

Likewise experiment on *Syzygium cuminii* seeds showed a remarkable drop in germination percent when seeds were desiccated below 40% moisture content from its initial moisture content of 50% and no seeds survived desiccation below 20% moisture content. Also storage of *S. cumininii* seeds with it is initial moisture content stored better at 16^0 C than at 25^0 C, but could not survived after 12 week of storage (Thomsen 1998).

Also according to Thomsen (1998), the seeds of *Vochysia guatemalensis* Aubl. with initial moisture content of 26% and germination of 99% dried to 12, 10, 7 and 2% moisture content gave germination of 95, 93, 90 and 84 respectively. At 5^0 C germination was 58, 61, 76 and 41%. Those stored at 15^0C germination was 13, 49, 86 and 77%. Seeds did not survive at -17^0C and only1% germination was attained for 2% moisture content. Thomsen (1999) also reported the drop in germination percent after desiccation of *Warbugia salutaris* (Bertol.f.) Chiov. seeds from initial of 46% moisture (germination 86%) to 84, 82, 70, 55, 45 and 25% germination for 18, 16, 13, 12, 10 and 7% moisture content respectively.

Various studies conducted on storage of recalcitrant seeds showed very short duration by which seeds can be stored without a significant loss of viability. Kumar and Bangarwa (1996) recorded good germination of *Azadirachta indica* A. Juss. seed after storage for 60 days at 4^0C in cloth bags with its initial moisture content of 30%. Another study by Msanga (1996) on the same species, seeds were dried from 38 to 25 and 15% moisture content and stored for 8 weeks gave germination of 90, 72 and 62% and 36, 33 and 29% for unstored and stored seeds respectively. Richard *et al.* (1998) observed storage of *Syzygium cuminii* to be possible for only 2 months under hydrated storage at 16^0C. The study by Ngulube and Mkandawire (1997) revealed possibility of storing seeds of *Uapaca kirkiana* up to 2 months and achieved germination of 52%, if packed in cloth bags and stored at 8^0C with initial moisture content of 43%.

However another study by Msanga *et al.* (1999b) showed that *Uapaca kirkiana* seeds with 50% moisture content and germination of 76% desiccated to 40, 30, 20, 10, 8 and 5% moisture content had germination of 60, 56, 48 and 8 % respectively. No seed survived desiccation below 10% moisture content. After 2 weeks storage, germination was highest (66%) with moisture content of 50%. After 8 weeks storage the highest germination (40%) was also found in seeds stored at the same conditions.

while the seeds, which were stored at 4, and 25^{0}C had germination of 28 and 8% respectively. The effect of packaging materials observed from the same studies revealed the highest storage period of 5 months to be attained by seeds stored at 16^{0}C with 50% moisture content in polyethylene bags, while the lowest storage period (3 months) was observed in seeds stored at 25^{0}C in aluminum foil bags.

Other studies have shown a dramatic loss of viability on storage of recalcitrant species. A study by Msanga *et al.* (1999a) on *Sorindeia madagascariensis* revealed a remarkable drop in initial germination of 86% after storage for four weeks at 25, 16 and 4^{0}C with 43% moisture content. After 2 weeks storage germination was highest (47%) in seeds stored at 25^{0}C with 30% moisture content. After 4 weeks of storage the best survival (34%) was obtained in seeds stored with 43% moisture content at 25^{0}C and lowest germination in seeds stored with 20% moisture content at 16^{0}C. The best germination obtained at higher storage temperature (25^{0}C) match better with other studies by Chin and Roberts (1980) on some tropical species with recalcitrant seeds, which are susceptible to chilling injury at low temperature (10 to 15^{0}C).

2.4.2 Orthodox and Intermediate seed species

Orthodox seeds are tolerant to desiccation and therefore seed moisture content and temperature are the factors most critical to longevity in storage. Further more, they desiccate naturally on the mother plant. They can also be dried to low moisture content without harm and the lower the moisture content and temperature the longer they survive (Chin, 1990).

According to Schmidt (2000) most orthodox seed can be stored safely for at least one to two years at moisture content of 8-10% or below and potential storage period is prolonged by cold storage. The longevity of orthodox seeds can be manipulated dramatically by selecting widely different storage environment so much that long-term seed storage is possible. Consequently decrease in seed moisture content and storage temperature increase seed longevity in a predictable way (Ellis and Roberts, 1980). According to FAO/IPIGRI (1994), at -18^0C with 3-7% moisture content it is possible to store seed in gene banks.

Based on extensive research with seeds of numerous crop species, Ellis and Roberts (1980) have proposed the following equation to quantify the relationship between temperature, moisture content, and seed longevity in storage:

$$V = Ki - P/10K_E - C_W Log_{10}{}^m - C_H t - C_Q t^2$$

V = probit of percent viability after P days

m = seed storage moisture content at t^0C

K = is probit of initial seed lot viability

$K_{E.}$ $C_{W.}$ C_H and C_Q are species constants

Once the constants have been determined, viability retention for a species can theoretically be predicted for any reasonable period of storage in a wide range of environments.

Ellis *et al.* (1990) observed that there are groups of species, which can be dried, to moisture content low enough to qualify as orthodox, but due to they sensitive to a low temperature they are termed intermediate species. Evidence exists of some species, which are intermediate between orthodox and recalcitrant. The study by Robbins (1998) on storage of Champ (*Michelia champaca* L.), revealed the seeds to have some orthodox and some recalcitrant characteristics. It was possible to store seeds under moist storage for at least 7 months, at 5^0C or for at least 4 months in a pit, at about 13^0C. Ellis *et al.*, (1992) revealed that papaya (*Carica papaya* L.) to be intermediate for desiccation tolerance between orthodox and recalcitrant, exhibiting signs of desiccation stress at moisture content < 8%. However, according to Magill *et al.*, (1994) and Wood *et al.*, (2000), some seed lots of papaya survived desiccation to 5% moisture content.

The information about storage behaviour for *C. africana, C. densiflora, S. cocculoides* and *S. spinosa* is very scanty. Msanga (1998) reported *S. cocculoides* and *S. spinosa* to be intermediate between orthodox and recalcitrant, but nothing is mentioned on appropriate storage conditions. Likewise Mbuya *et al.* (1994), pointed out that the seed of *S. spinosa* and *S. cocculoides* have hard seed coats which can be stored, but also he didn't specify storage conditions. It is therefore crucial, to determine appropriate storage condition and desiccation tolerance for these indigenous fruit trees.

CHAPTER 3

3. MATERIALS AND METHODS

Fruits were collected from Iringa and Moshi. Laboratory experiments were conducted in Morogoro at the National Tree Programme (NTSP) (at $6^0 50'$S, $37^0 39'$E), which is located along the Dodoma highway about 5 km from Morogoro town, Tanzania.

3.1 Fruit collection and processing

Ripe fruits of *Cordyla africana, C. densiflora, Strychnos cocculoides* and *S. spinosa* which physically appeared to have no damage were be picked by hand from the crown of 30 trees per species (Table 1). *Strychnos cocculoides* and *S. spinosa* were collected from 23 to 25 November 2000, while *Cordyla densiflora* were collected from 14 to 15 December 2000 and *C. africana* were collected from 9 to 10 February 2001. After collection, the fruits were immediately transported to Morogoro for extraction and experimentation.

For *C. africana* and *C. densiflora,* fruits were extracted by removing pulp and skin using a brash and seeds washed in water, whereas S. *cocculoides* and *S. spinosa* fruits were first cracked with a piece of wood, the pulp scooped out by hand, the seeds squeezed out, collected in plastic bucket and poured in a concrete mixer containing a mixture of sand and gravels (2-3 cm diameter) in a ratio of 3:1. The concrete mixer was run for about half an hour, and then clean seeds were separated by floatation whereby the pulp and empty seeds that floated on water were discarded. Filled seeds that sunk to the bottom were retained and spread in thin layers on the wire mesh trays in the shade for one day to dry surface water.

Table 1. A summary of description of sites from where fruits were collected.

Species	Site	Vegetation type	Location			Rainfall (mm/yr)
			Longitude (E)	Latitude (S)	Altitude (m a.s.l.)	
C. africana	Rau F.R in Moshi	Riverine forest	$37^0 22'$	$3^0 23'$	750	870
C. densiflora	Mtandika F.R in Mahenge, Iringa	Acacia commifora wood land	$35^0 45'$	$6^0 10'$	1130	538
S. cocculoides *S. spinosa*	Kwatanga F.R in Iringa	Miombo woodland	$34^0 46'$	$8^0 23'$	1240	900

3.2 Climate, vegetation and soils

3.2.1 *Cordyla africana*

Fruits of *C. africana* were collected from Rau Forest Reserve situated on the southern slopes of mount Kilimanjaro in Moshi municipality, 3 km southeast from Moshi Township. The climate of the area is characterized by oceanic rainfall with continental temperatures. The average rainfall is 870 mm/year and the hot season (January-February) has a mean maximum temperature of $+34^0$ C and the cold season (June-August) has its mean minimum temperature of $+25^0$ C. The soils are dominantly loam developed on young rocks of volcanic origin. The soils are fluvisoils and nutrient rich gleysols on alluvial sand (Falck and Roponen, 1994).

Vegetation of Rau Forest Reserve is mainly riverrine forest. The dominant species are *Rauvolfia caffra, Voacanga africana, Tabenaemontana ventricosa, Saba comorensis, Markhamia platycalyx, Kigelia africana, Cordia africana, Ipomea sp, Macaranga kilimandscharica, Albizia schimperiana, Newtonia buchananii, Oxystigma msoo, Khaya anthotheca, Ficus exasperata, Ficus syncomorus, Milicia excelsa, Flacortia indica, Trichilia emetica, Vangueria madagascariensis* and *Trema orientalis*.

3.2.2 *Cordyla densiflora*

Fruits of *C. densiflora* were collected from Mahenge village in Iringa rural District about 70 km for Iringa town. The climate of the area is characterized by unimodal rainfall pattern with the rainfall season starting in November through April. Dry season is from May to late October. The mean annual rainfall is 500 mm. The temperature of the area is isohyperthermic (21 to 30^0C). Soils are read loams and alluvial clay (chromic cambisol, eutric fluvisol) (FAO, 1983).

The main vegetation types are Acacia woodland and Commifora thickets. The dominant species include, *Acacia nigrescens, A. Senegal, A. tortilis, Adansonia digitata, Albizia amara, A. harvey, Commifora africana, C. ugogoensis, Delonix elata, Entandrophragma bussei, Euphorbia candelobram, Lonchocarpus capassa,* and *Xeroderris stuhlmanii*.

3.2.3 *Strychnos cocculoides and S. spinosa*

Strychnos cocculoides and *S. spinosa* fruits were collected in Kwatanga in Mufindi District in Iringa, about 160 km northeast from Iringa town. The climate of the area is characterized by one long rainfall normally from February to May. The average rainfall is 900 mm/year. Temperatures are isothermic ranging from 15^0 C to 26^0 C. The soils are yellow and sands (cambic arenosol).

The main vegetation type is dorminated by miombo, the main species are: *Afzelia quanzensis, Brachystegia boehmiii, B. spiciformis, Combretum collinum, C. molle, C. zeyheri, Julbernadia globiflora, Pericopsis angolensis, Terminalia sericea, Vitex ferruginea, Parinari curateliflolia* and *V. mombassae.*

3.3 Experimental design and treatment

For each species, three trials were carried out i.e. initial trial, seed desiccation sensitivity and storage.

3.3.1 Seed desiccation sensitivity

For each species, a Randomised Complete Block Design (RCBD) with four replications was used. Treatments were different target moisture content of seed to be attained after desiccation, i.e. initial seed moisture content, and 75, 50, 25 and 12.5% of initial moisture content (Table 2).

Table 2 Target moisture content for *C. africana*, *C. densiflora*, *S. cocculoides* and *S. spinosa* seed

Species	Target moisture content (% of initial moisture content				
	Initial	75	50	25	12.5
C. africana	50	38	25	13	8
C. densiflora	54	41	27	14	10
S. cocculoides	43	32	22	11	5
S. spinosa	41	31	21	10	5

3.3.2 Seed storage

One storage experiment was conducted for each species to test the effect of seed moisture content, storage temperature and container material on seed germination and seed vigour. A 5 x 4 x 3 factorial experiment with four replications was conducted for each species. Factor one was moisture contents at five levels i.e. initial moisture content and 75, 50, 25 and 12.5% of initial moisture content. Factor two was storage temperature at four levels, -20, 4, 16 and 25^0 C and factor three was packaging materials at three levels, polyethylene bags (gauge 500), cotton cloth bags and punched aluminum foil bags of size 22x30 cm with 8 punch holes.

3.4 Experimental establishment and management

3.4.1 Determination of fruit and seed dimensions and initial moisture content of seed

3.4.1.1 Fruit and seed dimensions

Fresh fruit and seed dimensions i.e. width and length were determined by measuring 1000 fruits and seeds using a small caliper. Number of seeds and fruits per kilogram were determined by weighing four replicates of fresh 1000 fruits and seeds by using a laboratory weighing scale as elaborated in ISTA (1993).

3.4.1.2 Seed moisture content and application of fungicide

For each species, the initial moisture content and moisture content after storage on fresh weight basis (fwb) of the components of the seed were determined for seed coat and embryo (cotyledons and embryonic axis) by the low constant temperature 103^{0}C for 17 hours method (ISTA, 1993). For all species and all treatments, 100 grams of seed was grinded using meat mincer and two samples of approximately 20 grams each were drawn for moisture content determination. Means of two samples were calculated. When the difference between two samples exceeded the tolerance level of 2.5 % set by Bonner (1984) (Table 3), the moisture content determination was repeated.

Before seed storage, for all species and all treatments, seeds were dusted with fungicide Gamoxone® (2, 3 - dichlro - 1, 4 - napthoquinone) in their respective storage material (polyethylene bags (gauge 500), cotton cloth bags and punched aluminum foil bags of size 22x30 cm with 8 punch holes. This was done to prevent fungi attack which is big problem in the tropics (Mereno and Ramirez, 1985).

Table 3 Tolerance levels for differences between two measurements in determination of moisture contents

Class	NPK	Initial MC%	Tolerance %
Small seeds	> 5000	< 12	0.3
Small seeds	> 5000	> 12	0.5
Large seeds	< 5000	< 12	0.4
Large seeds	< 5000	12 – 25	0.8
Large seeds	< 5000	> 25	2.5*

* Tolerance level used

NPK: Number of clean seed per kg; MC: Moisture content

Source: Bonner (1984)

3.4.2 Initial germination

For all species i.e. *C. africana*, *C. densiflora*, *S. cocculoides* and *S. spinosa*, the initial germination test before seed desiccation and storage trials was carried out in clean sand, which passed through 0.8 mm sieve and retained on a 0.05 mm sieve as specified by ISTA (1993). Each plot consisted of 25 seeds in four replicates, in plastic bowl of 20cm diameter and 8cm depth. Seeds were distributed on top of the sand without touching each other and then covered with sand to uniform depth of 2 cm for *C. africana* and *C. densiflora* and 1 cm for *S. cocculoides* and *S. spinosa.* Water was applied manually to maintain moist medium all the time without becoming waterlogged. The bowls were kept in germination room with continuous artificial daylight and ambient temperature (25-30^{0}C). All seed viability estimates were subsequently related to this initial seed germination percent.

3.4.3 Seed desiccation sensitivity trials

Seed desiccation sensitivity was carried out for each species at 25^{0}C using silica gel according to the International Plant Genetic Resources Institute (IPGRI) screening protocol for recalcitrant and intermediate tropical forest tree seeds (Ouedraogo, 1996). The procedure was as follows:

- Seeds were desiccated by mixing them with equal amount of silica gel and enclosed in plastic bags (gauge 500), that is a separate bag for each desiccation time.
- Bags were placed under ambient temperature of 25^{0}C.
- A control stock of seed was maintained at the initial moisture content to determine if the time factor affects the results. This was achieved by placing fresh seed in similar containers with vermiculite in place of the silica gel.
- The silica gel was changed as required and always in all bags at the same time.
- Seeds were aerated by mixing them twice daily to avoid anoxia, as well as when weighing and changing silica gel.

- Loss of water was monitored periodically by weighing seeds (seeds were sieved to remove silica gel prior to weighing) and the duration of drying was noted. The frequency of this monitoring was higher in the beginning but was reduced thereafter.
- Seeds were dried to achieve target moisture content (TMC).
- The target weight for the seed batch from each plastic bag was calculated as indicated in equation 1 below.
- A sample of 4 replicates of 25 seeds was drawn from each treatment and tested for germination as described above.
- Aeration and sampling of controls were done simultaneously with the seed undergoing desiccation.

$$\text{*Weight of seed (g) at TMC} = \frac{100 - \text{IMC}}{100 - \text{TMC}} \times \text{Initial seed weight (g)} \text{ -------- equation 1}$$

IMC = Initial moisture content

TMC = Target moisture content

*Adapted from Ouedraogo (1996)

3.4.4 Storage trials

For each species, seeds were mixed with vermiculite and placed in three packaging materials (cotton cloth bags, aluminum foil and polyethylene bags – gauge 500) and stored at –20, 4, 16 and 25^{0}C at five moisture content levels i.e. initial moisture content, 75, 50, 25 and 12.5% of initial moisture content (Table 2). Samples of 4 replicates of 25 seeds were drawn from each treatment and tested for germination at

2, 4, 8 and 20 weeks after seed placement. Germination test was carried out in sand (ISTA 1993) as described in section 3.4.2.

3.5 Assessment of experiments

3.5.1 Germination counts

For all trials, germination for all species was recorded daily until no further germination occurred. The criterion for germination was visible protrusion of leaves for *C. africana* and *C. densiflora* or cotyledons for *S. cocculoides* and *S. spinosa* on the surface of the sand.

3.5.2 Cumulative germination

For all species, data for cumulative germination were recorded daily till termination of experiment.

3.5.3 Germination phases

For all species, the imbibition period (the number of days from sowing to commencement of germination) and the total germination period (the number of days from sowing to completion of germination) were recorded. These values were used to determine the time between commencement and completion of germination.

3.5.4 Viability test

At the termination of each experiment, all ungerminated seeds for all species were tested for viability by cutting test. The number of viable seeds and nonviable seeds were recorded for every treatment.

3.5.5 Seed vigour test

(a) Radicle elongation

Radicle elongation, germination energy and germination value were used to determine seed vigour for all treatments. For each species and for all treatments, seed vigour was determined by germinating 10 seeds in four replicates in a germination cabinet supplied continuously with artificial illumination with temperature controlled at 25^0 C and 30^0 C at night and day respectively. The seeds were placed 2 cm apart on a moist blotter paper, moistened with deionised water between 2 thin glass plates (30 cm x 10 cm) held together by elastic bands.
Seeds were inspected daily. The length of radicle from the point of attachment with the seed to the tip was measured to the nearest millimeter with a ruler at 4, 6, 8, 12, 16 and 20 days after sowing for *C. africana* and *C. densiflora* and 8, 12, 16, 20 and 24 days for and *S. cocculoides*, *S. spinosa*. Seed vigour was recorded as final radicle extension expressed in mm per total days of elongation.

(b) Germination energy and germination value

Germination energy and germination values were calculated as indicated in appendix 1 Germination energy which is a measure of germination speed and hence expresses the vigour of the seed and of the seedling it produces as suggested by Aldhous (1972) that those seeds that germinate rapidly and vigorously under the favorable conditions of the laboratory to be capable of producing vigorous seedlings in field conditions.

3.6 Data analysis

3.6.1 Germination percent, germination energy radicle elongation and germination value

On each assessment, the number of germinated seeds for all species were expressed as percentage of all seeds sown per plot. The germination energy, defined as the germination percentage when the mean daily germination (cumulative germination percentage divided by the time elapsed since sowing date) reaches peak, were also determined for all treatments. In addition, germination value (GV), which is a composite value, which combines both germination speed and total germination and provides an objective means of evaluating the results of germination test were calculated for all treatments using the formula of.Djanshir and Poubeik (1976):

GV = ($\sum$DGS/N) GP/10

Where:

GV = Germination value

GP = Germination percent at the end of the test

DGS = Daily germination speed, obtained by dividing the cumulative germination percent by the number of days since sowing

$\sum$DGS = The total obtained by adding every DGS figure obtained from the daily germination counts

N = the number of daily counts, starting from the date of first germination

10 = Constant

3.6.2 Statistical analysis

For each species, plot means and standard error for final cumulative germination and daily germination percentages and final radicle elongation for five levels of moisture content for unstored and undesiccated seeds were calculated and used as basis for comparisons for stored and desiccated seeds respectively.

Prior to analysis of variance (ANOVA), percentage data (mean daily germination and final germination percent) were transformed into arc sine values to normalise data as suggested by Webster and Oliver (1990). For all treatments and each species, ANOVA of 5 x 4 x 3 factorial design in a Randomized Complete block Design (RCBD) for daily and final cumulative germination percent as well as final radicle elongation after storage were performed using General Linear Models (GLM) procedure of SAS (SAS, 1991). Mean and standard deviation were calculated for each treatment and where significant differerence were observed treatment were declared to be significantly different at $P \leq 0.05$. Dancan's Multiple Range test (Gomez and Gomez, 1983) was used for separation of significantly different treatment means.

CHAPTER FOUR

4. RESULTS

4.1 Fruit and Seed dimension

For *C. africana*, the fruits were egg shaped width, ranged from 2.4 to 4.2 cm with mean of 3.6 cm, length ranged from 2.9 to 5.7 cm with mean of 4.5 cm. The seed width ranged from 1.4 to 2.2 cm with mean of 1.8 cm and length ranged from 2.3 to 3.3 with mean of 2.7 cm (Table 4). Number of seed per kilogram for *C. africana* was 240. For *C. densiflora*, fruits were egg shaped, width ranged from 3.5 to 5.7 cm with mean of 4.5 cm, length ranged from 3.2 to 6.5 cm with mean of 5.5 cm .The seed width ranged from 1.8 to 2.9 cm with mean of 2.2 cm and length ranged from 3.1 to 4.1 with mean of 3.6 cm. Number of fresh seed per kilogram for *C. densiflora* was 200 seed (Table 4).

For *S. cocculoides* fruits were spherical with a diameter ranging from 6 to 13 cm with mean of 10 cm. The seed had width ranging from 0.8 to 1.2 cm with mean of 1.0 cm, length ranged from 1.1 to 1.5 cm with mean of 1.3 cm, and there was 2,500 fresh seed per kilogram and each fruit contained an average of 38 seeds (Table 4).

Fruits of *S. spinosa* were also spherical with a diameter ranging from 8 to 15 cm with mean of 12 cm. The seed width ranged from 0.7 to 1.1 cm with mean of 0.9 cm, length ranged from 0.6 to 1.9 cm with mean of 1.2 cm, there was 3,250 seed per kg and each fruit contained an average of 60 seeds (Table 4)

Table 4 Fruit and seed *dimension for C. africana, C. densiflora, S. cocculoides* and *S. spinosa*

	Dimensions *	Species			
		C. africana	*C. densiflora*	*S. cocculoides*	*S. spinosa*
Fruit	MW (cm)	3.6± 0.77	4.5± 0.94	10± 3.16	12± 2.87
	ML (cm)	4.5± 0.84	5.5± 1.20	10±1.83	12± 2.87
	NPK	30± 1.05	25± 0.94	9± 1.05	9± 0.94
Seed	MW (cm)	1.8± 0.3	2.2± 0.46	1.0± 0.15	0.9± 0.13
	ML (cm)	2.7± 0.33	3.6± 0.3	1.3± 0.14	1.2± 0.10
	NPK	240± 0.82	200± 1.33	2500± 2.45	3250± 1.76
	NSF	2± 0.00	1 - 2± 0.00	38± 1.15	60± 1.49

* Means of 1000 seed/fruit ± standard error

MW = Mean width; ML = Mean length; NPK = number per kilogram, NSF = number of seed per fruit

4.2 Seed moisture content before and after storage

4.2.1 Seed initial moisture content

For *C. africana*, initial moisture contents of seed components i.e. seed coat, embryonic axis and endosperm were 21, 57 and 54% respectively. Overall initial moisture content of all seed components was 50% (Table 5). Corresponding values for *C. densiflora* seed components were 23, 59 and 57% respectively with overall initial moisture content of 54% (Table 5). Corresponding values for *S. cocculoides* seed were 15, 47 and 45% respectively (Table 5) with overall initial moisture content of 43%, while for *S. spinosa* were 13, 45 and 43% respectively with the overall mean of 41% (Table 5).

Table 5 Initial moisture content for *C. africana C. densiflora*, *S. cocculoides* and *S. spinosa* seed.

Species	Seed initial moisture content %			
	Seed coat	Embryonic axis	Endosperm	All components
C. africana	21	57	54	50
C. densiflora	23	59	57	54
S. cocculoides	15	47	45	43
S. spinosa	13	45	43	41

4.2.2 Seed moisture content after storage

4.2.2.1 Un desiccated seeds

For all species (*C. africana, C. densiflora, S. cocculoides* and *S. spinosa*), there was little change in seed moisture content noted after storage for 8 weeks under all storage conditions (Tables 6 a, b, c and d). However storage of these species with its initial moisture content of 50, 54, 43 and 41% respectively in polyethylene bags at 4^0 C retained its moisture up to four weeks then increased slightly by the eighth week but by the 20th week it had dropped (Tables 6 a, b, c and d). Seeds stored with its initial moisture content at 16, 25 and -20^0 C in cotton and aluminum foil showed a slight change in moisture content during the first two weeks of storage. For *C. africana* and *C. densiflora* seeds stored at 16^0 C and -20^0 C in cotton and aluminum foils, moisture contents increased from 50 to 52% and 54 to 56% respectively during this period. On the other hand, *C. africana* seeds stored in aluminum foils at 25^0 C maintained the initial moisture up to four weeks but by the eighth week moisture content had increased but it dropped by the 20th week (Table 6 a).

4.2.2.2 Desiccated seeds

Desiccated seeds for all species showed a remarkable change in moisture content during the 20th week of storage especially for seeds stored at 25^0C in cotton cloth bags. For *C. africana* and *C. densiflora*, seeds desiccated to 38% and 41% and stored at 25^0C in cotton cloth bags had their moisture content reduced to 33 and 36% respectively, while those stored at 4^0C in aluminium foil bags, their moisture content were maintained at 37 and 40% respectively (Tables 6a and b).

Same trend was noted for *S. cocculoides* and *S. spinosa* seeds, where seeds desiccated to 32 and 31% and stored at 25^0C in cotton cloth bags, moisture contents were reduced to 27 and 26% respectively by the 20th week of storage while those stored at 4^0C in aluminium foil bag maintained moisture content of 31 and 30% respectively (Tables 6c and d).

Table 6 a Mean moisture content changes during storage for *C. africana* seed

Temp (^{0}C)	PM	Initial moisture content (%)																								
		50					38					25					13					8				
		0*	2	4	8	20	0	2	4	8	20	0	2	4	8	20	0	2	4	8	20	0	2	4	8	20
4	CT	50	51	51	52	**42**	38	40	40	41	**34**	25	26	26	23	**20**	13	15	15	14	**12**	8	9	9	9	8
	AL	50	51	51	52	**44**	38	39	40	43	**37**	25	27	27	26	**23**	13	17	17	15	**13**	8	10	10	10	9
	PL	50	50	50	51	**43**	38	41	41	42	**35**	25	26	26	24	**21**	13	14	14	14	**12**	8	9	9	9	8
16	CT	50	52	52	53	**44**	38	41	41	42	**35**	25	25	25	24	**23**	13	14	14	14	**12**	8	9	9	9	8
	AL	50	52	52	52	**48**	38	40	41	43	**36**	25	26	26	25	**24**	13	16	16	15	**13**	8	8	8	8	8
	PL	50	51	51	51	**46**	38	41	41	39	**35**	25	26	26	23	**23**	13	15	15	14	**12**	8	9	9	9	8
25	CT	50	49	49	50	**40**	38	36	36	37	**33**	25	26	26	21	**19**	13	15	15	13	**10**	8	9	9	9	8
	AL	50	50	50	51	**43**	38	37	38	40	**35**	25	27	27	23	**21**	13	17	17	15	**12**	8	10	10	10	9
	PL	50	50	50	51	**42**	38	37	37	39	**34**	25	26	26	22	**18**	13	15	15	14	**11**	8	9	9	9	8
-20	CT	50	51	51	50	**46**	38	40	40	41	**34**	25	25	25	24	**20**	13	14	14	14	**11**	8	9	9	9	8
	AL	50	52	52	51	**48**	38	41	42	42	**35**	25	26	26	26	**24**	13	15	15	15	**12**	8	9	9	9	9
	PL	50	51	51	50	**45**	38	39	39	40	**35**	25	25	25	23	**22**	13	13	13	13	**11**	8	9	9	9	8

*Time after storage (weeks)

Bolded figures along each column separate five levels of moisture content

Temp = Temperature; PM = Packaging material; CT = Cotton cloth bag; AL = Aluminium foil; PL = Polyethylene bag

Table 6 b Mean moisture content changes during storage for *C. densiflora* seed

Temp (^{0}C)	PM	Initial moisture content (%) 50					38					25					13					8				
		0*	2	4	8	**20**	0	2	4	8	**20**	0	2	4	8	**20**	0	2	4	8	**20**	0	2	4	8	**20**
4	CT	54	55	55	56	**46**	41	43	43	44	**37**	27	28	28	25	**22**	14	19	19	18	**12**	10	11	11	11	**10**
	AL	54	55	56	57	**50**	41	42	45	46	**40**	27	29	29	28	**25**	14	21	21	19	**13**	10	12	12	12	**11**
	PL	54	54	54	55	**49**	41	44	44	45	**38**	27	28	28	26	**23**	14	18	18	18	**12**	10	11	11	11	**10**
16	CT	54	55	56	57	**50**	41	44	42	44	**38**	27	27	27	26	**25**	14	18	18	18	**12**	10	11	11	11	**10**
	AL	54	56	57	56	**52**	41	45	44	46	**39**	27	29	28	27	**26**	14	20	20	19	**13**	10	10	10	10	**10**
	PL	54	55	55	55	**50**	41	44	43	42	**38**	27	28	28	25	**25**	14	19	19	18	**12**	10	11	11	11	**10**
25	CT	54	53	53	54	**44**	41	39	39	40	**36**	27	28	28	23	**21**	14	19	19	17	**10**	10	11	11	11	**10**
	AL	54	55	55	56	**47**	41	41	41	43	**38**	27	29	29	25	**23**	14	21	21	19	**12**	10	12	12	12	**11**
	PL	54	54	54	55	**46**	41	40	40	42	**38**	27	28	28	24	**20**	14	19	19	18	**11**	10	11	11	11	**10**
-20	CT	54	56	55	54	**50**	41	43	43	44	**37**	27	27	27	26	**22**	14	18	18	18	**11**	10	11	11	11	**10**
	AL	54	57	56	55	**52**	41	44	45	45	**38**	27	28	28	28	**26**	14	19	19	19	**12**	10	11	11	11	**11**
	PL	54	55	55	54	**49**	41	42	42	43	**38**	27	27	27	25	**24**	14	17	17	17	**11**	10	11	11	11	**10**

*Time after storage (weeks)

Bolded figures along each column separate five levels of moisture content

Temp = Temperature; PM: Packaging material; CT: Cotton cloth; AL: Aluminium foils; PL: Polyethylene bag

Table 6 c Mean moisture content changes during storage for *S cocculoides* seed

Temp (^{0}C)	PM	Initial moisture content (%) 50					38					25					13					8				
		0*	2	4	8	**20**	0	2	4	8	**20**	0	2	4	8	**20**	0	2	4	8	**20**	0	2	4	8	**20**
4	CT	43	44	44	45	**35**	32	34	34	35	**28**	22	23	23	20	**17**	11	13	13	12	**10**	5	9	7	7	**6**
	AL	43	44	44	45	**34**	32	33	34	37	**31**	22	24	24	23	**20**	11	15	15	13	**11**	5	8	8	8	**7**
	PL	43	43	43	44	**36**	32	35	35	36	**29**	22	23	23	21	**18**	11	12	12	12	**10**	5	7	7	7	**6**
16	CT	43	45	45	46	**37**	32	35	35	36	**29**	22	22	22	21	**20**	11	12	12	12	**10**	5	7	7	7	**6**
	AL	43	45	45	45	**41**	32	34	35	37	**30**	22	23	23	22	**21**	11	14	14	13	**11**	5	6	6	6	**6**
	PL	43	44	44	44	**39**	32	35	35	33	**29**	22	23	23	20	**20**	11	13	13	12	**10**	5	7	7	7	**6**
25	CT	43	42	42	43	**33**	32	30	30	31	**27**	22	23	23	18	**16**	11	13	13	11	**8**	5	7	7	7	**6**
	AL	43	43	43	44	**36**	32	31	32	34	**29**	22	24	24	20	**18**	11	15	15	13	**10**	5	8	8	8	**6**
	PL	43	43	43	44	**35**	32	31	31	33	**28**	22	23	23	19	**15**	11	13	13	12	**9**	5	7	7	7	**6**
-20	CT	43	44	44	43	**39**	32	34	34	35	**28**	22	22	22	21	**17**	11	12	12	12	**9**	5	7	7	7	**6**
	AL	43	45	45	44	**41**	32	35	36	36	**29**	22	23	23	23	**21**	11	13	13	13	**10**	5	7	7	7	**7**
	PL	43	44	44	43	**38**	32	33	33	34	**29**	22	22	22	20	**19**	11	11	11	11	**9**	5	7	7	7	**6**

*Time after storage (weeks)

Bolded figures along each column separate five levels of moisture content

Temp = Temperature; PM: Packaging material; CT: Cotton cloth; AL: Aluminium foils; PL: Polyethylene bag

Table 6 d Mean moisture content changes during storage for *S. spinosa* seed

Temp (^{0}C)	PM	Initial moisture content (%)																								
		50					38					25					13					8				
		0*	2	4	8	20	0	2	4	8	20	0	2	4	8	20	0	2	4	8	20	0	2	4	8	20
4	CT	41	43	42	43	**33**	31	32	33	34	**27**	21	22	22	19	**16**	10	12	12	11	**9**	5	8	6	6	**5**
	AL	41	42	42	43	**32**	31	31	33	36	**30**	21	23	23	22	**19**	10	14	14	12	**10**	5	7	7	7	**6**
	PL	41	41	41	42	**34**	31	33	34	35	**28**	21	22	22	20	**17**	10	11	11	11	**9**	5	6	6	6	**5**
16	CT	41	43	43	44	**35**	31	33	34	35	**28**	21	21	21	20	**19**	10	11	11	11	**9**	5	6	6	6	**5**
	AL	41	43	43	43	**39**	31	32	34	36	**29**	21	22	22	21	**20**	10	13	13	12	**9**	5	5	5	5	**5**
	PL	41	42	42	42	**37**	31	33	34	32	**28**	21	22	22	19	**19**	10	12	12	11	**9**	5	6	6	6	**5**
25	CT	41	40	40	41	**31**	31	28	29	30	**26**	21	22	22	17	**15**	10	12	12	10	**7**	5	6	6	6	**5**
	AL	41	41	41	42	**34**	31	29	31	33	**28**	21	23	23	19	**17**	10	14	14	12	**9**	5	7	7	7	**5**
	PL	41	41	41	42	**33**	31	29	30	32	**27**	21	22	22	18	**14**	10	12	12	11	**8**	5	6	6	6	**5**
-20	CT	41	42	42	41	**37**	31	32	33	34	**27**	21	21	21	20	**16**	10	11	11	11	**8**	5	6	6	6	**5**
	AL	41	43	43	42	**39**	31	33	35	35	**28**	21	22	22	22	**20**	10	12	12	12	**8**	5	6	6	6	**6**
	PL	41	42	42	41	**36**	31	31	32	33	**28**	21	21	21	19	**18**	10	10	10	10	**8**	5	6	6	6	**5**

*Time after storage (weeks)

Bolded figures along each column separate five levels of moisture content

Temp = Temperature; PM: Packaging material; CT: Cotton cloth bag; AL: Aluminium foils; PL: Polyethylene bag

4.3 Seed desiccation sensitivity

4.3.1 Time taken to reach target moisture content

For *C. africana* seeds, critical moisture content of 13% was reached after desiccation for 16 days. It took 22 days of drying to reach the lowest moisture content of 8% (Table 7a). For this species, there was no seed that withstood desiccation below 8% moisture content. For *C. densiflora* seed, the critical moisture content of 10% was reached after desiccation for 18 days (Table 7a). For S.*cocculoides* and S. *spinosa* critical moisture content of 5% was attained after desiccation for 8 and 18 days respectively. For both species, there was no seed that withstood desiccation below 5% moisture content (Table 7b).

4.3.2 Desiccation sensitivity

4.3.2.1 Daily and final germination percent

For *C. africana* and *C. densiflora*, moisture content significantly ($P< 0.05$) influenced daily germination percent (Table 8), daily germination percent was higher at the higher moisture content (Figure 1). With exception of *S. spinosa* which had highest daily germination of 43% at 32 days after sowing, all other species had higher daily germination at later stages of germination. For *C. africana* seed with 13% moisture content, had the maximum daily germination of 35%, attained at 22 days after sowing.

Table 7a Effect of seed desiccation on final germination and radicle elongation for *C. africana* and *C. densiflora* seed

TMC (%)	TTMC (Days)	Seed status	FG (%)	RE (mm)
	C. africana			
50	0	Fresh	95±2.89	20.00±2.16
38	1	Desiccated	90±3.54	18.00±1.41
		Control	93±0.82	19±1.82
25	11	Desiccated	85±5.40	14.00±1.15
		Control	90±0.82	18.50±1.67
13	16	Desiccated	80±4.08	12.40±1.03
		Control	88±0.82	19.90±1.75
8	22	Desiccated	50±17.32	10.00±0.41
		Control	78±1.63	17.00±2.00

C. densiflora

TMC (%)	TTMC (Days)	Seed status	FG (%)	RE (mm)
54	0	Fresh	95±2.89	44.50±1.89
41	2	Desiccated	90±4.08	40.00±1.41
		Control	90±4.08	44.10±1.85
27	10	Desiccated	77.5±4.79	38.50±0.96
		Control	87.5±2.50	42.60±1.93
14	15	Desiccated	72.5±4.79	26.00±1.15
		Control	85±2.89	42.00±1.32
10	18	Desiccated	65±5.00	15.00±1.08
		Control	82.5±4.79	38.00±1.02

* Means of four replications followed by the standard error

TMC: Target moisture content; TTMC: Time to reach target moisture content; FG: final germination percent; RE: Radicle elongation.

Table 7 b Effect of seed desiccation on final germination and radicle elongation for *S. cocculoides* and *S. spinosa* seed

TMC (%)	TTMC (Days)	Seed status	FG (%)	RE (mm)
	S. cocculoides			
43	0	Fresh	89±3.42	54.00±2.12
32	1	Desiccated	88±0.82	52.00±1.41
		Control	89±1.08	53.87±1.38
22	3	Desiccated	85.5±4.72	50.05±2.00
		Control	88±1.63	53.50±1.67
11	5	Desiccated	85.25±3.50	48.00±0.91
		Control	87±1.22	51.95±1.92
5	8	Desiccated	79±1.29	46.25±1.93
		Control	84±2.45	51.50±1.55

S. spinosa

TMC (%)	TTMC (Days)	Seed status	FG (%)	RE (mm)
41	0	Fresh	97±3.00	48.50±0.84
31	1	Desiccated	93±1.91	47.00±1.78
		Control	97±1.78	48.20±1.37
21	7	Desiccated	92±1.41	44.75±1.11
		Control	96±1.47	47.95±1.72
10	13	Desiccated	92±1.41	42.00±1.47
		Control	95±2.04	47.50±1.65
5	18	Desiccated	90±2.00	38.00±1.41
		Control	95±2.04	47.12±1.22

* Means of four replications followed by the standard error

TMC: Target moisture content; TTMC: Time to reach target moisture content; FG: germination percent; RE: Radicle elongation.

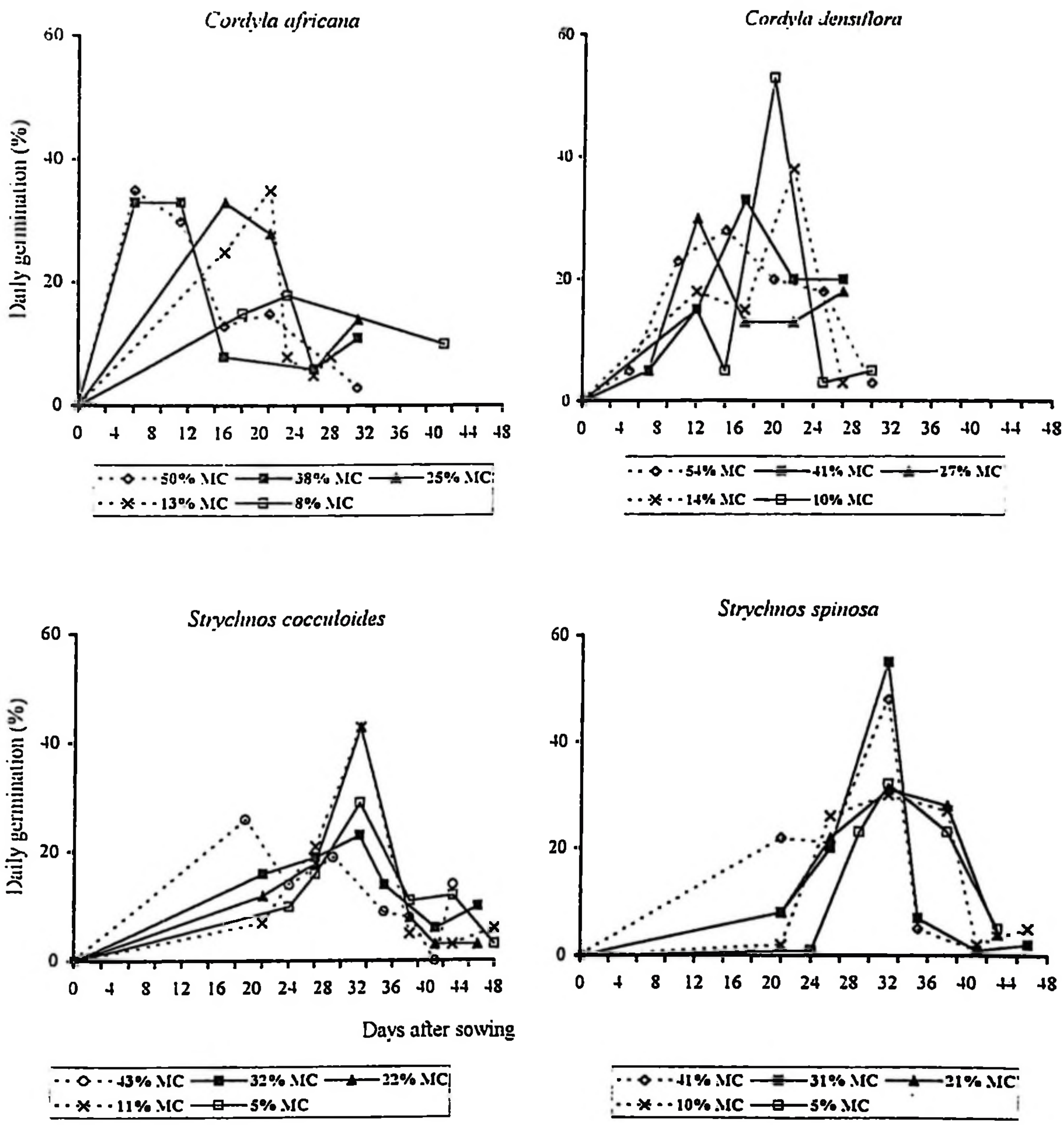


Figure 1. Effect of desiccation on daily germination percent of *C. africana, C. densiflora, S. cocculoides* and *S. spinosa seed*

whilst for *C. densiflora* seed moisture content of 10% gave maximum of daily germination of 53% attained after 21 days from sowing (Figure 1). For *S. cocculoides*, highest daily germination of 43% was recorded at 32 days after sowing for seeds stored at 11% moisture content (Figure 1). Generally, decrease in moisture content delayed attainment of maximum daily germination percent for both *C. africana* and C. *densiflora* while for *S. cocculoides* and *S. spinosa* higher moisture content resulted in earlier daily germination (Figure 1).

For both *C. africana* and *C. densiflora*, moisture content significantly ($P<0.05$) influenced final cumulative germination percent (Table 8). Desiccation steadily reduced final cumulative germination of the seeds (Figure 2). For *C. africana* and *C. densiflora*, desiccation period (Tables 7 a and b Figures 3 and 4) contributed to the aging of the seed and therefore contributed to the loss in viability of desiccated as well as the un desiccated seeds.

Final cumulative germination percent of *S. cocculoides* and *S. spinosa* seed was not significantly ($P>0.05$) affected by the desiccation. They maintained higher cumulative germination of 79 and 90 % respectively at lowest moisture content of 5% (Table 8).

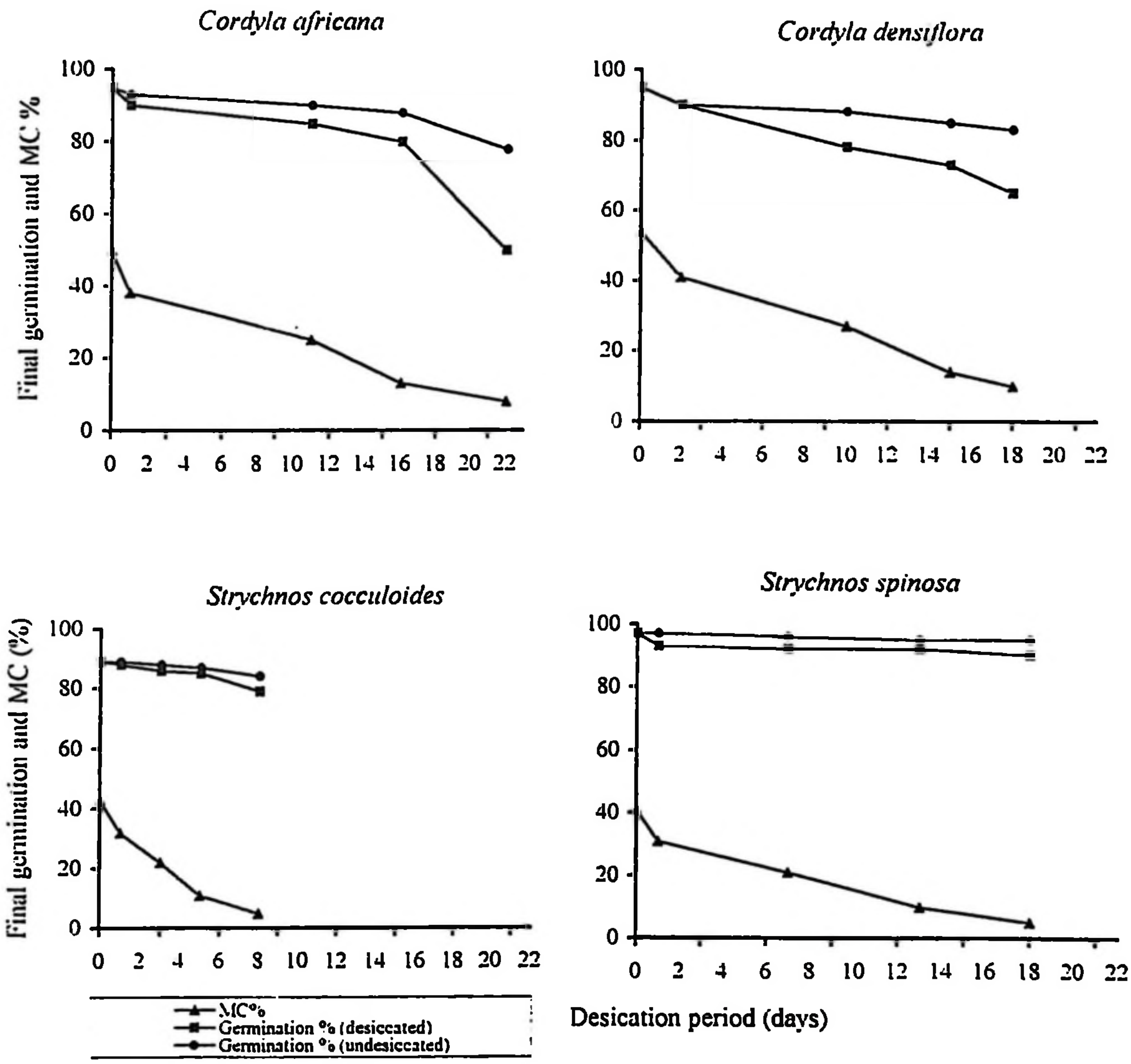


Figure 2 Effect of desiccation on final cumulative seed germination of *C. africana*, *C. densiflora*, *S. cocculoides* and *S. spinosa* seed

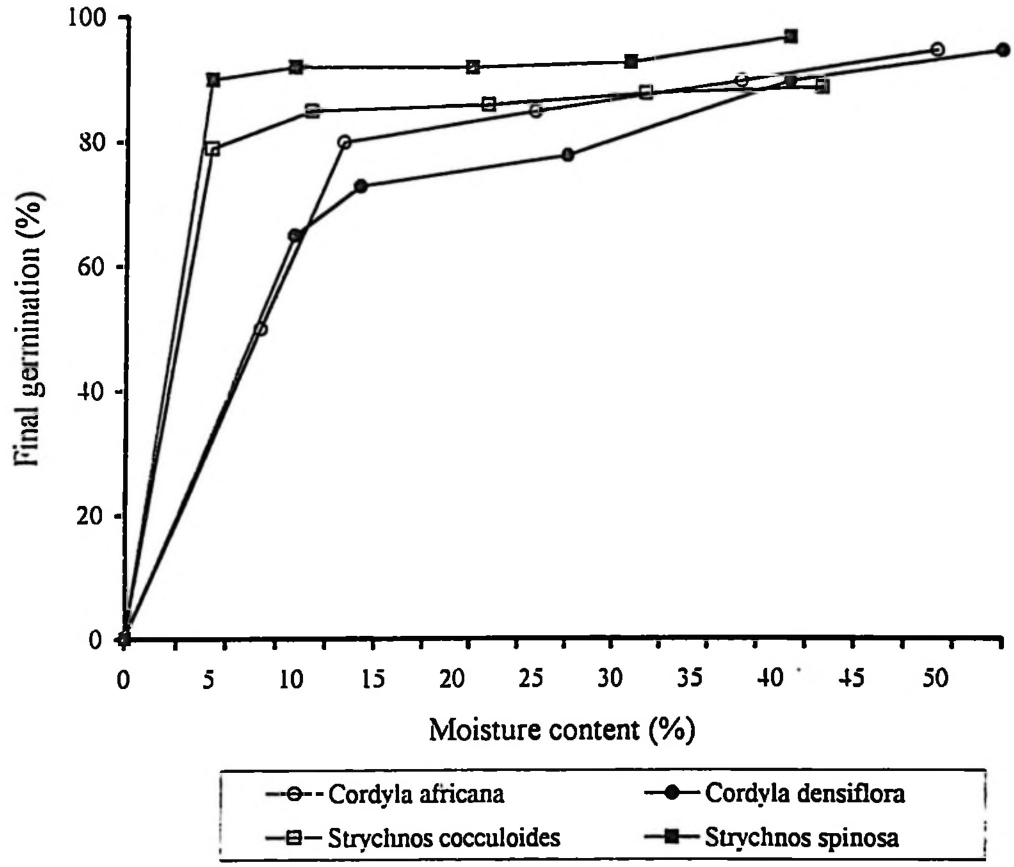


Figure 3 Relationship between final cumulative germination and moisture content of *C. africana, C. densiflora, S.cocculoides* and *S. spinosa* seeds.

4.3.3 Effect of desiccation on seed germination period, germination value, germination energy and radicle elongation

All species (*C. africana, C. densiflora, S. cocculoides* and *S. spinosa*), showed similar pattern of imbibition period. Imbibition period was shorter for un-desiccated seeds and longer for desiccated seeds with lowest moisture content (Table 8). For *C. africana*, shortest imbibition period of 6 days and highest germination value of 43.84 were attained for seeds with moisture content of 50%, while longest imbibition period of 23 days and lowest germination value (5.25) were attained for seeds with moisture content of 8% (Table 8). For *C. densiflora* shortest imbibition period of 5 days was attained for seeds with moisture content of 54%, while longest was 16 days for seeds with moisture content of 10%. Highest germination value of 28.66 was attained for seeds with higher moisture content of 54%. For all species germination energy did not show clear trend (Table 8).

For both *C. africana* and *C. densiflora* moisture content significantly ($P<0.05$) influenced radicle elongation. Longest radicle elongation of 20 and 44 mm was achieved for seeds with moisture content of 50 and 54% respectively, while the lowest moisture content of 8 and 10% resulted in shortest radicle elongation of 10 and 15 mm respectively (Table 8; Figure 4). For both *S. cocculoides* and *S. spinosa* moisture content had no significant ($P>0.05$) influence on radicle elongation (Table 8).
For all species, germination value and radicle elongation were higher for un desiccated seeds and decreased with decrease in seed moisture content. In contrast, higher germination energy was recorded in desiccated seeds. (Table 8).

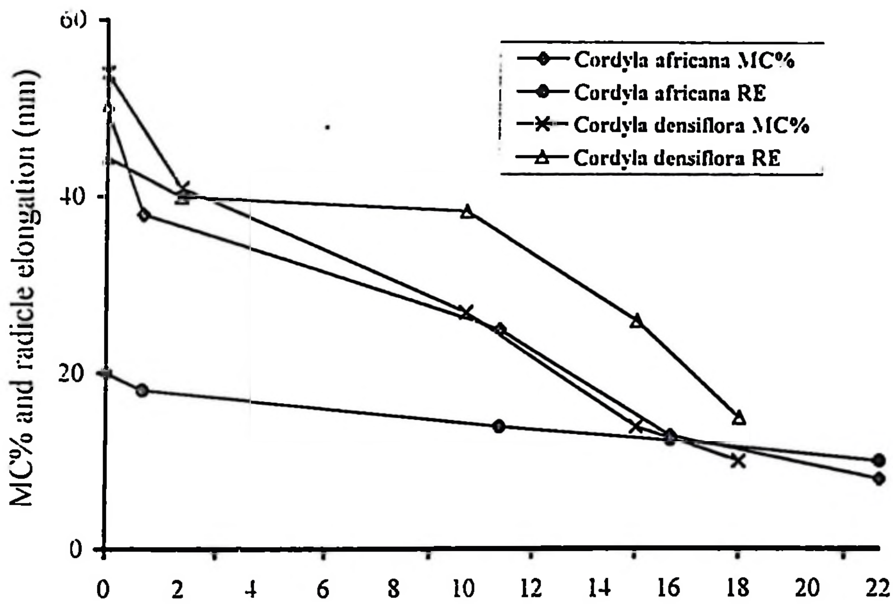
Table 8 Effect of desiccation on storage period, final germination, germination value, germination energy and radicle elongation

MC%	Germination period (days)[a]			FG[b]	GV	GE%	RE (mm)
	Imbibition		Total				
	C	T	T-C				
				C. africana seed			
50	6	31	25	95±2.89a*	43.84	35.00	20.00±2.16a
38	7	32	25	90±3.54a	35.22	65.00	10.00±1.41b
25	17	42	25	85±5.40ba	19.55	32.50	14.00±1.15ba
13	17	37	30	80±4.08b	17.42	60.00	12.40±1.03b
8	23	44	21	50±17.32c	5.25	32.50	10.00±0.41b
				C. densiflora seed			
54	5	30	25	95±2.89a	28.66	55.00	44.50±1.89a
41	7	27	20	90±4.08a	21.97	52.50	40.00±1.41a
27	8	28	20	78±4.79a	17.87	35.00	38.50±0.96a
14	13	28	15	73±4.79ba	13.48	70.00	26.00±1.15ba
10	16	31	15	65±5.00b	10.16	57.50	15.00±1.08b
				S. cocculoides seed			
43	19	44	25	89±3.42a	16.38	26.00	54.00±2.12a
32	21	46	25	88±0.82a	14.37	5850	52.00±1.41a
22	22	47	25	86±4.72a	14.15	72.00	50.05±2.00a
11	22	47	25	85±3.50a	13.20	71.00	48.00±0.91a
5	23	48	25	79±1.29a	10.77	54.50	46.25±1.93a
				S. spinosa seed			
41	21	41	20	97±3.00	20.66	91.00	48.50±0.84a
31	21	46	25	93±1.91	16.86	83.00	47.00±1.78a
21	22	42	20	92±1.41	15.19	61.00	44.75±1.11a
10	22	47	25	92±1.41	14.21	58.00	42.00±1.47a
5	23	43	20	90±2.00	13.12	56.00	38.25±1.41a

* Means of four replicates followed by standard error. Means with the same letter along
the same column are not significantly different at P≤ 0.05

[a] Imbibition (C) – Number of days from sowing to commencement of germination; T – Total germination period (i.e. number of days from sowing to completion of germination); [b] FG – final germination percentage; T-C time between commencement and completion of germination; GV – germination value; GE – germination energy; RE – radicle elongation

$r^2 = 0.98$



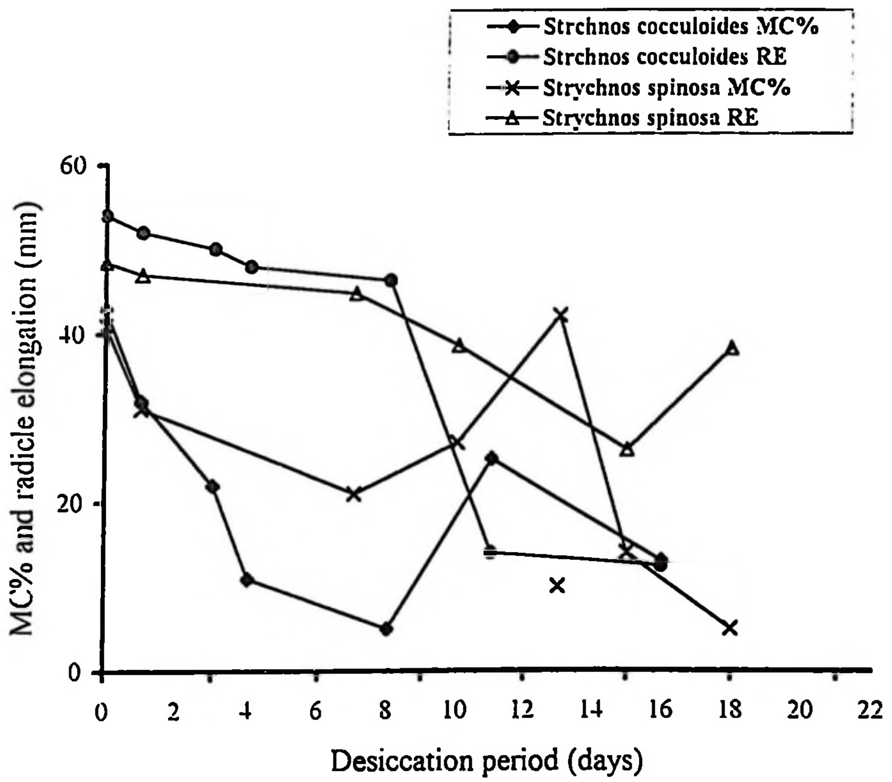


Figure 4 Effect of seed desiccation on radicle elongation (RE mm) of *C. africana*, *C. densiflora*, *S. cocculoides* and *S. spinosa* seed.

4.4 Storage trial

4.4.1 Daily germination and final germination percent

4.4.1.1 Daily germination percent

During the first two weeks of storage of *C. africana* seed, moisture content and temperature significantly influenced daily germination percent ($P<0.05$; Table 9). Highest daily germination of 33% was recorded for seeds stored with moisture content of 38% at 16^0C in aluminium foil bags, after 25 days of sowing (Tables 10a,b, c and d). These were followed by those stored with moisture content of 50% at 16^0C in cotton cloth bags after 25 days of sowing, while lowest germination was noted for seeds stored at 4^0 C. Seed stored at -20^0 C did not survive (Tables 10a, b, c and d). Packaging material had no significant influence ($P> 0.05$) on daily seed germination during the first eight weeks of storage.

For *C. africana* seeds, very little germination was recorded after 20 weeks storage (Table 10d). The packaging material started to influence germination percent ($P< 0.05$) of *C. africana* seed after storage for eight weeks (Tables 9 and 10c). Highest germination percent was achieved for seeds that were stored in cotton bags at 16^0C with moisture content of 38% (Tables 10a, b, c and d). There was also great interaction between moisture content and temperature at 20 weeks of seed storage whilst interaction between temperature and packaging material was noted after storage for eight weeks (Table 9).

For *C. densiflora* seeds, moisture content, temperature and packaging material had very strong influence on daily germination percent (P< 0.05; Table 11). Highest daily germination percent of 60% was recorded for seeds with moisture content of 41%stored at 16^{0}C in cotton bags followed by those with moisture content of 41% stored at 16^{0}C in aluminum foil bags 13 days after sowing. Generally, very low germination was recorded for seed with lowest moisture content (10%). However there were strong interactions between seed moisture content and temperature, moisture content and packaging material, temperature and packaging material and moisture content, temperature and packaging material. (P< 0.05) ; Table 11) throughout the storage period.

For *S. cocculoides* and *S. spinosa*, temperature and seed moisture content significantly (P < 0.05) influenced daily germination percent (Tables 13 and 15). For both species, packaging material significantly (P< 0.005) influenced daily germination percent within the first eight weeks of storage (Tables 13 and 15). Highest daily germination of 56% was recorded after two weeks of storage for *S. cocculoides* seed with moisture content of 43% at 16^0 C in polyethylene bags (Table 14 a). Corresponding daily germination was 57% for *S. spinosa* seed with moisture content of 21% stored for four weeks at -20^{0}C in aluminium foil bags (Table 16d). Generally seeds of *S. cocculoides* and *S. spinosa* survived at the lowest moisture content (5%) and lowest storage temperature (–20^{0}C) as opposed to seeds of *C. africana* and *C. densiflora*.

4.4.1.2 Final cumulative germination percent

For both *C. africana* and *C. densiflora*, moisture content and temperature significantly ($P < 0.05$) influenced final cumulative germination percent (Tables 17 and18). For *C. africana* seed, after storage for two weeks, the highest final cumulative germination of 90% was achieved for seeds stored with moisture content of 50% in cotton cloth bags at 16^0 C. On the other hand, *C. densiflora* retained highest germination of 95% after storage for two weeks with moisture content of 54% at 25^0 C in aluminium foil bags (Figures 5 and 6). Seeds stored at 4^0 C had lowest final cumulative germination percent. In both cases no seed survived at -20^0 C (Figures 5 and 6). For both *C. africana* and *C. densiflora* seeds stored in polyethylene bags had lowest final germination percent. Likewise for both *C. africana* and *C. densiflora* seeds stored with high moisture content had higher final cumulative germination percent (Figures 5 and 6). For both species survival of seeds was very low after the first week of storage and was only for those seeds stored at 16 and 25^0 C (Figures 5 and 6).

C. africana seeds showed a remarkable interaction between moisture content and temperature, and between temperature and packaging material ($P < 0.05$) (Table 17) whereas for *C. densiflora* there were strong interactions between moisture content and temperature, and moisture content and packaging material, temperature and packaging material as well as moisture content, temperature and packaging material ($P< 0.05$) (Table 18). In general there was a slight drop in cumulative germination percent of both *C. africana* and *C. densiflora* seeds after storage for eight weeks at 16^0 C and 25^0 C in cotton bags, while seed storage at 4^0 C showed a remarkable fall in germination percent (Figures 5 and 6). No seeds survived at 4^0C after eight weeks of storage (Figures 5 and 6).

For both *S. cocculoides* and *S. spinosa* moisture content and temperature significantly ($P < 0.05$) influenced final cumulative germination percent throughout the storage period (20 weeks) (Tables 19 and 20). After two weeks storage, the highest cumulative germination percentages of 88% and 95% at 16^0 C were recorded for seeds of *S. cocculoides* and *S. spinosa* stored with moisture content of 32% at 4^0 C in polyethylene bags at 16^0 C and 41% in cotton cloth bags respectively (Figures 7 and 8). For *S. cocculoides*, packaging material influenced cumulative germination percent after eight weeks of storage ($P < 0.05$) (Table 19), while packaging material did not affect cumulative germination of *S. spinosa* seed ($P > 0.05$) (Table 20)

Generally *Strychnos* species survived well even under very low temperature (-20^0 C) and lower moisture content (5%). *S. cocculoides* seed retained higher germination (79%) even after 20 weeks storage with 43% moisture content at 16^0C in aluminium foil bags (Figure 7). The final cumulative germination of S. *spinosa* stored with moisture content of 41% at 16^0 C and 21 and 31% moisture contents at 4^0 C in polyethylene bags was 88 % (Figure 8). For both *S. cocculoides* and *S. spinosa* seeds, aluminium foil and polyethylene bags improved seed storability (Figures 7 and 8). There were remarkable interactions between moisture content and temperature and temperature, and packaging material for both *S. cocculoides* and *S. spinosa* seeds (Tables 20).

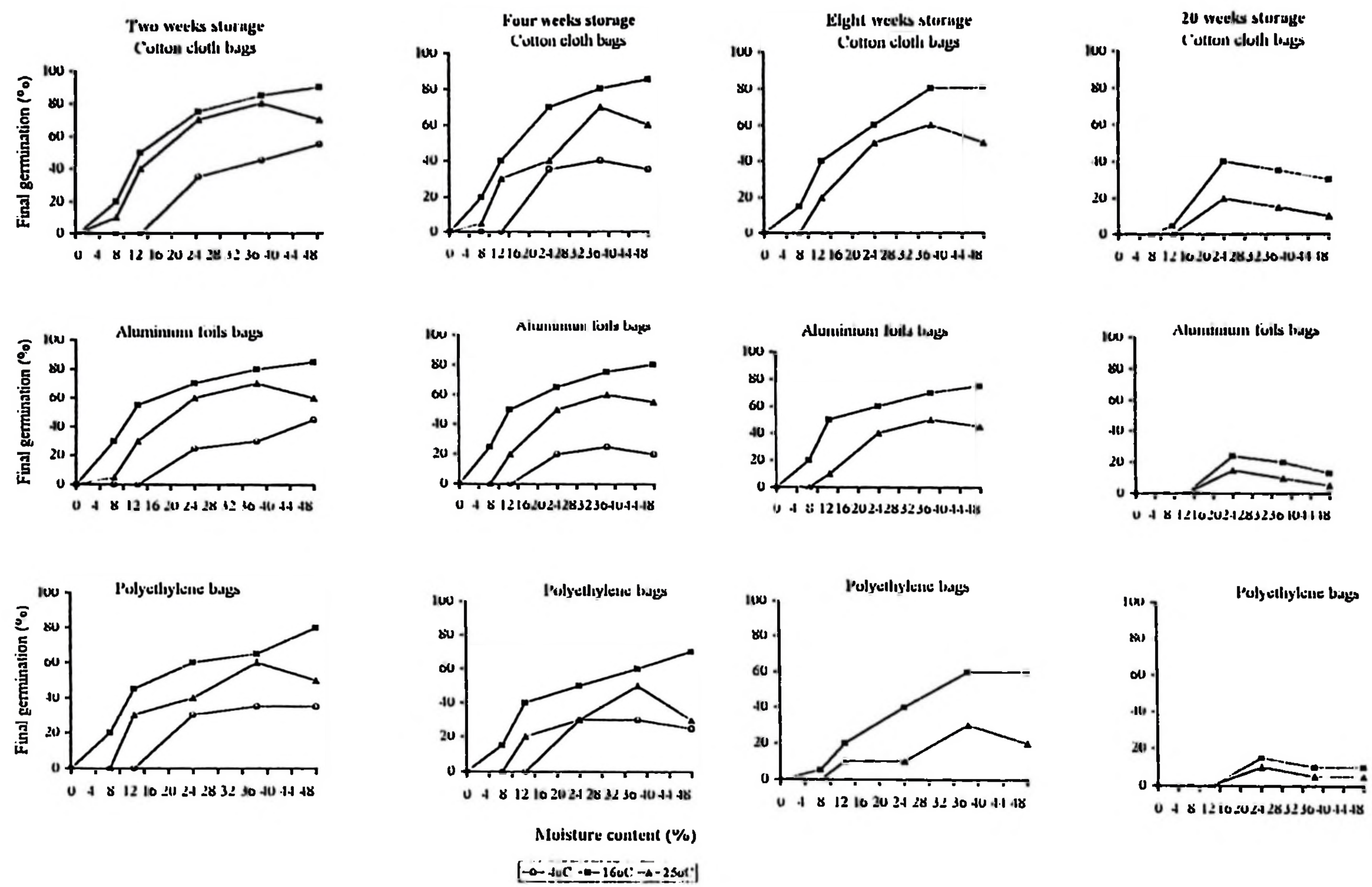


Figure 5: Effect of storage conditions on final cumulative germination percent of *C. africana* seeds after storage for 20 weeks.

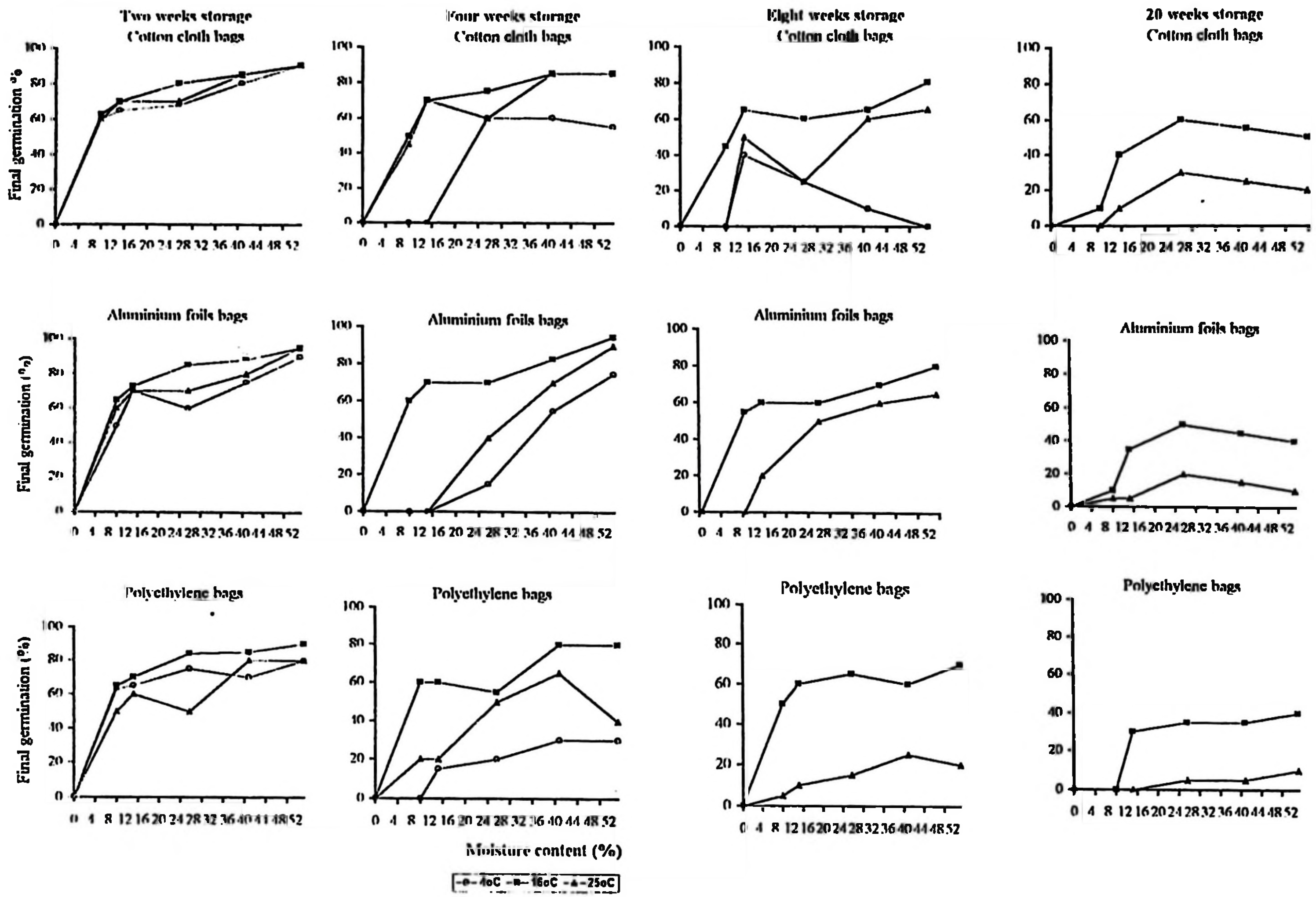


Figure 6: Effect of storage conditions on final cumulative germination percent of *C. densiflora* seeds after storage for 20 weeks.

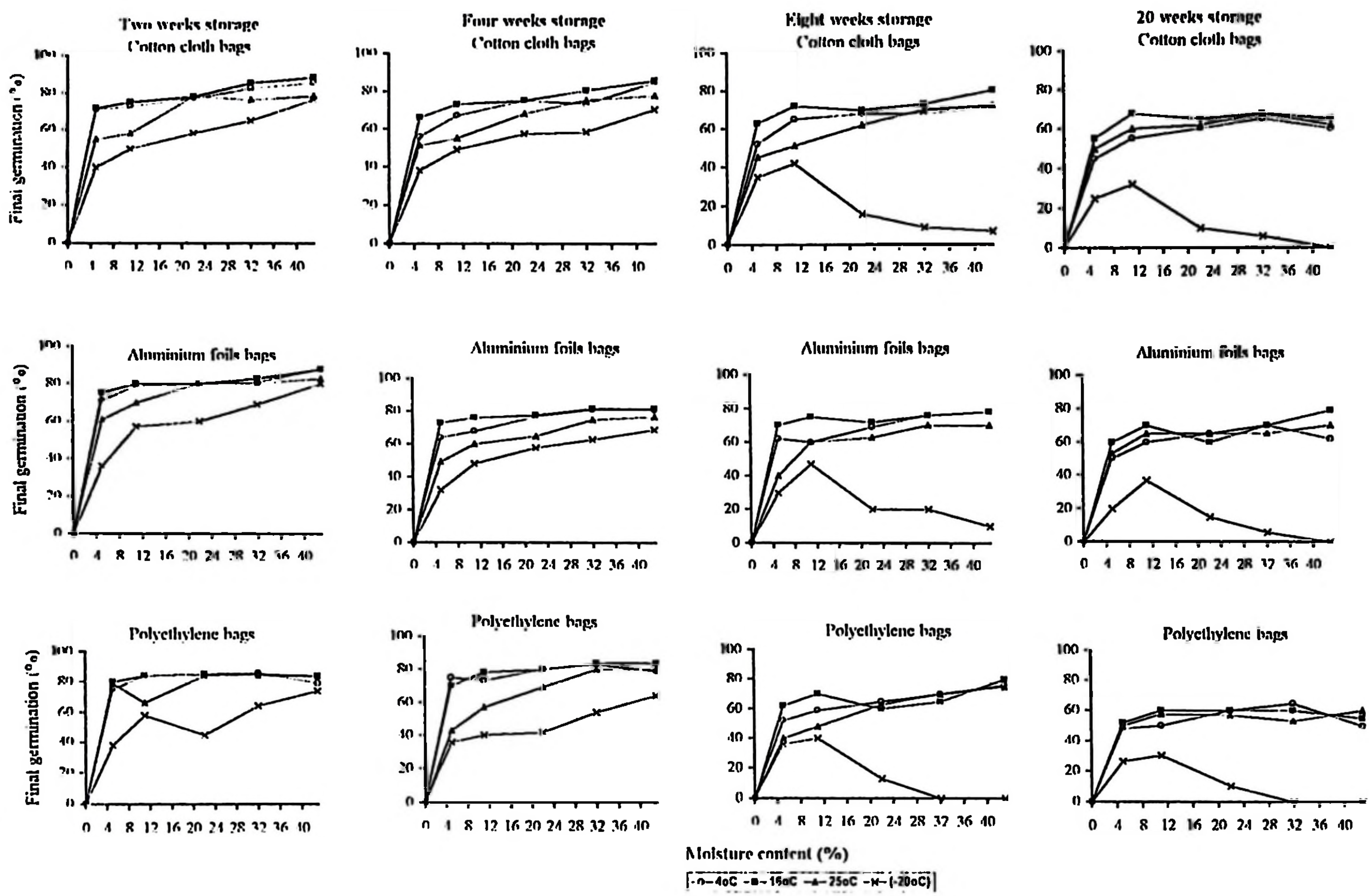


Figure 7: Effect of storage conditions on final cumulative germination percent of *S. cocculoides* seeds after storage for 20 weeks.

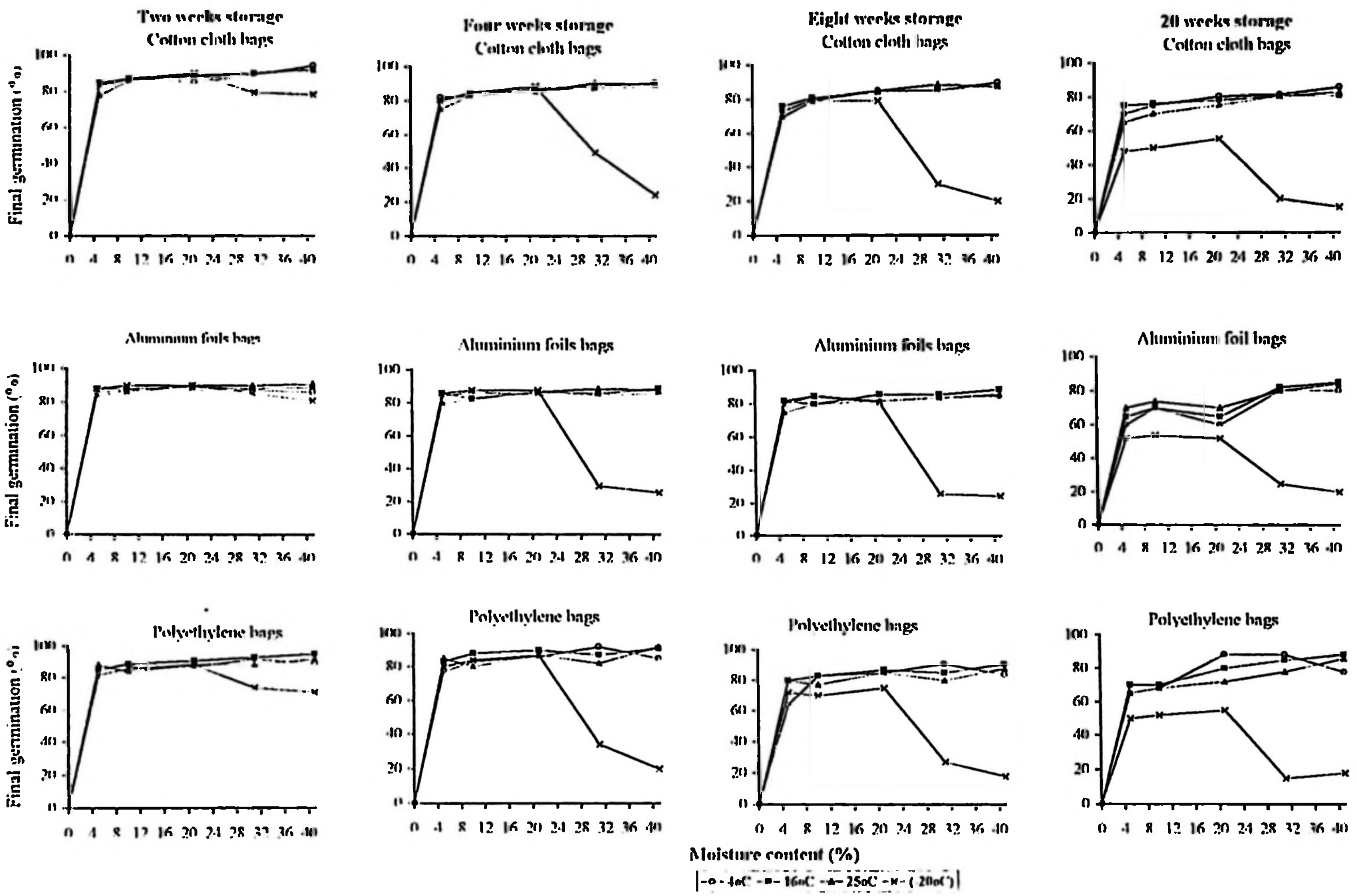


Figure 8: Effect of storage conditions on final cumulative germination percent of *S. spinosa* seeds after storage for 20 weeks.

Table 9 Summary of probabilities for greater F-ratio for daily germination percent for *C. africana* after 20 weeks storage

SP	DAS	BLK	MC	TEMP	PM	MC*TEMP	MC*PM	TEMP*PM	MC*TEMP*PM
2	15	0.0735	0.0001	0.0001	0.1092	0.0183	0.0216	0.8885	0.0324
	20	0.3186	0.0001	0.0001	0.0745	0.0003	0.9802	0.3809	0.9905
	25	0.9488	0.0001	0.0001	0.3197	0.0003	0.4779	0.5839	0.6531
	30	0.4110	0.0001	0.0001	0.1261	0.0164	0.7753	0.3711	0.7130
	35	0.0165	0.0001	0.0001	0.8483	0.0099	0.8960	0.7961	0.8656
	40	0.7597	0.0001	0.0096	0.0979	0.0001	0.0198	0.5001	0.6092
4	16	0.0735	0.0001	0.0001	0.1092	0.0183	0.0216	0.8885	0.0324
	21	0.3186	0.0001	0.0001	0.0745	0.0003	0.9802	0.3809	0.9905
	26	0.9488	0.0001	0.0001	0.3197	0.0003	0.4779	0.5839	0.6531
	31	0.4110	0.0001	0.0001	0.1261	0.0164	0.7753	0.3711	0.7130
	36	0.0165	0.0001	0.0001	0.8483	0.0099	0.8960	0.7961	0.8656
	41	0.7597	0.0001	0.0096	0.0979	0.0001	0.0198	0.5001	0.6092
8	18	0.9754	0.0042	0.0001	0.0001	0.0477	0.1179	0.0001	0.1286
	23	0.2607	0.0001	0.0001	0.0003	0.0001	0.1609	0.0002	0.0200
	28	0.1602	0.0001	0.0001	0.0653	0.0001	0.9420	0.1515	0.7022
	33	0.1038	0.0169	0.0001	0.5782	0.1422	0.8031	0.9335	0.9375
	38	0.0073	0.0476	0.0001	0.4650	0.2763	0.7912	0.8046	0.8081
	43	-	-	-	-	-	-	-	-
20	20	0.3942	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	25	0.7413	0.0001	0.0001	0.0321	0.0001	0.0106	0.2202	0.0016
	30	0.2635	0.0001	0.0001	0.0003	0.0001	0.037	0.0001	0.0001
	35	0.0033	0.0012	0.1127	0.6696	0.0248	0.9183	0.9797	1.0000
	40	0.0030	0.0011	0.0910	0.9364	0.0140	0.9998	0.9735	1.0000
	45	-	-	-	-	-	-	-	-

SP: Storage period (weeks); DAS: Days after sowing; BLK: Block; TEMP: Temperature; MC: moisture content %; PM: Packaging material

Table 10 (a) Effect of storage conditions on daily germination percent for *C. africana* after storage for 2 weeks

DAS*	PM*	50%[1]				38%				25%				13%				8%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
15	C	13b	15a	10b	0	10a	10d	20b	0	3a	10a	15c	0	0	10b	0b	0	0	3d	0	0
	A	10b	10a	5d	0	0a	5d	13b	0	0a	5a	10c	0	0	5b	5b	0	0	10c	0	0
	P	2b	10a	15b	0	0a	5d	0b	0	8a	5a	5c	0	0	10b	10d	0	0	5d	0	0
20	C	8c	15b	13b	0	10c	15a	15d	0	8c	10b	18a	0	0	13a	15a	0	0	5d	0	0
	A	5c	18b	20b	0	10c	15a	18d	0	10e	20b	18a	0	0	18a	8a	0	0	8d	0	0
	P	6c	18b	8b	0	5c	15a	15d	0	8c	15c	15a	0	0	10a	5a	0	0	5a	0	0
25	C	8a	20d	23c	0	8b	28b	23b	0	13b	25b	10d	0	0	20b	20b	0	0	10b	0	0
	A	8a	10d	5c	0	5b	33b	23b	0	8b	23b	13d	0	0	15b	13b	0	0	5b	0	0
	P	15a	18d	13c	0	18b	23b	28b	0	8b	13b	13d	0	0	13b	8b	0	0	8b	0	0
30	C	14a	13c	13b	0	8c	20c	23d	0	5c	25b	20c	0	0	5c	5c	0	0	3c	0	0
	A	10c	20b	15c	0	13c	20c	13d	0	5c	15c	18c	0	0	13d	3d	0	0	8b	0	0
	P	5b	20a	5b	0	8d	20b	13c	0	5c	15c	5d	0	0	5a	5b	0	0	3c	0	0
35	C	8c	20b	5b	0	10a	13b	0a	0	8b	5a	8d	0	0	3b	0a	0	0	0	0	0
	A	3c	15a	10c	0	3c	8d	5c	0	3c	8a	3b	0	0	5b	3c	0	0	0	0	0
	P	5c	13a	5d	0	5c	3b	5c	0	3c	13c	3b	0	0	8b	3b	0	0	0	0	0
40	C	6a	8c	8c	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A	10c	13a	5c	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P	3b	3a	5c	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^{0}C)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table 10 (b) Effect of storage conditions on daily germination percent for *C. africana* after storage for 4 weeks

DAS*	PM*	50%[1]				38%				25%				13%				8%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	16b	25	-20	4	16	25	-20	
16	C	0b	10a	10b	0	8b	15a	5c	0	3a	15a	5c	0	0	5b	5b	0	0	5b	0	0
	A	5b	25a	5d	0	0b	15a	5a	0	5a	10a	5c	0	0	5b	5b	0	0	5b	0	0
	P	5b	5a	0b	0	0b	5a	5a	0	13a	0a	0c	0	0	10a	0a	0	0	0a	0	0
21	C	10c	25b	10b	0	13c	18b	8b	0	5c	20b	15a	0	0	13a	0a	0	0	3b	0	0
	A	3c	18b	18b	0	13c	13b	23b	0	3c	15b	10a	0	0	8a	0a	0	0	15d	0	0
	P	10c	23b	23b	0	10c	20b	10b	0	3c	13c	16a	0	0	13b	8b	0	0	3b	0	0
26	C	5a	15d	10c	0	8a	28d	28d	0	8b	23b	23d	0	0	13b	5b	0	0	5b	0	0
	A	8a	15d	15c	0	8a	28d	10d	0	10b	20b	10d	0	0	25b	5b	0	0	0a	0	0
	P	5a	18d	8c	0	5a	18d	25d	0	3b	15b	4d	0	0	3c	5b	0	0	5b	0	0
31	C	10c	30c	23b	0	10c	15c	20c	0	8c	5b	5c	0	0	8d	20d	0	0	8b	0	0
	A	3b	15b	15c	0	4b	15b	5c	0	3c	15b	10c	0	0	8a	10c	0	0	5b	0	0
	P	3c	25a	0b	0	10c	18a	5c	0	3c	18b	10d	0	0	15b	3b	0	0	5b	0	0
36	C	10c	5b	8b	0	0c	5b	10b	0	13b	8c	13d	0	0	3b	0a	0	0	0a	0	0
	A	3c	8a	3c	0	1a	5b	8c	0	0c	5c	15b	0	0	5b	0a	0	0	0a	0	0
	P	3a	0a	0d	0	5c	0a	5b	0	0c	0a	0b	0	0	0b	5b	0	0	3b	0	0
41	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^{0}C)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table 10(c) Effect of storage conditions on daily germination percent for *C. africana* after storage for 8 weeks

DAS*	PM*	50%[1]				38%				25%				13%				8%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
18	C	0	10b	5a	0	0	15c	5b	0	0	15c	5b	0	0	10c	0a	0	0	5b	0	0
	A	0	15b	25c	0	0	20c	0a	0	0	15c	15c	0	0	10c	0a	0	0	0a	0	0
	P	0	0a	0a	0	0	0a	10c	0	0	0a	0a	0	0	0a	0a	0	0	0a	0	0
23	C	0	48d	35c	0	0	23d	23d	0	0	15c	18c	0	0	20d	5b	0	0	3b	0	0
	A	0	35c	5a	0	0	15c	15c	0	0	13c	5b	0	0	15d	0a	0	0	10c	0	0
	P	0	35c	10b	0	0	30d	3b	0	0	15c	3b	0	0	5b	3b	0	0	3b	0	0
28	C	0	13b	3a	0	0	18c	18c	0	0	15c	15c	0	0	0a	10c	0	0	5b	0	0
	A	0	10b	3a	0	0	23d	15c	0	0	13c	10c	0	0	10c	5b	0	0	3b	0	0
	P	0	15b	0a	0	0	10c	8b	0	0	18c	5b	0	0	5b	3b	0	0	0a	0	0
33	C	0	10b	5a	0	0	13c	10c	0	0	15c	13c	0	0	5b	5b	0	0	3b	0	0
	A	0	8a	13b	0	0	8b	15c	0	0	15c	5b	0	0	10c	5b	0	0	5b	0	0
	P	0	8a	10b	0	0	13c	8b	0	0	8b	0a	0	0	10c	5b	0	0	0a	0	0
38	C	0	0a	3a	0	0	13c	5b	0	0	0a	0a	0	0	5b	0a	0	0	0a	0	0
	A	0	8a	0a	0	0	5b	5b	0	0	5b	5b	0	0	5b	0a	0	0	3b	0	0
	P	0	3a	0a	0	0	8b	3b	0	0	0a	0a	0	0	0a	0a	0	0	3b	0	0
43	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (°C)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table 10 (d) Effect of storage conditions on daily germination percent for *C. africana* after storage for 20 weeks

DAS*	PM*	50%[1]				38%				25%				13%				8%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
20	C	0	0	0	0	0	25d	0a	0	0	0	0	0	0	0	0	0	0	0	0	0
	A	0	0	0	0	0	0a	0a	0	0	0	0	0	0	0	0	0	0	0	0	0
	P	0	0	0	0	0	0a	0a	0	0	0	0	0	0	0	0	0	0	0	0	0
25	C	0	15c	10c	0	0	0a	10c	0	0	15c	10c	0	0	5b	0	0	0	0	0	0
	A	0	10c	0a	0	0	15c	10c	0	0	10c	10c	0	0	0b	0	0	0	0	0	0
	P	0	10c	5b	0	0	5b	0a	0	0	10c	5b	0	0	0b	0	0	0	0	0	0
30	C	0	15c	0a	0	0	10c	5b	0	0	20d	10c	0	0	0	0	0	0	0	0	0
	A	0	3b	5b	0	0	5b	0a	0	0	15d	5b	0	0	0	0	0	0	0	0	0
	P	0	0a	0a	0	0	8b	5b	0	0	5b	8b	0	0	0	0	0	0	0	0	0
35	C	0	0a	0	0	0	0	0	0	0	5b	0	0	0	0	0	0	0	0	0	0
	A	0	2b	0	0	0	0	0	0	0	0a	0	0	0	0	0	0	0	0	0	0
	P	0	0a	0	0	0	0	0	0	0	0a	0	0	0	0	0	0	0	0	0	0
40	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^0C)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table 11 Summary of probabilities for greater F-ratio for daily germination percent for *C. densiflora* after 20 weeks storage

SP	DAS	BLK	MC	TEMP	PM	MC*TEMP	MC*PM	TEMP*PM	MC*TEMP*PM
2	8	0.0391	0.0001	0.0001	0.0001	0.0001	0.0004	0.0001	0.0001
	13	0.2708	0.0001	0.0001	0.0979	0.0001	0.0001	0.0001	0.0001
	18	0.1215	0.0001	0.0001	0.0135	0.0001	0.3552	0.0877	0.0265
	23	0.4249	0.0626	0.0001	0.6021	0.0001	0.0141	0.3323	0.4960
	28	0.5983	0.0001	0.0001	0.0539	0.0001	0.0029	0.0340	0.0001
	33	0.8715	0.0001	0.0001	0.0033	0.0001	0.0096	0.0001	0.0001
4	10	0.3146	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	15	0.5156	0.0001	0.0001	0.0444	0.0001	0.0003	0.0001	0.0001
	20	0.5146	0.0001	0.0001	0.0001	0.0001	0.0014	0.0001	0.0090
	25	0.5690	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	30	0.6022	0.0001	0.0001	0.0001	0.0001	0.0339	0.0003	0.0001
	35	0.9919	0.0001	0.0001	0.0026	0.0001	0.0109	0.0001	0.0002
8	11	0.0959	0.0001	0.0001	0.0010	0.0001	0.0001	0.0117	0.0001
	16	0.9859	0.0001	0.0001	0.0001	0.0001	0.0190	0.0001	0.0002
	21	0.8006	0.0001	0.0001	0.0001	0.0001	0.0012	0.0001	0.0001
	26	0.0939	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0009
	31	0.8244	0.0150	0.0001	0.1232	0.0005	0.0023	0.0001	0.0001
	36	0.8083	0.2808	0.0001	0.0200	0.0684	0.3132	0.2269	0.0001
20	13	0.3678	0.0001	0.0001	0.0663	0.0001	0.1639	0.3017	0.2602
	18	0.0579	0.0001	0.0001	0.0004	0.0001	0.4439	0.0007	0.2363
	23	0.0029	0.0001	0.0001	0.0377	0.0001	0.0741	0.0546	0.0744
	28	0.6109	0.0019	0.0001	0.0790	0.0001	0.0058	0.0204	0.0001
	33	0.9983	0.0077	0.0001	0.0599	0.0001	0.0001	0.0110	0.0001
	38	-	-	-	-	-	-	-	-

SP: Storage period (weeks); DAS: Days after sowing; BLK: Block; TEMP: Temperature; MC: moisture content %; PM: Packaging material

Table 12(a) Effect of storage conditions on daily germination percent for *C. densiflora* after storage for 2 weeks

DAS*	PM*	54%[1]				41%				27%				14%				10%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
8	C	5b	15b	10b	0	0a	15b	8b	0	0a	13b	0	0	0	8b	0	0	10b	16c	5b	0
	A	5b	15b	35b	0	5b	30b	30b	0	5b	18b	0	0	0	20c	0	0	0a	10b	5b	0
	P	0b	5b	15b	0	13b	10b	0b	0	8b	0a	0	0	0	20c	0	0	0a	3a	5b	0
13	C	20b	20b	45b	0	50d	60d	33c	0	0a	13b	13b	0	5b	13b	15b	0	20b	16b	20c	0
	A	10b	25b	35b	0	30c	50b	15b	0	23b	13b	25b	0	10b	10b	15b	0	3b	13b	23c	0
	P	10b	30b	5b	0	20b	20d	40d	0	13b	25b	0a	0	15b	10b	5b	0	3b	28b	20c	0
18	C	30c	45d	20b	0	10b	5b	35c	0	20b	10b	10b	0	25b	35c	20b	0	15b	16b	18c	0
	A	30c	38d	30b	0	10b	30c	35c	0	10b	15b	15b	0	20b	25b	20b	0	15b	28b	18c	0
	P	30c	20b	15b	0	20b	5b	20b	0	20b	33c	5b	0	10b	25b	23b	0	13b	20b	10b	0
23	C	15b	5b	10b	0	20b	13b	5b	0	18b	28b	15b	0	15b	13b	15b	0	8b	8b	8b	0
	A	30c	0a	3b	0	30b	8b	0a	0	10b	18b	5b	0	15b	15b	15b	0	8b	8b	8b	0
	P	35c	5b	25c	0	15b	10b	15b	0	13b	10b	0b	0	15b	15b	10b	0	8b	10b	10b	0
28	C	15b	5b	5b	0	0b	0a	5b	0	30b	13b	31b	0	20b	3b	5b	0	7b	7b	7b	0
	A	5b	18c	0a	0	0b	0a	0a	0	0a	13b	25b	0	25b	3b	5b	0	25b	7b	7b	0
	P	5b	20c	20c	0	3b	0a	5b	0	22b	14b	20b	0	25b	0a	13b	0	10b	5b	5a	0
33	C	5b	0a	0	0	0	0	0	0	0a	5a	2a	0	0	0	15b	0	0a	0	0	0
	A	10b	0a	0	0	0	0	0	0	13b	10b	0a	0	0	0	15b	0	18b	0	0	0
	P	0a	10b	0	0	0	0	0	0	0a	0a	25b	0	0	0	10b	0	30c	0	0	0

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^{0}C)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table 12(b) Effect of storage conditions on daily germination percent for *C. densiflora* after storage for 4 weeks

DAS*	PM*	54%[1]				41%				27%				14%				10%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
10	C	0a	15b	5b	0	5b	13b	15b	0	0	10b	5b	0	0a	13b	0	0	0	0	0	0
	A	18b	30c	20c	0	0a	15b	10b	0	0	15b	0a	0	0a	13b	0	0	0	0	0	0
	P	0a	13b	0a	0	0a	5b	0a	0	0	0a	0a	0	0a	10b	0	0	0	0	0	0
15	C	10b	33c	20b	0	0a	55d	25b	0	0a	15b	8b	0	0a	20b	15b	0	0	8b	8b	0
	A	43c	10b	25b	0	5a	40c	20b	0	5a	13b	0a	0	0a	20b	0a	0	0	8b	0a	0
	P	5a	43c	10b	0	5a	25b	5a	0	0a	10b	8b	0	10b	15b	10b	0	0	8b	0a	0
20	C	10b	25c	20b	0	20b	13b	15b	0	10b	23b	10b	0	0a	20b	20b	0	0	10b	4a	0
	A	13b	45c	20b	0	15b	15b	15b	0	5a	18b	15b	0	0a	20b	0a	0	0	10b	0a	0
	P	5b	20b	15b	0	5a	10b	20b	0	0a	10b	10b	0	0a	8b	5a	0	0	10b	8b	0
25	C	25b	13b	40c	0	20b	5a	15b	0	15b	20b	15b	0	0a	15b	15b	0	0	18b	12b	0
	A	8b	5b	20b	0	25b	13b	20b	0	3a	18b	3a	0	0a	15b	0a	0	0	28c	0a	0
	P	10b	8b	5b	0	10b	30b	18b	0	10b	10b	18b	0	5b	18b	0a	0	0	28c	8b	0
30	C	10b	0a	0a	0	15b	0a	10b	0	25b	5a	15b	0	0a	3a	5a	0	0	10b	18b	0
	A	0a	5b	5b	0	10b	0a	5a	0	3a	8b	33b	0	0a	3a	0a	0	0	5a	0a	0
	P	10b	0a	10b	0	10b	10b	15b	0	10b	25b	10b	0	0a	10b	3a	0	0	5a	4a	0
35	C	0	0	0	0	0	0	0	0	0	3a	8b	0	0	0	0	0	0	5a	3a	0
	A	0	0	0	0	0	0	0	0	0	0a	0a	0	0	0	0	0	0	10b	0a	0
	P	0	0	0	0	0	0	0	0	0	0a	5a	0	0	0	0	0	0	10b	0a	0

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^0C)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table12 (c) Effect of storage conditions on daily germination percent for *C. densiflora* after storage for 8 weeks

DAS*	PM*	54%[1]				41%				27%				14%				10%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
11	C	0	13	0a	0	0	5b	0	0	0	0a	10b	0	0	5b	5b	0	0	0	0	0
	A	0	20b	18b	0	0	0a	0	0	0	15b	0a	0	0	0a	0a	0	0	0	0	0
	P	0	0a	0a	0	0	5b	0	0	0	5a	0a	0	0	5b	0a	0	0	0	0	0
16	C	0	15b	25c	0	0	35c	0	0	5b	15c	10b	0	8b	10b	20c	0	0	5b	0	0
	A	0	23c	13b	0	0	10b	0	0	0a	10b	10b	0	0a	10b	5b	0	0	10b	0	0
	P	0	23c	5a	0	0	15b	0	0	0a	10b	0a	0	0a	15c	0a	0	0	5b	0	0
21	C	0	23c	20b	0	0	15b	0	0	10a	13b	5a	0	8b	15c	10b	0	0	10b	0	0
	A	0	15b	25c	0	0	10b	0	0	0a	18c	13b	0	0a	10b	5a	0	0	10b	0	0
	P	0	25c	0a	0	0	15b	0	0	0a	18c	0a	0	0a	15c	0a	0	0	13b	0	0
26	C	0	13b	20c	0	0	8b	0	0	0a	10b	0a	0	18c	25d	15c	0	0	10b	0	0
	A	0	18b	15b	0	0	20c	0	0	0a	15c	5a	0	0a	18c	5a	0	0	18b	0	0
	P	0	10b	0a	0	0	13b	0	0	0	13b	0a	0	0a	13c	0a	0	0	23c	0	0
31	C	0	10b	0a	0	0	3a	0	0	10b	13b	0a	0	8b	8b	0a	0	0	5b	0	0
	A	0	2a	5a	0	0	20c	0	0	0a	3a	13b	0	0a	13c	5a	0	0	8b	0	0
	P	0	13b	0a	0	0	8b	0	0	0a	10b	0a	0	0a	8b	0a	0	0	10b	0	0
36	C	0	8b	0	0	0	0a	0	0	0	10b	0a	0	0	3b	0	0	0	15b	0	0
	A	0	10b	0	0	0	10b	0	0	0	0a	10b	0	0	10b	0	0	0	10b	0	0
	P	0	0a	0	0	0	5b	0	0	0	10b	0a	0	0	5b	0	0	0	0a	0	0

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^{0}C)

. Three means of the same storage day with the same letter within the column are not significantly different at $P < 0.05$

Table12 (d) Effect of storage conditions on daily germination percent for *C. densiflora* after storage for 20 weeks

DAS*	PM*	54%[1]				41%				27%				14%				10%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
13	C	0	5b	3b	0	0	15b	0	0	0	20c	4a	0	0	5b	0	0	0	0	0	0
	A	0	5b	0a	0	0	10b	0	0	0	20c	0a	0	0	5b	0	0	0	0	0	0
	P	0	5b	0a	0	0	8b	0	0	0	5b	0a	0	0	6b	0	0	0	0	0	0
18	C	0	15c	8b	0	0	15b	10b	0	0	20c	12b	0	0	20c	5a	0	0	5b	0	0
	A	0	15c	5b	0	0	20c	5a	0	0	10b	10b	0	0	10b	0a	0	0	5b	0	0
	P	0	15c	5b	0	0	16b	0a	0	0	10b	0a	0	0	14c	0a	0	0	0a	0	0
23	C	0	5b	10b	0	0	20c	15b	0	0	20c	15c	0	0	15c	15c	0	0	5b	0	0
	A	0	10b	5a	0	0	15b	10b	0	0	5b	10b	0	0	15c	5a	0	0	5b	0	0
	P	0	20c	8b	0	0	10b	5a	0	0	15c	5b	0	0	10b	0a	0	0	0a	0	0
28	C	0	10b	0	0	0	5b	0	0	0	0a	0	0	0	0a	0	0	0	0	0	0
	A	0	10b	0	0	0	0a	0	0	0	10b	0	0	0	5b	0	0	0	0	0	0
	P	0	0a	0	0	0	1a	0	0	0	5b	0	0	0	0a	0	0	0	0	0	0
33	C	0	15b	0	0	0	0	0	0	0	0a	0	0	0	0	0	0	0	0	0	0
	A	0	0a	0	0	0	0	0	0	0	5b	0	0	0	0	0	0	0	0	0	0
	P	0	0a	0	0	0	0	0	0	0	0a	0	0	0	0	0	0	0	0	0	0
38	C	0	0	0	0	0	9b	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A	0	0	0	0	0	0a	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P	0	0	0	0	0	0a	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^{0}C)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table 13 Summary of probabilities for greater F-ratio for daily germination percent for *S. cocculoides* after 20 weeks storage

SP	DAS	BLK	MC	TEMP	PM	MC*TEMP	MC*PM	TEMP*PM	MC*TEMP*PM
2	17	0.2739	0.0011	0.0001	0.4538	0.0001	0.1587	0.0274	0.0002
	22	0.4193	0.0001	0.0001	0.5247	0.0001	0.0043	0.0001	0.0005
	27	0.2456	0.0001	0.0001	0.0165	0.0001	0.0304	0.0001	0.0001
	32	0.4619	0.0001	0.0012	0.0363	0.0001	0.5877	0.0192	0.0059
	37	0.8473	0.0001	0.0001	0.1184	0.0001	0.0846	0.0013	0.0274
	42	0.9331	0.0010	0.0001	0.0020	0.0001	0.0834	0.7322	0.0293
4	18	0.7754	0.0001	0.0001	0.5505	0.0001	0.3183	0.2588	0.5634
	23	0.1178	0.0008	0.0001	0.0005	0.0001	0.5374	0.0110	0.0058
	28	0.2857	0.0001	0.0001	0.0005	0.0001	0.0180	0.3966	0.0684
	33	0.8185	0.0001	0.0002	0.2507	0.0001	0.4805	0.0949	0.0275
	38	0.5601	0.0001	0.0004	0.9897	0.0001	0.4374	0.0110	0.0001
	43	0.5313	0.0001	0.0920	0.09113	0.0001	0.1563	0.1930	0.0196
8	20	0.3431	0.0001	0.0001	0.0026	0.0001	0.7014	0.0503	0.0003
	25	0.3259	0.0001	0.0001	0.0029	0.0001	0.6335	0.0002	0.0619
	30	0.6572	0.0001	0.0001	0.1356	0.0001	0.0036	0.1011	0.0038
	35	0.5587	0.0001	0.0001	0.6466	0.0001	0.0801	0.2343	0.0703
	40	0.9246	0.0001	0.0001	0.0039	0.0001	0.4800	0.0036	0.0470
	45	0.3942	0.4090	0.3942	0.3699	0.4509	0.4378	0.4269	0.4688
20	22	0.7754	0.0001	0.0001	0.5505	0.0001	0.3183	0.2588	0.5634
	27	0.4754	0.0013	0.0001	0.0001	0.0001	0.0001	0.0721	0.0098
	32	0.0398	0.0001	0.0001	0.7487	0.0001	0.0016	0.0059	0.0001
	37	0.2457	0.0001	0.0001	0.0799	0.0001	0.0263	0.6377	0.0034
	42	0.5397	0.0001	0.0001	0.0830	0.0001	0.0001	0.0008	0.0040
	47	0.3071	0.0001	0.0001	0.2789	0.0001	0.1486	0.1884	0.0096

SP: Storage period (weeks); DAS: Days after sowing; BLK: Block; TEMP: Temperature; MC: moisture content %; PM: Packaging material

Table 14 (a) Effect of storage conditions on daily germination percent *for S. cocculoides* after storage for 2 weeks

DAS*	PM*	43%[1]				32%				22%				11%				5%			
		4:	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
17	C	6b	5b	3b	11c	12c	5b	8b	5b	11c	3b	8b	2b	8b	8b	4b	3b	3b	8b	8b	0
	A	1a	4b	6b	2a	2a	2a	20c	7b	4b	7b	4b	4b	12c	9b	15c	4b	4b	8b	8b	0
	P	3b	2b	8b	3b	9b	2a	18c	3b	10c	9b	3b	2b	14c	6b	0a	5b	1a	8b	14c	0
22	C	6b	20c	27c	26c	30c	26c	41d	13c	24c	38c	20c	27c	31c	32c	25c	10c	32c	35c	31c	3a
	A	15c	17c	21c	24c	28c	29c	56d	14c	27c	28c	38c	32c	20c	29c	11c	15c	35c	19c	22c	0a
	P	9b	12c	46d	19c	32c	36c	53d	9b	24c	34c	33c	7b	28c	30c	27c	19c	30c	35c	33c	0a
27	C	55d	43d	41d	22c	27c	44d	22c	31c	12b	36c	33c	25c	31c	18c	28c	29c	35c	9b	8b	21c
	A	27c	54d	48d	32c	33c	39c	5b	39c	15b	32c	30c	7b	36c	20c	30c	20c	25c	17c	14c	4a
	P	54d	56d	21c	21c	34c	34c	8b	31c	41c	35c	36c	14c	37c	36c	37c	23c	43d	15c	19c	4a
32	C	15c	16c	6b	7b	2a	8b	1a	8b	7b	1a	7b	1a	2a	7b	1a	5a	1a	12c	5b	11c
	A	39c	5b	9b	7b	9b	8b	0a	4b	7b	8b	3b	5b	3a	7b	7b	17c	5b	13c	13c	10c
	P	9b	13c	6b	12c	4a	7b	3a	12c	5b	2a	6b	17c	3a	4a	1a	10b	1a	11c	8b	11c
37	C	1a	2a	0a	6b	4b	3b	3b	4b	26c	0a	6b	3b	0a	6b	0a	3a	0a	8b	3a	4b
	A	2a	0a	0a	5b	5b	6b	0a	4b	27c	3b	1a	13c	6b	8b	2a	1b	2b	20c	3a	10c
	P	4b	0a	1a	8b	3b	4b	2a	5b	5b	3b	5b	5b	0a	6b	1a	1b	0a	12c	7b	11c
42	C	0a	3b	0a	4b	5b	0	0	4b	0	0a	4b	0	1a	4b	0a	0	0	0	0	2a
	A	4b	8b	0a	10c	4b	0	0	2b	0	3b	3b	0	3b	7b	7b	0	0	0	0	12c
	P	0a	1a	7b	12c	4b	0	0	4b	0	3b	1a	0	2a	2a	0a	0	0	0	0	8b

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; : temperature (^{0}C)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table 14 (b) Effect of storage conditions on daily germination percent for *S. cocculoides* after storage for 4 weeks

DAS*	PM*	43%[1]				32%				22%				11%				5%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
18	C	3a	6b	6b	3a	8b	27c	9b	4a	13b	6b	12b	0a	7b	13b	2a	0a	8b	6b	7b	2a
	A	6a	10b	6b	6a	9b	30c	7b	2a	9b	11b	6b	3a	3b	9b	3a	0a	6b	8b	3b	3a
	P	2a	10b	11b	5a	7b	10c	6b	3a	8b	5b	8b	0a	6b	9b	3a	0a	10b	9b	3b	4a
23	C	9b	20c	8b	9b	13c	36d	5a	22c	26c	30d	13c	3a	29c	25c	5a	5a	12c	17c	22c	6a
	A	15c	13c	20c	6a	12c	39d	8b	24c	17c	21c	17c	4a	31d	25c	22c	9b	13c	19c	14c	23c
	P	6b	9b	16c	4a	15c	15c	10b	15c	9b	32d	9b	0a	25c	20c	21c	2a	13c	14c	13c	6a
28	C	43d	36c	45d	23c	33c	11c	39c	6a	19c	21c	26c	13c	22c	19b	24c	8a	27c	30c	20c	8a
	A	45d	45d	40d	33c	44d	12c	38c	4a	22c	29c	15b	14c	23c	17b	30c	25c	42d	27c	15b	4a
	P	43d	47d	44d	31c	46d	39d	53c	20c	39c	23c	20c	19c	26c	26c	31c	21c	40d	37c	15b	6a
33	C	25c	19b	18b	19b	16b	5a	17b	7a	9a	9a	7a	27c	9a	11b	5a	28c	2a	6a	2a	17c
	A	11b	12b	11b	20c	12b	1a	12b	13b	19b	11b	12b	27c	7a	17b	1a	9b	0a	12b	7b	2a
	P	26c	21c	10b	14b	16b	13b	8a	5a	22c	15b	13b	15b	6a	14b	0a	15b	2a	1a	6b	10b
38	C	4a	4a	0a	18c	3a	1a	5b	4a	4a	7b	10b	13c	0a	5a	11c	8b	3a	5a	1a	9b
	A	3a	2a	0a	4a	3a	0a	10b	8b	10b	6b	14c	10b	3a	8b	3a	3a	2a	10b	10b	1a
	P	2a	7b	0a	8b	2a	8b	3a	5a	5a	4a	19c	8b	10b	10b	3a	16c	4a	6b	0a	10b
43	C	0	0a	0	0	0	0	0	0a	0	0	0	0	0	0	8b	0	2a	3b	0	0
	A	0	2b	0	0	0	0	0	4b	0	0	0	0	0	0	1a	0	1a	2a	0	0
	P	0	0a	0	0	0	0	0	6b	0	0	0	0	0	0	0a	0	3b	3b	0	0

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^{0}C)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table 14 (c) Effect of storage conditions on daily germination percent for *S. cocculoides* after storage for 8 weeks

DAS*	PM*	43%[1]				32%				22%				11%				5%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
20	C	17c	22d	5b	0a	4a	15c	4a	2a	9b	7b	24c	0a	10b	8b	1a	1a	8b	1a	0	0
	A	25d	18c	5b	0a	10b	14c	4a	1a	5b	7b	24c	0a	8b	10b	10b	0a	12c	7b	0	0
	P	23d	18c	2b	0a	5a	7b	4a	0a	9b	9b	5a	4a	8b	9b	3a	0a	2a	5a	0	0
25	C	38d	41c	13c	0a	10b	35d	19c	1a	35d	14c	31d	2a	11c	5a	23c	0a	5a	12c	8b	0
	A	38d	39d	12c	0a	13c	30d	19c	1a	41c	14c	26c	3a	19c	10b	5a	0a	9b	16c	9b	0
	P	36d	39d	4a	0a	12c	36d	19c	0a	39d	17c	12c	2a	19c	8b	6a	0a	5a	6a	5a	0
30	C	11c	10b	16c	6b	41c	18c	26c	2a	9b	21c	8b	9b	33d	30d	32d	13c	22c	30d	10b	14c
	A	11c	6a	14c	6b	35d	27c	26c	15c	19c	21c	6b	7b	20c	27c	25c	14c	26c	18c	12c	8b
	P	14c	6a	17c	0a	28c	9b	26c	0a	9b	16c	29c	5b	20c	24c	18c	14c	23c	32d	9b	14c
35	C	4b	3a	32d	1a	12c	4b	18c	3a	5b	21c	3a	2a	7b	21d	5a	28c	17c	21d	12c	8b
	A	3b	12c	34d	3a	18c	2a	18c	2a	1a	19c	3a	4b	11c	8b	20c	33d	15c	11c	9b	7b
	P	3b	15c	49c	0a	30d	7b	18c	2a	5b	9b	2a	0a	11c	15c	21d	26d	22d	19c	5b	8b
40	C	1a	3b	7b	0a	0a	1a	4b	1a	8b	8b	1a	3b	0a	8b	0a	0a	0a	0a	14c	13c
	A	2a	3b	6b	1a	0a	3b	4b	1a	3b	11c	2a	7b	2a	20c	0a	0a	0a	19c	11c	16c
	P	0a	3b	4b	0a	0a	3b	4b	0a	4b	4b	2a	1a	1a	13c	0a	0a	0a	0a	24d	14c
45	C	0	0	0	0	0	0	0	0	3a	0	0	0	0	0	0	0	0	0	0	0
	A	0*	0	0	0	0	0	0	0	0a	0	0	0	0	0	0	0	0	0	0	0
	P	0	0	0	0	0	0	0	0	3a	0	0	0	0	0	0	0	0	0	0	0

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^0C)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table14 (d) Effect of storage conditions on daily germination percent for *S. cocculoides* after storage for 20 weeks

DAS*	PM*	43%[1]				32%				22%				11%				5%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
22	C	6b	6b	6b	0a	10b	12c	8b	0a	12c	10b	6b	0a	2a	7b	6b	1a	7b	5b	3b	0a
	A	6b	8b	10b	0a	11c	12c	9b	0a	7b	6b	8b	0a	9b	7b	6b	1a	5b	6b	4b	0a
	P	5b	1a	4a	0a	7b	5b	4b	0a	9b	3a	4a	0a	7b	9b	4b	2a	3b	8b	6b	0a
27	C	28c	19c	28c	0a	23c	26c	32c	0a	14c	18c	20c	1a	8b	10b	15c	4a	12c	16c	16c	5a
	A	28c	17c	17c	0a	25c	26c	32c	0a	29c	22c	18c	3a	15c	11c	19c	5a	12c	24c	24c	5a
	P	27c	25c	28c	0a	13c	12c	5a	0a	15c	9b	17c	1a	11c	11c	14c	6a	4a	8b	8b	2a
32	C	10b	31d	11b	0a	11b	25d	13c	5b	32d	27d	11	4a	15c	40e	21d	9b	13c	11c	11c	8b
	A	11b	32d	30d	0a	12b	24d	11b	5b	17c	15c	17	4a	23d	38c	19c	8b	12c	15c	15c	7b
	P	13c	20d	11c	0a	23d	20d	30d	0a	31d	28d	28d	5b	14c	29d	20d	11b	15c	14c	14c	9b
37	C	10c	3a	11c	0a	2a	2a	8b	1a	1a	2a	14c	3a	17c	5b	11b	11b	8b	17c	17c	9b
	A	11c	8b	8b	0a	1a	2a	7b	1a	7b	11c	20d	2a	6b	8b	10b	14c	15c	10b	10b	6b
	P	4a	6b	11	0a	2a	3a	11c	0	3a	2a	5	3	10b	4a	11b	5a	16c	14c	14c	8b
42	C	3a	4a	3a	0a	10b	2a	4a	0a	1a	1a	7b	3a	7b	2a	2a	6a	4a	4a	7b	2a
	A	3a	1a	1a	0a	10b	2a	2a	0a	5b	4a	1a	5b	6b	3a	6b	7b	6b	2a	2a	1a
	P	2a	3a	3a	0a	10b	9b	3a	0a	1a	6b	2a	1a	6b	2a	5b	2a	8b	6b	16c	6b
47	C	4b	0a	3b	0a	9b	6b	1a	0a	0a	7b	4b	0a	5b	4b	6b	1a	1a	2a	2a	1a
	A	3b	4b	4b	0a	9b	6b	4b	0a	0a	2a	1a	1a	1a	4b	5b	2a	0a	3a	6b	1a
	P	1a	0a	3b	0a	10c	11c	0a	0a	1a	4a	1a	0a	2a	3b	1a	4b	2a	2a	4b	1a

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^{0}C)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table 15 Summary of probabilities for greater F-ratio for daily germination percent for *S. spinosa* after 20 weeks storage

SP	DAS	BLK	MC	TEMP	PM	MC*TEMP	MC*PM	TEMP*PM	MC*TEMP*PM
2	17	0.0471	0.0001	0.0023	0.0001	0.0001	0.0327	0.0001	0.0012
	22	0.2184	0.0001	0.0463	0.0320	0.0001	0.0777	0.0001	0.0148
	27	0.3471	0.0161	0.3286	0.0194	0.0499	0.1767	0.0294	0.0031
	32	0.6444	0.0001	0.0027	0.5816	0.0001	0.0256	0.1099	0.0738
	37	0.2146	0.0001	0.0001	0.1092	0.0001	0.3793	0.1176	0.0001
	42	-	-	-	-	-	-	-	-
4	18	0.9898	0.0004	0.0001	0.0059	0.0001	0.0149	0.9573	0.0415
	23	0.3591	0.0001	0.0001	0.0688	0.0001	0.3041	0.0001	0.2919
	28	0.9648	0.0001	0.0001	0.0164	0.0001	0.0001	0.8131	0.0490
	33	0.2622	0.0131	0.8930	0.0213	0.0001	0.0001	0.0042	0.0001
	38	0.1372	0.0001	0.0001	0.1615	0.0001	0.4697	0.0283	0.0019
	43	0.3942	0.4090	0.3942	0.3699	0.4509	0.4378	0.4269	0.4688
8	20	0.9928	0.0001	0.0001	0.4888	0.0001	0.0001	0.0147	0.0059
	25	0.2011	0.0005	0.0001	0.4606	0.0001	0.0025	0.0924	0.0461
	30	0.1234	0.0001	0.0001	0.0006	0.0001	0.1373	0.1014	0.0030
	35	0.4623	0.0005	0.0306	0.0004	0.0001	0.0022	0.5980	0.0001
	40	0.2474	0.0087	0.0001	0.0122	0.0001	0.0001	0.0005	0.0001
	45	-	-	-	-	-	-	-	-
20	22	0.7708	0.0001	0.0001	0.3276	0.0001	0.2743	0.0012	0.1422
	27	0.6716	0.0001	0.0001	0.1100	0.0001	0.1058	0.0356	0.0014
	32	0.3363	0.0001	0.0001	0.3731	0.0004	0.4544	0.0580	0.0040
	37	0.7801	0.0001	0.0001	0.1432	0.0054	0.0303	0.0004	0.0004
	42	0.3743	0.0001	0.0001	0.0001	0.0001	0.0002	0.0186	0.0001
	47	0.2210	0.0001	0.0001	0.0118	0.0001	0.0001	0.2005	0.0002

SP: Storage period (weeks); DAS: Days after sowing; BLK: Block; TEMP: Temperature; MC: moisture content %; PM: Packaging material

Table 16 (a) Effect of storage conditions on daily germination percent for *S. spinosa* after storage for 2 weeks

DAS*	PM*	41%[1]				31%				21%				10%				5%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
17	C	18c	13c	23d	14c	17c	3a	4a	3a	21d	15c	12c	10c	2a	0a	4a	6b	2a	0a	12c	2a
	A	14c	43c	44e	23d	25d	9b	4a	9b	16c	9b	12c	11c	2a	20d	3a	10c	1a	14c	10c	6b
	P	7b	27d	48c	18c	38d	10b	4a	6b	14c	12c	20d	8b	2a	11c	2a	4a	2a	8b	12c	2a
22	C	27d	51c	32d	29d	11c	34d	51c	37d	40c	49e	43c	45e	38d	48c	46c	46c	36d	35d	43c	42c
	A	34d	17c	19c	15c	33d	34d	46c	20c	45c	48c	46c	47c	52c	36d	36d	40c	40e	38d	25c	40c
	P	33d	33d	16c	26d	49c	38d	38d	18c	45c	51e	48c	47c	52c	47e	34d	42c	48c	49c	33d	38d
27	C	27d	21d	32d	21d	50e	26d	28d	23d	26d	18c	31d	31d	40c	28d	29d	22d	39d	37d	14c	26d
	A	23d	23d	24d	21d	22d	22d	30d	24d	20d	28d	24d	28d	33d	27d	35d	35d	29d	29d	26d	28d
	P	36d	18c	18c	14c	4a	20d	37d	11c	21d	27d	19c	29d	24d	25d	36d	29d	24d	22d	25d	28d
32	C	16c	4a	3a	10c	7b	17c	7b	12c	2a	6b	3a	4a	5b	11c	7b	11c	7b	11c	6b	11c
	A	8b	3a	2a	12c	5b	10c	10c	27d	6b	4a	8b	4a	0a	5b	13c	3a	16c	5b	15c	9b
	P	7b	4a	5b	8b	1a	12c	9b	21d	6b	1a	2a	4a	6b	6b	13c	12c	7b	4a	11c	10c
37	C	6b	3a	5b	5b	4b	8b	0a	5b	0a	0a	0a	0a	0a	0a	0a	2a	0a	2a	3a	3a
	A	8b	3a	2a	10c	2a	13c	0a	5b	0a	0a	0a	0a	0a	0a	0a	3a	0a	3a	8b	5b
	P	6b	14c	4a	6b	1a	13c	0a	18c	0a	0a	0a	0a	0a	0a	0a	0a	0a	1a	7b	7b
42	C	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a
	A	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a
	P	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (°C)

. Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table 16 (b) Effect of storage conditions on daily germination percent for *S. spinosa* after storage for 4 weeks

DAS*	PM*	41%[1]				31%				21%				10%				5%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
18	C	4a	9b	10b	0a	18c	5a	21d	2a	8b	13c	1a	7b	3a	9b	5a	5a	1a	1a	4a	1a
	A	8b	10b	12c	0a	10b	12c	16c	0a	12c	8b	2a	5a	2a	11c	3a	5a	1a	10b	9b	7b
	P	8b	15c	12c	0a	12c	14c	20d	0a	17c	7b	2a	11c	4a	11c	2a	13c	2a	9b	21d	2a
23	C	13c	20d	25d	0a	17c	27d	33d	6b	31d	27d	37d	6b	36d	14c	36d	47e	28d	24	34d	34d
	A	10c	14c	18c	2a	22d	22d	22d	2a	26d	20d	40e	12c	39e	12c	32d	38c	44c	36d	24d	38d
	P	11c	25d	18c	0a	27d	32d	26d	1a	24d	36d	37d	11c	46c	27d	32d	39c	40c	46c	25d	32d
28	C	53c	24d	42c	4a	22d	37d	21d	11c	33d	33d	26d	33d	39e	48e	35d	23d	42e	41c	35d	34d
	A	51c	20d	49c	3a	25d	47c	32d	2a	43c	45e	33d	57e	29d	45c	35d	31d	23d	30d	21d	32d
	P	47c	20d	54c	5a	22d	37d	17c	1a	37d	39c	35d	46c	26d	42c	32d	29d	31d	21d	8b	31d
33	C	13c	26d	8b	6b	27d	19c	12c	14c	9b	7b	22d	32d	5a	8b	8b	11c	11c	15c	1a	11c
	A	9b	41c	6b	14c	25d	0a	14c	21d	4a	7b	13c	8b	17c	13c	13c	14c	16c	7b	24d	10c
	P	11c	24d	5b	7b	20d	4a	13c	21d	5a	4a	14c	12c	8b	8b	0a	0a	5a	7	28	15c
38	C	7b	9b	4a	14c	4a	0a	3a	16c	8b	6b	0a	11c	0a	6b	0a	0a	0a	0a	1a	0a
	A	9b	4a	3a	8b	3a	6b	5b	6b	1a	7b	0a	6b	0a	2a	0a	0a	0a	0a	0a	0a
	P	8b	6b	3a	8b	11c	0a	6b	14c	3a	4a	0a	7b	0a	0a	0a	4b	0a	0a	4b	0a
43	C	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a
	A	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a
	P	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a	0a

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^{0}C)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table16(c) Effect of storage conditions on daily germination percent for *S. spinosa* after storage for 8 weeks

DAS*	PM*	41%[1]				31%				21%				10%				5%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
20	C	33d	33d	29d	0a	10c	30d	38d	2a	37d	11c	33d	19c	35d	14c	4a	13c	24d	40c	0a	17c
	A	37d	26d	28d	7b	3a	24d	16c	2a	26d	13c	5a	21d	40e	28d	14c	14c	18c	35d	4a	34d
	P	31d	34d	26d	2a	12c	24d	21d	1a	35d	14c	20d	13c	31d	30d	10c	14c	26d	36d	9b	28d
25	C	27d	33d	30d	0a	25d	43e	38d	9b	37d	22d	26d	34d	34d	38d	26d	27d	12c	26d	4a	34d
	A	27d	40c	31d	5b	22d	38d	23d	8b	29d	25d	42e	24d	30d	23d	15c	27d	33d	27d	34d	26d
	P	31d	39d	28d	0a	32d	38d	27d	5b	28d	26d	33d	21d	38d	27d	29d	21d	19c	21d	24d	21d
30	C	27d	17c	8b	3a	48c	5a	3a	8b	14c	45c	24d	20d	5a	12c	45e	32d	21d	3a	32d	18c
	A	22d	19c	27d	3a	55c	24d	24d	8b	23d	44c	24d	34d	5a	19c	49e	36d	23d	9b	35d	14c
	P	16c	15c	32d	5a	44c	5a	13c	10b	15c	39d	31d	39d	3a	14c	30d	34d	19c	23d	21d	18c
35	C	3a	4a	15c	11c	2a	5a	7b	11c	7b	5b	2a	6b	6b	17c	2a	9b	16c	1a	26d	0a
	A	0a	4a	0a	1a	4a	0a	21d	8b	4a	2a	7b	2a	11c	5b	3a	4c	8b	3a	1a	0a
	P	3a	3a	2a	10c	1a	11c	14c	11c	5b	2a	1a	2a	11c	13c	1a	0a	5b	0a	26d	5b
40	C	0a	0a	7b	6b	0a	4a	3a	0a	0a	2a	0a	2a	0a	0a	2a	3a	0	6b	8b	0a
	A	0a	0a	0a	9b	0a	0a	0a	0a	0a	2a	7b	0a	0a	6b	2a	5b	0	7b	1a	6b
	P	1a	0a	0a	1a	1a	7b	3a	0a	0a	1a	0a	0a	0a	0a	7b	2a	0	0a	0a	1a
45	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^{0}C)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table 16 (d) Effect of storage conditions on daily germination percent for *S. spinosa* after storage for 20 weeks

DAS*	PM*	41%[1]				31%				21%				10%				5%			
		4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
22	C	18c	20d	25d	0a	20d	14c	15c	0a	27d	14c	15c	3a	14c	15c	13c	4a	16c	15c	8b	6b
	A	13c	22d	13c	0a	9b	14c	16c	0a	21d	17c	16c	7b	13c	13c	17c	8b	10c	10c	14c	10c
	P	10c	19c	17c	0a	17c	15c	6b	0a	15c	18c	15c	11c	13c	10c	8b	6b	18c	12c	10c	8b
27	C	32d	32d	37d	2a	33d	41e	33d	5b	27d	27d	16c	9b	17c	33d	27d	30d	32d	37	38d	30d
	A	32d	28d	37d	6b	22d	26d	35d	8b	29d	14c	18c	8b	27d	31d	27d	30d	28d	31	35d	30d
	P	19c	38d	36d	4a	22d	37d	16c	2a	22d	9b	23d	22d	25d	34d	28d	30d	23d	40e	33d	30d
32	C	19c	11c	12c	8b	21d	25d	30d	7b	16c	28d	29d	29d	25d	16c	18c	12c	12c	10c	12c	7b
	A	19c	16c	31d	11c	34d	22d	19c	15c	18c	23d	28d	29d	18d	14c	18c	12c	12c	15c	14c	7b
	P	31d	13c	12c	10c	39d	17	36d	6b	32d	23d	24d	10c	12c	16c	18c	12c	12c	11c	16c	7b
37	C	10c	9b	6b	3a	4b	0a	2a	8b	9b	9b	10c	8b	17c	8b	8b	3a	6b	8b	5b	3a
	A	11c	11c	10c	3a	13c	15c	9b	0a	9b	19c	9b	8b	8b	8b	8b	3a	7b	5b	5b	3a
	P	11c	3a	11c	4b	3a	2a	17c	6b	12c	20d	0a	5b	8b	8b	10c	3a	6b	5b	4b	3a
42	C	5b	5b	2a	2a	1a	0a	0a	0a	1a	0a	5b	6b	2a	4b	3a	1a	4b	3a	2a	2a
	A	4b	5b	4b	0a	0a	1a	2a	0a	1a	7b	3a	6b	4b	4b	4b	1a	4b	2a	2a	2a
	P	5b	11c	7b	0a	4b	10c	5b	1a	7b	10c	1a	7b	8b	2a	4b	1a	4b	2a	2a	2a
47	C	1a	3a	0a	0a	2a	0a	1a	0a	0a	0	0a	0	0	0	0	0	0	2a	0	0
	A	1a	3a	0a	0a	2a	5b	1a	2a	0a	0	2a	0	0	0	0	0	0	0a	0	0
	P	2a	4b	3a	0a	4b	4b	1a	0a	3a	0	0a	0	0	0	0	0	0	0a	0	0

*DAS: Days after storage; PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^{0}C)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table 17 Summary of probabilities for greater F-ratio for final germination percent for *C. africana* after 20 weeks storage

SP	DAS	BLK	MC	TEMP	PM	MC*TEMP	MC*PM	TEMP*PM	MC*TEMP*PM
2	15	0.0735	0.0001	0.0001	0.1092	0.0183	0.0216	0.8885	0.0324
	20	0.0534	0.0001	0.0001	0.0982	0.0001	0.4774	0.5287	0.7061
	25	0.1106	0.0001	0.0001	0.0051	0.0001	0.9406	0.2003	0.9875
	30	0.4689	0.0001	0.0001	0.0001	0.0001	0.9255	0.0055	0.9737
	35	0.0776	0.0001	0.0001	0.0001	0.0001	0.7148	0.0093	0.9808
	40	0.1787	0.0001	0.0001	0.0001	0.0001	0.7650	0.0127	0.9936
4	16	0.0735	0.0001	0.0001	0.1092	0.0183	0.0216	0.8885	0.0324
	21	0.0534	0.0001	0.001	0.0982	0.0001	0.4774	0.5287	0.7061
	26	0.1106	0.0001	0.0001	0.0051	0.0001	0.9406	0.2003	0.9875
	31	0.4689	0.0001	0.0001	0.0001	0.0001	0.9255	0.0055	0.9737
	36	0.0776	0.0001	0.0001	0.0001	0.0001	0.7148	0.0093	0.9808
	41	0.1787	0.0001	0.0001	0.0001	0.0001	0.7650	0.0127	0.9936
8	18	0.9754	0.0042	0.0001	0.0001	0.0477	0.1179	0.0001	0.1286
	23	0.7360	0.0001	0.0001	0.0001	0.0001	0.7135	0.0008	0.7689
	28	0.2006	0.0001	0.0001	0.0001	0.0001	0.9446	0.0001	0.2608
	33	0.0154	0.0001	0.0001	0.0001	0.0001	0.6584	0.0001	0.0941
	38	0.3532	0.0001	0.0001	0.0001	0.0001	0.7062	0.0001	0.4636
	43	0.3532	0.0001	0.0001	0.0001	0.0001	0.7062	0.0001	0.4636
20	20	0.3942	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	25	0.7690	0.0001	0.0001	0.0002	0.0001	0.0130	0.0028	0.1438
	30	0.2660	0.0001	0.0001	0.0001	0.0001	0.1696	0.0001	0.8387
	35	0.2304	0.0001	0.0001	0.0001	0.0001	0.1563	0.0001	0.8023
	40	0.2304	0.0001	0.0001	0.0001	0.0001	0.1563	0.0001	0.8023
	45	0.2304	0.0001	0.0001	0.0001	0.0001	0.1563	0.0001	0.8023

SP: Storage period (weeks); DAS: Days after sowing; BLK: Block; TEMP: Temperature; MC: moisture content %; PM: Packaging material

Table 18 Summary of for greater F-ratio for final germination percent for C. *densiflora* after 20 weeks storage

SP	DAS	BLK	MC	TEMP	PM	MC*TEMP	MC*PM	TEMP*PM	MC*TEMP*PM
2	8	0.0391	0.0001	0.0001	0.0001	0.0001	0.0004	0.0001	0.0001
	13	0.4156	0.0001	0.0001	0.0067	0.0001	0.0001	0.0001	0.0001
	18	0.3374	0.0001	0.0001	0.0001	0.0001	0.0020	0.0001	0.0204
	23	0.8342	0.0001	0.0001	0.0001	0.0001	0.2073	0.0001	0.0030
	28	0 6073	0.0001	0.0001	0.0009	0.0001	0.3831	0.0001	0.0068
	33	0.7131	0.0001	0.0001	0.0174	0.0001	0.7880	0.0403	0.9599
4	10	0.3146	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	15	0.5972	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	20	0.7591	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	25	0.1381	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	30	0.3584	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	35	0.3704	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
8	11	0.0959	0.0001	0.0001	0.0010	0.0001	0.0001	0.0117	0.0001
	16	0.8350	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	21	0.7077	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	26	0.1739	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	31	0.1089	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	36	0.0317	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
20	13	0.3678	0.0001	0.0001	0.0663	0.0001	0.1639	0.3017	0.2602
	18	0.0502	0.0001	0.0001	0.0001	0.0001	0.1071	0.0001	0.4994
	23	0.0001	0.0001	0.0001	0.0001	0.0001	0.0248	0.0001	0.0078
	28	0.0001	0.0001	0.0001	0.0001	0.0001	0.1194	0.0001	0.0495
	33	0.0001	0.0001	0.0001	0.0001	0.0001	0.1748	0.0001	0.1298
	38	0.0001	0.0001	0.0001	0.0001	0.0001	0.1748	0.0001	0.1298

SP: Storage period (weeks); DAS: Days after sowing; BLK: Block; TEMP: Temperature; MC: moisture content %; PM: Packaging material

Table 19 Summary of probabilities for greater F-ratio for final germination percent for *S. cocculoides* after 20 weeks storage

SP	DAS	BLK	MC	TEMP	PM	MC*TEMP	MC*PM	TEMP*PM	MC*TEMP*PM
2	17	0.2739	0.0011	0.0001	0.4538	0.0001	0.1587	0.0274	0.0002
	22	0.5014	0.0001	0.0001	0.7324	0.0001	0.0795	0.0001	0.0002
	27	0.3996	0.0001	0.0001	0.0021	0.0001	0.0186	0.0001	0.0007
	32	0.9477	0.0001	0.0001	0.0089	0.0001	0.0101	0.0001	0.0296
	37	0.7582	0.0001	0.0001	0.0160	0.0001	0.1728	0.0009	0.7868
	42	0.6322	0.0001	0.0001	0.0003	0.0001	0.1879	0.0029	0.5065
4	18	0.7754	0.0001	0.0001	0.5505	0.0001	0.3183	0.2588	0.5634
	23	0.1898	0.0001	0.0001	0.0007	0.0001	0.3066	0.0406	0.0029
	28	0.6763	0.0001	0.0001	0.0500	0.0007	0.1625	0.2395	0.0012
	33	0.7124	0.0001	0.0001	0.5730	0.0060	0.8997	0.0484	0.0465
	38	0.9285	0.0001	0.0001	0.4298	0.0008	0.7303	0.0048	0.5937
	43	0.8742	0.0001	0.0001	0.6115	0.0073	0.8250	0.0069	0.7896
8	20	0.3431	0.0001	0.0001	0.0026	0.0001	0.7014	0.0503	0.0003
	25	0.6085	0.0001	0.0001	0.0001	0.0001	0.7269	0.0001	0.0067
	30	0.5989	0.0001	0.0001	0.0001	0.0001	0.0105	0.3955	0.0001
	35	0.1587	0.0001	0.0001	0.0001	0.0001	0.0927	0.0073	0.0001
	40	0.3087	0.0001	0.0001	0.0001	0.0001	0.2313	0.0072	0.0001
	45	0.3575	0.0001	0.0001	0.0001	0.0001	0.1820	0.0067	0.0001
20	22	0.7754	0.0001	0.0001	0.5505	0.0001	0.3183	0.2588	0.5634
	27	0.2140	0.0081	0.0001	0.0001	0.0001	0.0001	0.0702	0.0874
	32	0.9139	0.0001	0.0001	0.0001	0.0001	0.0008	0.0477	0.0203
	37	0.6492	0.0001	0.0001	0.0001	0.0001	0.2996	0.1642	0.6556
	42	0.9542	0.0001	0.0001	0.0001	0.0001	0.0126	0.2423	0.4985
	47	0.8257	0.0001	0.0001	0.0001	0.0001	0.0736	0.4345	0.3087

SP: Storage period (weeks); DAS: Days after sowing; BLK: Block; TEMP: Temperature; MC: moisture content %; PM: Packaging material

Table 20 Summary of probabilities for greater F-ratio for final germination percent for *S. spinosa* after 20 weeks storage

SP	DAS	BLK	MC	TEMP	PM	MC*TEMP	MC*PM	TEMP*PM	MC*TEMP*PM
2	17	0.0471	0.0001	0.0023	0.0001	0.0001	0.0327	0.0001	0.0012
	22	0.6711	0.0001	0.0001	0.0329	0.0001	0.4573	0.0001	0.0001
	27	0.0607	0.0001	0.0001	0.6643	0.0001	0.5645	0.0354	0.0519
	32	0.0964	0.0001	0.0001	0.1562	0.0001	0.7245	0.0601	0.0767
	37	0.4254	0.0554	0.0002	0.8118	0.0001	0.3904	0.049	0.8966
	42	0.4043	0.0559	0.0003	0.8175	0.0001	0.3878	0.0458	0.9094
4	18	0.9898	0.0004	0.0001	0.0059	0.0001	0.0149	0.9573	0.0415
	23	0.3643	0.0001	0.0001	0.0039	0.0001	0.0234	0.0004	0.2633
	28	0.2445	0.0001	0.0001	0.5549	0.0001	0.0007	0.0034	0.0003
	33	0.2656	0.0001	0.0001	0.4187	0.0001	0.1051	0.1067	0.8659
	38	0.9313	0.0001	0.0001	0.9651	0.0001	0.2538	0.5795	0.3176
	43	0.9241	0.0001	0.0001	0.9758	0.0001	0.2547	0.6004	0.3306
8	20	0.9928	0.0001	0.0001	0.4888	0.0001	0.0001	0.0147	0.0059
	25	0.4445	0.0005	0.0001	0.7574	0.0001	0.0001	0.0213	0.0001
	30	0.3624	0.0001	0.0001	0.0002	0.0001	0.0010	0.6518	0.0001
	35	0.7071	0.0001	0.0001	0.2989	0.0001	0.2469	0.4321	0.0116
	40	0.2864	0.0001	0.0001	0.1069	0.0001	0.1302	0.1101	0.2297
	45	0.3847	0.0001	0.0001	0.1607	0.0001	0.4993	0.1669	0.4344
20	22	0.7708	0.0001	0.0001	0.3276	0.0001	0.2743	0.0012	0.1422
	27	0.9363	0.0001	0.0001	0.0576	0.0001	0.1700	0.0131	0.0029
	32	0.4596	0.0946	0.0001	0.0280	0.0001	0.4092	0.0020	0.0456
	37	0.4535	0.0001	0.0001	0.0281	0.0001	0.7535	0.0951	0.7620
	42	0.1166	0.0001	0.0001	0.8917	0.0001	0.7182	0.0244	0.2871
	47	0.2027	0.0001	0.0001	0.9661	0.0001	0.4800	0.0115	0.0813

SP: Storage period (weeks); DAS: Days after sowing; BLK: Block; TEMP: Temperature; MC: moisture content %; PM: Packaging material

4.4.2 Radicle elongation, germination value and germination energy

4.4.2.1 Radicle elongation

For *C. africana* and *C. densiflora*, radicle elongation was significantly ($P < 0.05$) affected by moisture content, temperature and packaging material (Table 21 and 22). In general, storage of seed with high moisture content at 16^0 C resulted in optimum radicle elongation. For *C. africana* after two weeks of storage highest radicle elongation (19mm) was recorded in seeds stored with moisture content of 50% at 16^0 C in cotton bags followed by those with moisture content of 38% at 16^0C in cotton bags (18mm). Radicle elongation was least for seeds which were stored with moisture content of 25% at 4^0 C in polyethylene bags (Figure 9). For *C. densiflora*, the highest radicle elongation was 42 mm for seeds which were stored with moisture content of 54% at 16^0C in cotton bags followed by those which were stored with moisture content of 41% at 16^0 C in cotton bags (41mm), while the least radicle elongation (8mm) was recorded for seeds which were stored with moisture content of 10% at 4^0 C in polyethylene bags (Figure 10).

For both *C. africana* and *C. densiflora*, there were significant interaction between moisture content and temperature and temperature, and packaging material ($P < 0.05$) (Tables 21 and 22). Generally for both *C. africana* and *C. densiflora* seeds that were stored with their initial moisture content at 16^0 C in cotton bags had higher radicle elongation than those under other storage conditions, while, in both cases no radicle elongated for seeds that were stored at -20^0 C, while those stored at 4^0 C no radicle elongated beyond four weeks of storage and very little elongation was noted for seeds stored at 25^0 C (Figures 9 and 10). In addition, radicle elongation declined with increase in the storage time for all storage conditions (Figures 9 and 10). After 20 weeks of storage the highest radicle elongation was recorded in seeds which was stored with moisture contents of 38% (12mm) and 54% (27mm) at 16^0 C in cotton bags for *C. africana* and *C. densiflora* respectively (Figures 9 and 10). Therefore, for both *C. africana* and *C. densiflora* cotton bags and 16^0 C temperature improved radicle elongation (Figures 9 and 10) and there was strong interaction between moisture content and temperature, and temperature and packaging material ($P < 0.05$) (Tables 21 and 22).

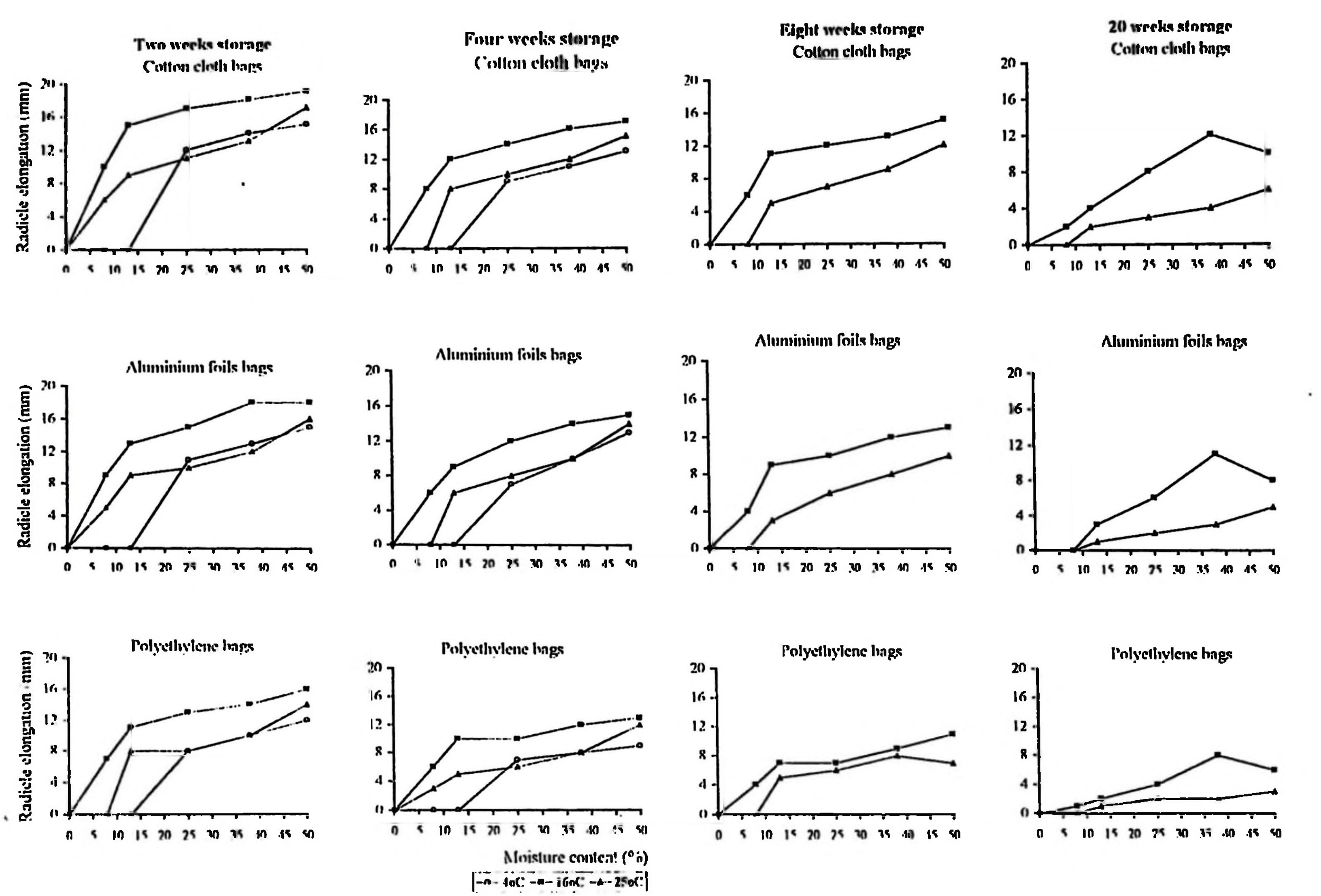


Figure 9: Effect of storage conditions on radicle elongation (mm) of *C. africana* seeds after storage for 20 weeks.

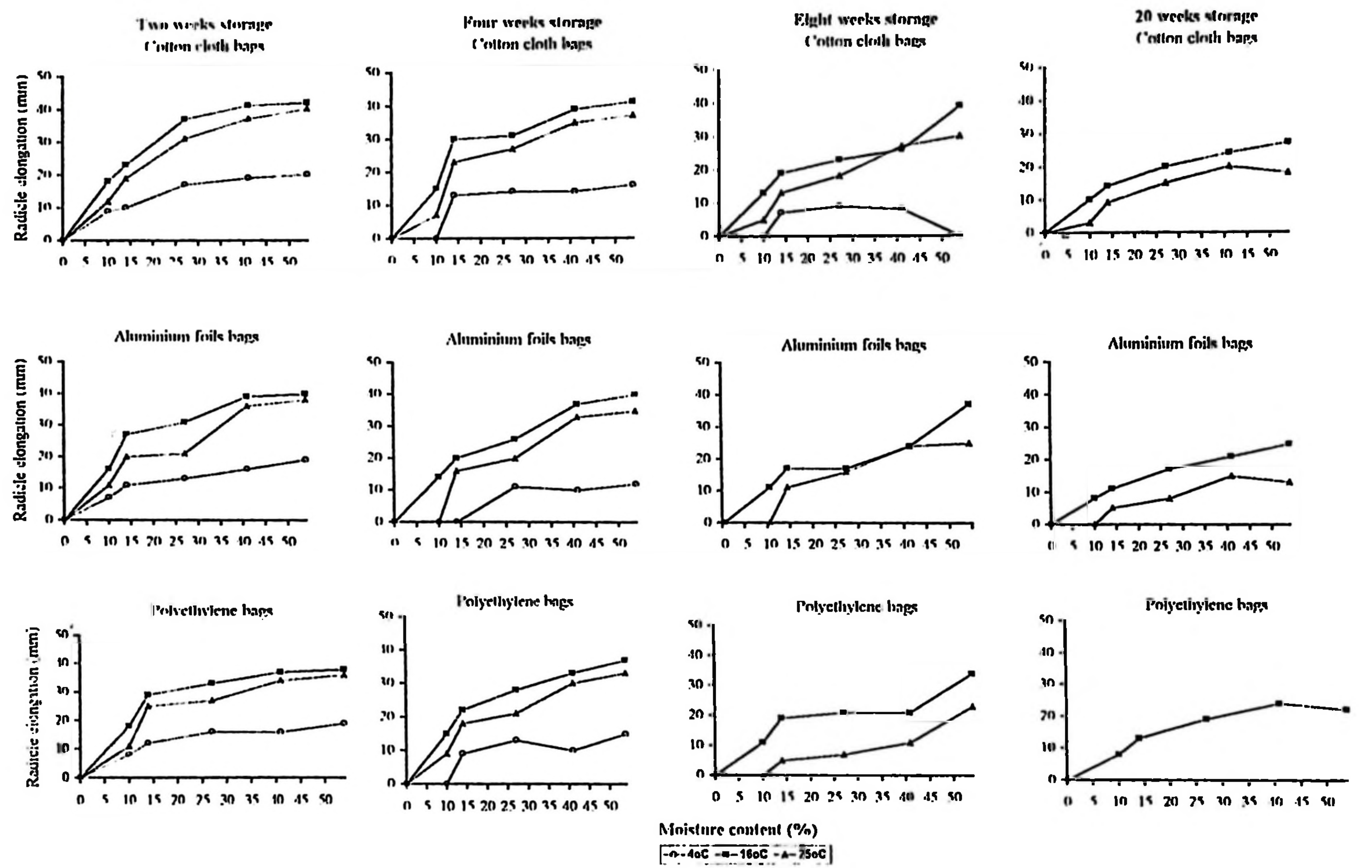


Figure 10: Effect of storage conditions on radicle elongation (mm) of *C. densiflora* seeds after storage for 20 weeks.

Table 21 Summary of ANOVA probabilities for greater F-ratio for Radicle elongation (mm) for *C. africana* after 20 weeks storage

SP	DAS	BLK	MC	TEMP	PM	MC*TEMP	MC*PM	TEMP*PM	MC*TEMP*PM
2	15	-	-	-	-	-	-	-	-
	20	-	-	-	-	-	-	-	-
	25	0.0040	0.0001	0.0001	0.0001	0.0001	0.6326	0.0001	0.3830
	30	0.0010	0.0001	0.0001	0.0001	0.0001	0.0505	0.0001	0.4990
	35	0.0037	0.0001	0.0001	0.0001	0.0001	0.0431	0.0001	0.1794
	40	0.0327	0.0001	0.0001	0.0001	0.0001	0.1283	0.0001	0.0025
4	16	-	-	-	-	-	-	-	-
	21	-	-	-	-	-	-	-	-
	26	0.0040	0.0001	0.0001	0.0001	0.0001	0.6326	0.0001	0.3830
	31	0.0010	0.0001	0.0001	0.0001	0.0001	0.0505	0.0001	0.4990
	36	0.0037	0.0001	0.0001	0.0001	0.0001	0.0431	0.0001	0.1794
	41	0.0327	0.0001	0.0001	0.0001	0.0001	0.1283	0.0001	0.0025
8	18	-	-	-	-	-	-	-	-
	23	-	-	-	-	-	-	-	-
	28	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	33	0.0649	0.0001	0.0001	0.0001	0.0001	0.0567	0.0001	0.0033
	38	0.0086	0.0001	0.0001	0.0001	0.0001	0.4059	0.0001	0.0335
	43	0.0015	0.0001	0.0001	0.0001	0.0001	0.0126	0.0001	0.0002
20	20	-	-	-	-	-	-	-	-
	25	-	-	-	-	-	-	-	-
	30	-	-	-	-	-	-	-	-
	35	0.9054	0.0001	0.0001	0.0001	0.0001	0.0039	0.0001	0.0001
	40	0.3188	0.0001	0.0001	0.0001	0.0001	0.0004	0.0001	0.0185
	45	0 1813	0.0001	0.0001	0.0001	0.0001	0.0097	0.0001	0.2023

SP: Storage period (weeks); DAS: Days after sowing; BLK: Block; TEMP: Temperature; MC: moisture content %; PM: Packaging material

Table 22 Summary of ANOVA probabilities for greater F-ratio for radicle elongation (mm) for *C. densijlora* after 20 weeks storage

SP	DAS	BLK	MC	TEMP	PM	MC*TEMP	MC*PM	TEMP*PM	MC*TEMP*PM
2	8	0.2433	0.0001	0.0001	0.1050	0.0001	0.0442	0.1447	0.6304
	13	0.9185	0.0001	0.0001	0.0002	0.0001	0.0917	0.1770	0.9705
	18	0.8433	0.0001	0.0001	0.0001	0.0001	0.0063	0.0009	0.4101
	23	0.7860	0.0001	0.0001	0.0001	0.0001	0.2213	0.0001	0.2812
	28	0.7312	0.0001	0.0001	0.0001	0.0001	0.0001	0.0045	0.6117
	33	0.6939	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
4	10	0.7957	0.0001	0.0001	0.8151	0.0001	0.0002	0.0935	0.0013
	15	0.3301	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0104
	20	0.1702	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0003
	25	0.2362	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	30	0.2341	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	35	0.1298	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
8	11	0.0279	0.0001	0.0001	1.0000	0.0001	0.5067	1.0000	0.5839
	16	0.0430	0.0001	0.0001	0.0002	0.0001	0.0054	0.0040	0.0093
	21	0.1805	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	26	0.3683	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	31	0.3371	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	36	0.4730	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
20	13	-	-	-	-	-	-	-	-
	18	0.1339	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	23	0.0417	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	28	0.0835	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	33	0.0024	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	38	0.0037	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

SP: Storage period (weeks); DAS: Days after sowing; BLK: Block; TEMP: Temperature; MC: moisture content %; PM: Packaging material

For *S. cocculoides* and *S. spinosa*, moisture content, temperature and packaging material significantly ($P < 0.05$) contributed very much to radicle elongation (Tables 23 and 24). The highest radicle elongation of 55mm and 43mm were reached for seeds which were stored with moisture content of 43% at 16^0 C in cotton bags and polyethylene bags and those stored with moisture content of 41% at 16^0 C in cotton and aluminum foil bags for *S. cocculoides* and *S. spinosa* respectively (Figures 11 and 12). Contrary to *C. africana* and *C. densiflora*, radicle elongation for *S. cocculoides* and *S. spinosa* was not very sensitive and *C. densiflora*, radicle elongation for *S. cocculoides* and *S. spinosa* was not very sensitive to extreme of temperature (-20^0 C) and moisture content (5%) (Figures 11 and 12). Consequently after 20 weeks of storage radicle continued to elongate for seed that were stored at –20^0 C and moisture content of 5%. Maximum radicle elongation was 20mm and 13mm in cotton bags for *S. cocculoides* and *S. spinosa* respectively (Figures 11 and 12). For both *S. cocculoides* and *S. spinosa*, strong interactions were noted between moisture content and temperature, and temperature and packaging material ($P < 0.05$; Tables 23 and 24).

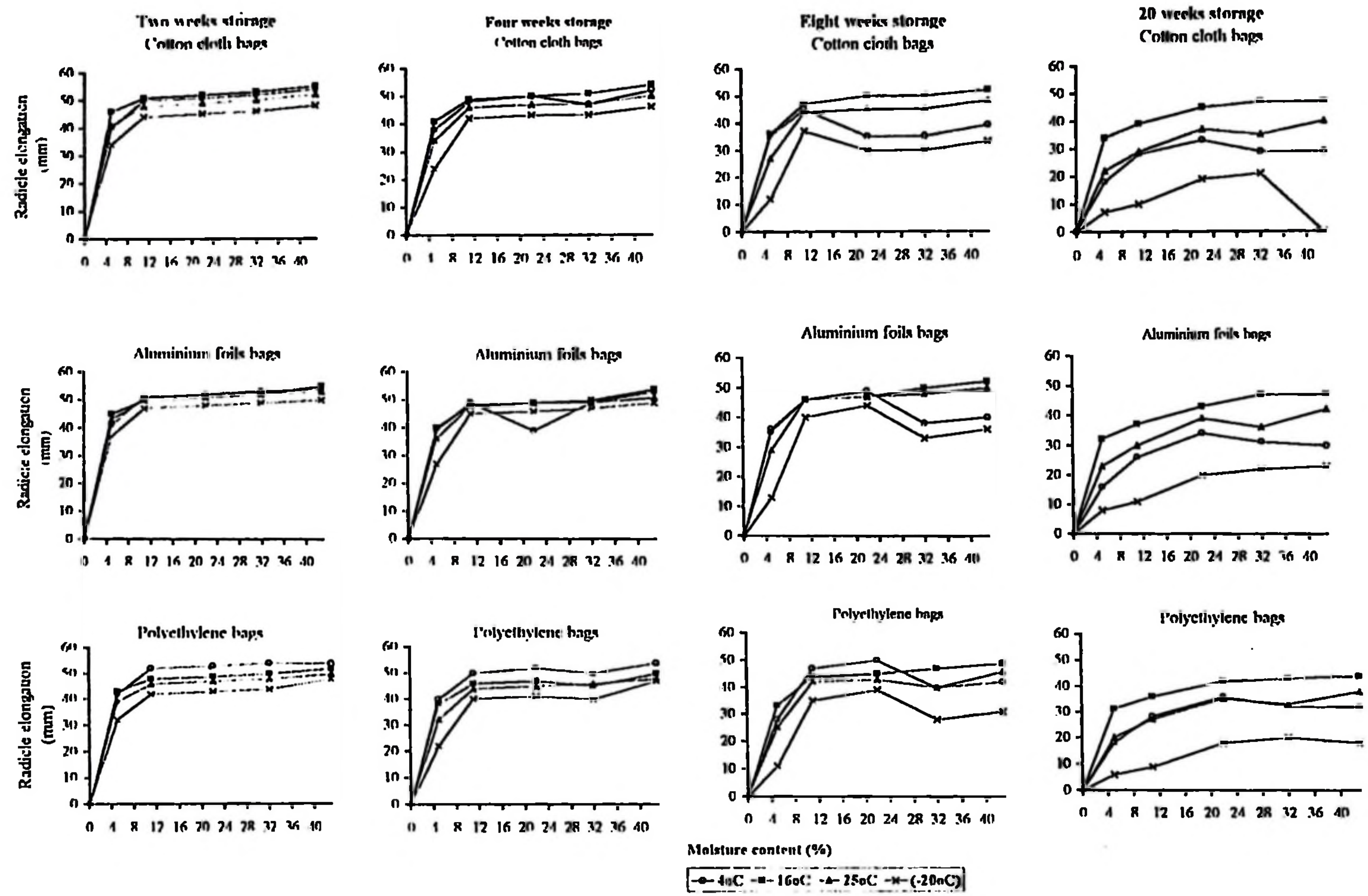


Figure 11: Effect of storage conditions on radicle elongation (mm) of *S. cocculoides* seeds after storage for 20 weeks.

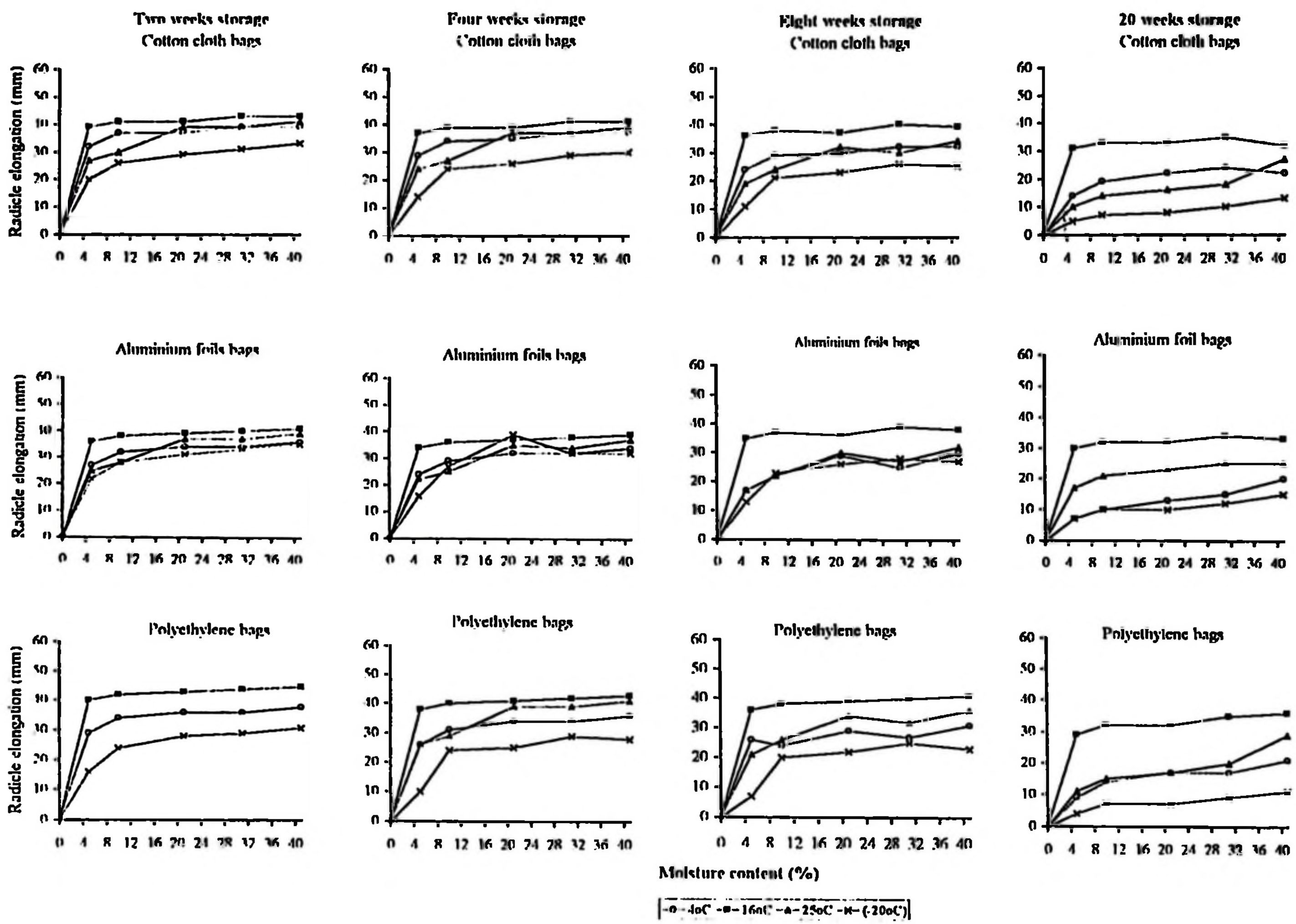


Figure 12: Effect of storage conditions on radicle elongation (mm) of *S. spinosa* seeds after storage for 20 weeks.

Table 23 Summary of ANOVA probabilities for greater F-ratio for radicle elongation (mm) for *S. cocculoides* after 20 weeks storage

SP	DAS	BLK	MC	TEMP	PM	MC*TEMP	MC*PM	TEMP*PM	MC*TEMP*PM
2	17	0.9781	0.0001	0.0001	0.0001	0.0001	0.9143	0.0001	0.6691
	22	0.4811	0.0001	0.0001	0.0001	0.5974	0.9883	0.0001	1.0000
	27	0.3027	0.0001	0.0001	0.0001	0.0001	0.9797	0.0001	0.9824
	32	0.3166	0.0001	0.0001	0.0001	0.0001	0.8943	0.0001	0.9546
	37	0.6338	0.0001	0.0001	0.0001	0.0001	0.9912	0.0001	1.0000
	42	0.6338	0.0001	0.0001	0.0001	0.0001	0.9941	0.0001	0.9028
4	18	0.3605	0.0001	0.0001	0.0001	0.0047	0.2791	0.0001	0.2996
	23	0.5322	0.0001	0.0001	0.0001	0.0759	0.1194	0.0001	0.6560
	28	0.3866	0.0001	0.0001	0.0001	0.0001	0.7178	0.0001	0.9998
	33	0.4622	0.0001	0.0001	0.0001	0.0001	0.0049	0.0001	0.8212
	38	0.3261	0.0001	0.0001	0.0001	0.0001	0.9475	0.0001	0.9926
	43	0.4718	0.0001	0.0001	0.0001	0.0001	0.5720	0.0001	0.1758
8	20	0.0511	0.0001	0.0001	0.0001	0.0001	0.9078	0.0001	0.0001
	25	0.1632	0.0001	0.0001	0.0001	0.0001	0.0023	0.0001	0.0437
	30	0.7473	0.0001	0.0001	0.0001	0.0001	0.0664	0.0001	0.0008
	35	0.3133	0.0001	0.0001	0.0001	0.0001	0.0058	0.0001	0.0001
	40	0.4428	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	45	0.4041	0.0001	0.0001	0.0001	0.0001	0.3074	0.0001	0.2347
20	22	0.3605	0.0001	0.0001	0.0001	0.0047	0.2791	0.0001	0.2996
	27	0.6283	0.0001	0.0001	0.0001	0.0001	0.0699	0.0001	0.0001
	32	0.8837	0.0001	0.0001	0.0001	0.0001	0.3320	0.0001	0.0018
	37	0.5379	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	42	0.8050	0.0001	0.0001	0.0001	0.0001	0.0053	0.0001	0.0263
	47	0.6939	0.0001	0.0001	0.0001	0.0001	0.2345	0.0001	0.8820

SP: Storage period (weeks); DAS: Days after sowing; BLK: Block; TEMP: Temperature; MC: moisture content %; PM: Packaging material

Table 24 Summary of ANOVA probabilities for greater F-ratio for radicle elongation (mm) for *S. spinosa* after 20 weeks storage

SP	DAS	BLK	MC	TEMP	PM	MC*TEMP	MC*PM	TEMP*PM	MC*TEMP*PM
2	17	0.6457	0.0001	0.0001	0.0001	0.2880	0.7681	0.0001	0.9575
	22	0.9944	0.0001	0.0001	0.0549	0.0001	0.0962	0.0001	0.0008
	27	0.8388	0.0001	0.0001	0.0214	0.0001	0.0001	0.0001	0.0001
	32	0.9946	0.0001	0.0001	0.0001	0.0001	0.0117	0.0001	0.0001
	37	0.8890	0.0001	0.0001	0.0001	0.0001	0.1673	0.0001	0.5935
	42	0.9244	0.0001	0.0001	0.0001	0.0001	0.5486	0.0001	0.9501
4	18	0.5986	0.0001	0.0001	0.0001	0.0012	0.0393	0.0001	0.8932
	23	0.7347	0.0001	0.0001	0.0005	0.0001	0.2140	0.0001	0.5071
	28	0.8267	0.0001	0.0001	0.0107	0.0001	0.0102	0.0001	0.0066
	33	0.7509	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	38	0.7604	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	43	0.8408	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
8	20	0.5370	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0080
	25	0.8932	0.0001	0.0001	0.0001	0.0001	0.56712	0.0001	0.0683
	30	0.9692	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0026
	35	0.8736	0.0001	0.0001	0.0001	0.0001	0.0153	0.0001	0.0001
	40	0.9056	0.0001	0.0001	0.0001	0.0001	0.0064	0.0001	0.0001
	45	0.8846	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
20	22	0.3942	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	27	0.4708	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	32	0.9504	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	37	0.7800	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	42	0.7528	0.0001	0.0001	0.0001	0.0001	0.0029	0.0001	0.0001
	47	0.6876	0.0001	0.0001	0.0001	0.0001	0.0057	0.0001	0.0001

SP: Storage period (weeks); DAS: Days after sowing; BLK: Block; TEMP: Temperature; MC: moisture content %; PM: Packaging material

4.4.2 2 Germination phases

Imbibition period (the number of days from sowing to completion of germination) for *C. africana* and *C. densiflora* was shortest for seeds that were stored with their initial moisture content at 16^{0}C in cotton bags (14 and 6 days respectively) and longest for seeds with lowest moisture content that were stored at 4^0 C in polyethylene bags (Tables

20a,b). Imbibition period increased with reduction stet moisture content and increase in storage period.

For *C. africana* and *C. densiflora*, total germination period was longest (40 days) for seeds that were stored at 4°C and shortest (36 and 26) for seed that were stored at 16°C respectively (Tables 25 and 26). *Strychnos cocculoides* and *S. spinosa* followed the same trend (Tables 27 and 28). The shortest imbibition period (16 days) was recorded for seeds that were stored at 16°C with initial moisture content of 34 and 41% for *S. cocculoides* and *S. spinosa* respectively and the longest (22 days) for seeds stored at -20°C (Tables 27 and 28). Generally for all species, packaging material had no effect on imbibition period and total germination period (Tables 25, 26, 27 and 28).

4.4.3 Germination value and germination energy

For *C. africana* and *C. densiflora* seeds, germination energy and germination value were higher in seeds which were stored with their initial moisture content of 50 and 54% at 16°C in cotton bags respectively (Figures 13 and 14). Highest germination value of 17.4 was attained by *C. africana* seeds after four weeks of storage with moisture content of 50% at 16° C in aluminum foil bags (Figure 13), whilst *C. densiflora* seeds had highest germination value of 48 for seeds that were stored with moisture content of 54% at 16° C in polyethylene bags (Figure 14) after two weeks of storage.

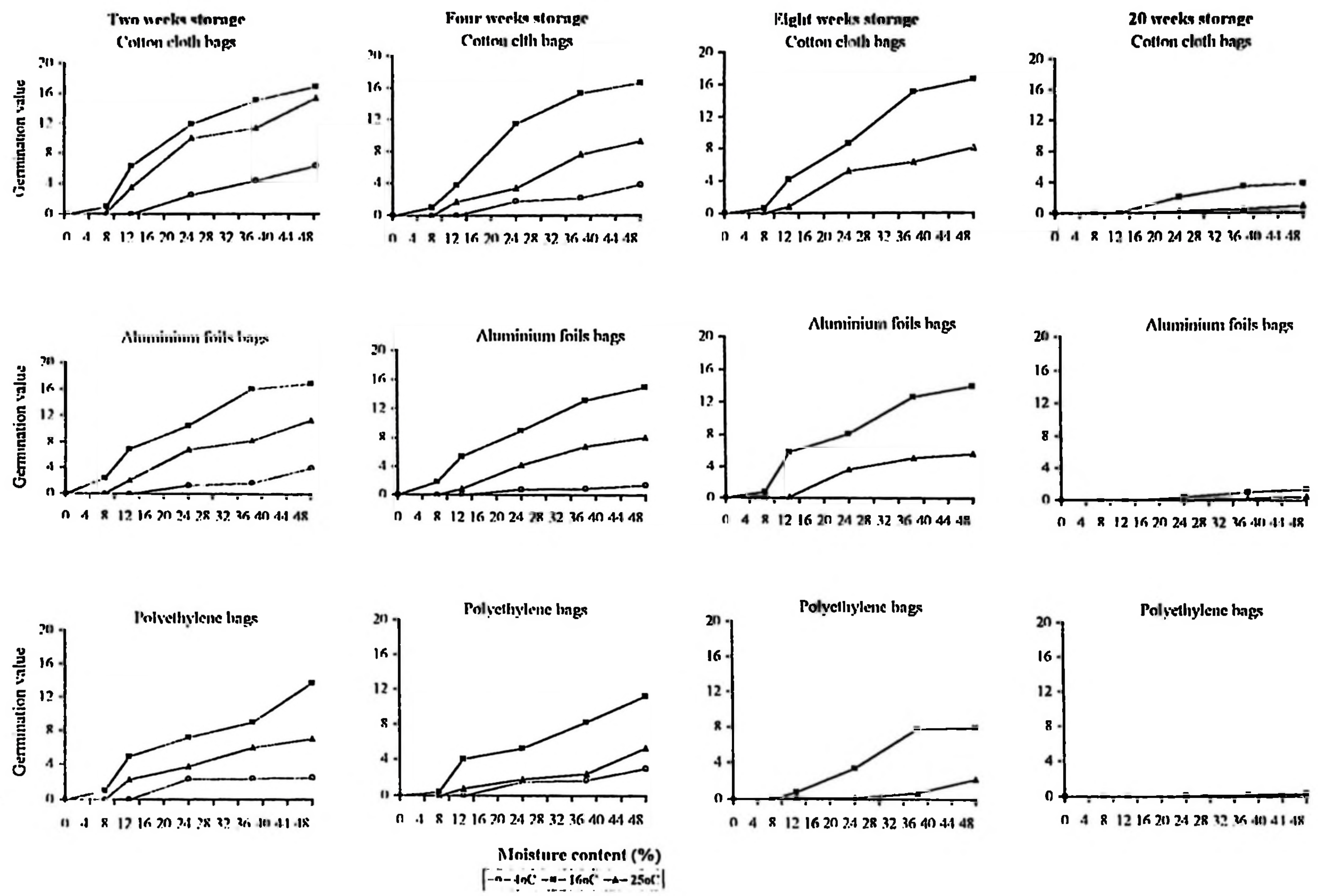


Figure 13 Effect of storage conditions on germination value of *C. africana* seeds after storage for 20 weeks.

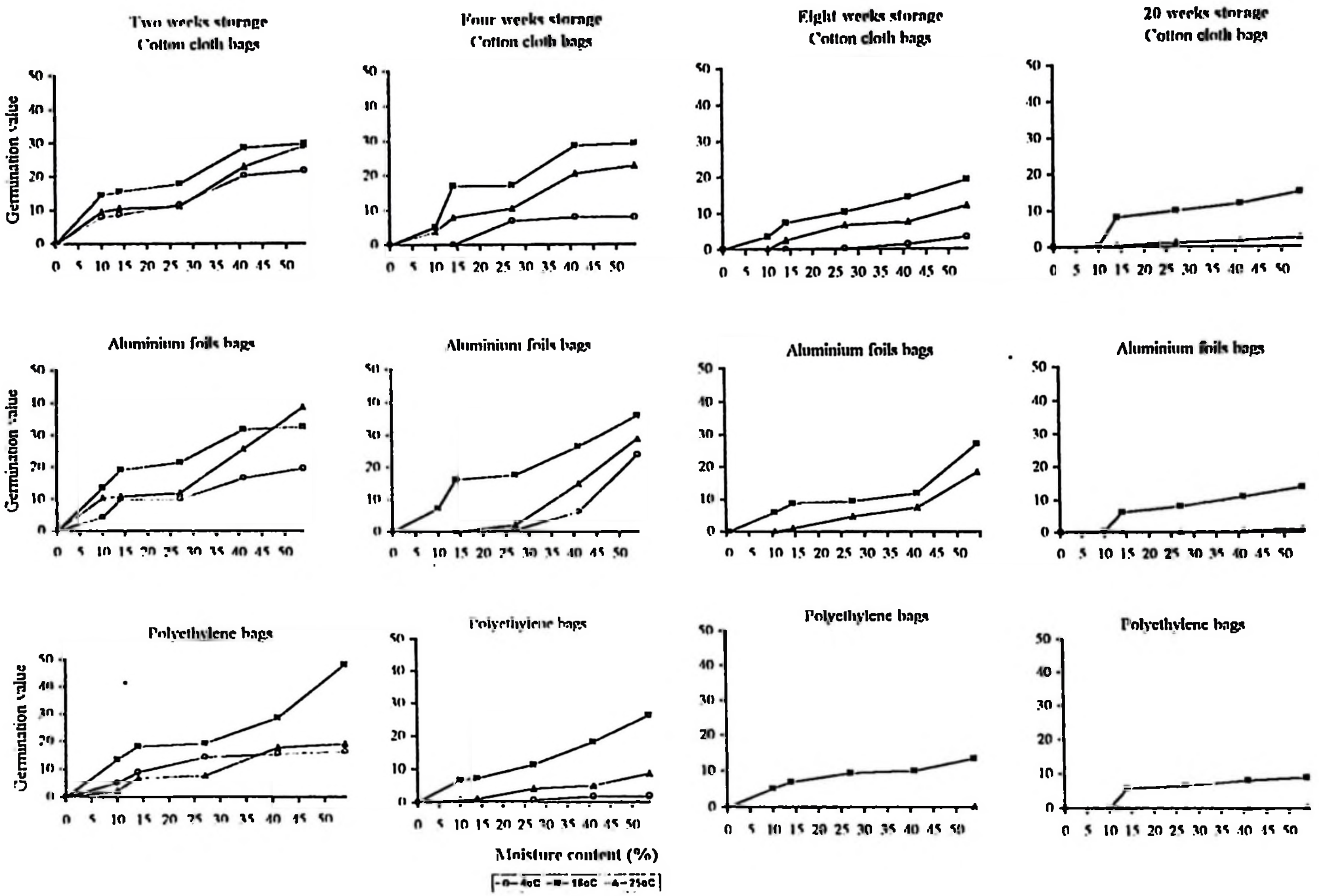


Figure 14: Effect of storage conditions on germination value of *C. densiflora* seeds after storage for 20 weeks.

For *S. cocculoides* and *S. spinosa*, germination value and germination energy were higher for seeds that were stored at 16^0 C followed by those stored at 4^0 C in polyethylene bags. No remarkable trend was noted for moisture content and packaging material. *For S. cocculoides* seeds, the highest germination value (23.85) was attained after 20 weeks of storage of seeds with moisture content of 32% at 16^0 C in aluminum foil bags (Figure 15). *S. spinosa* seeds had highest germination value of 35.45 for seeds that were stored with moisture content of 31% at 16^0 C in polyethylene bags (Figure 16). Both *S. cocculoides* and *S. spinosa* had lowest germination values for seeds that were stored at–20^0 C.

The highest germination energy for *C. africana* (80%) was recorded for seeds that were stored with moisture content of 50% at 16^0 C in cotton bags after two weeks of storage (Figure 17). For *C. densiflora* the highest germination energy (87.5%) was recorded for seeds that were stored with 41% moisture content at 16^0 C in aluminum foil bags (Figure 18). For both *C. africana* and *C. densiflora* germination value and germination energy were very much reduced for seeds that were stored at 4^{0}C and nothing was recoded at –20^{0}C.

The highest germination energy for *S. cocculoides* (77.5%) was recorded for seeds that were stored with moisture content of 22% at 16^0 C in polyethylene bags (Figure 19) after storage for 2 weeks. *S. spinosa* had highest germination energy of 88% for seeds that were stored with moisture content of 31% at 4^0 C in polyethylene bags (Figure 20).

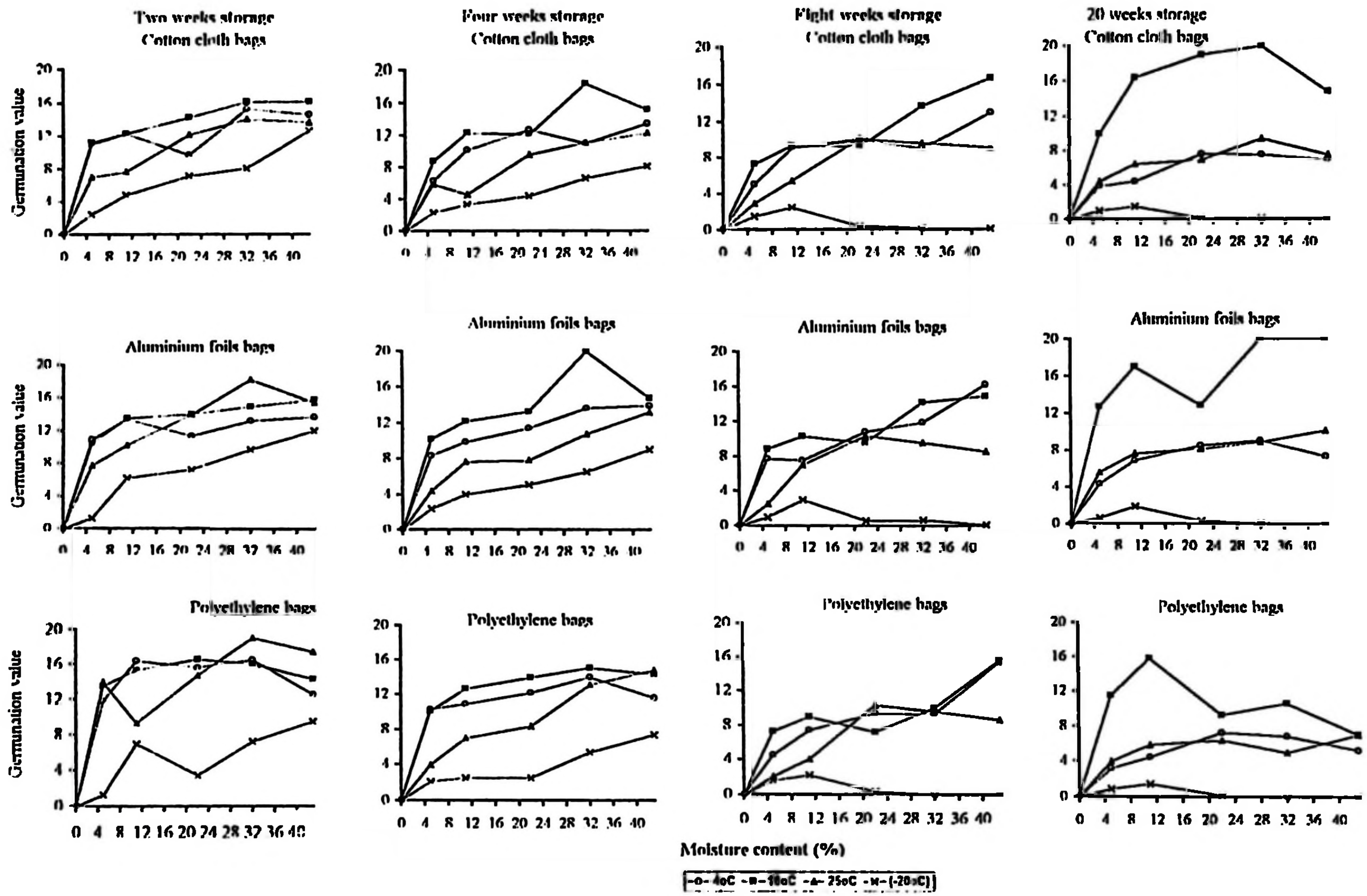


Figure 15: Effect of storage conditions on germination value of *S. cocculoides* seeds after storage for 20 weeks.

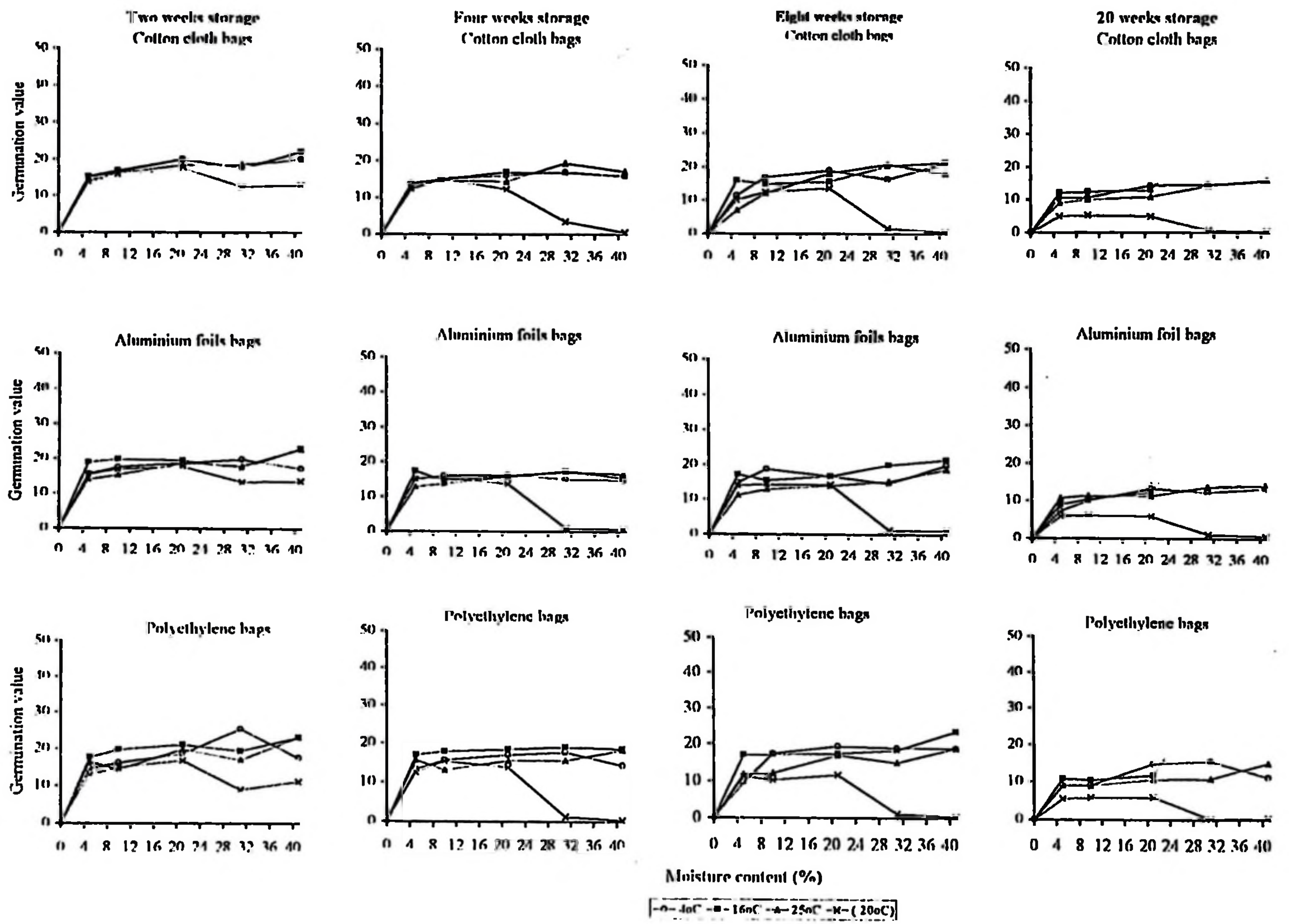


Figure 16: Effect of storage conditions on germination value of *S. spinosa* seeds after storage for 20 weeks.

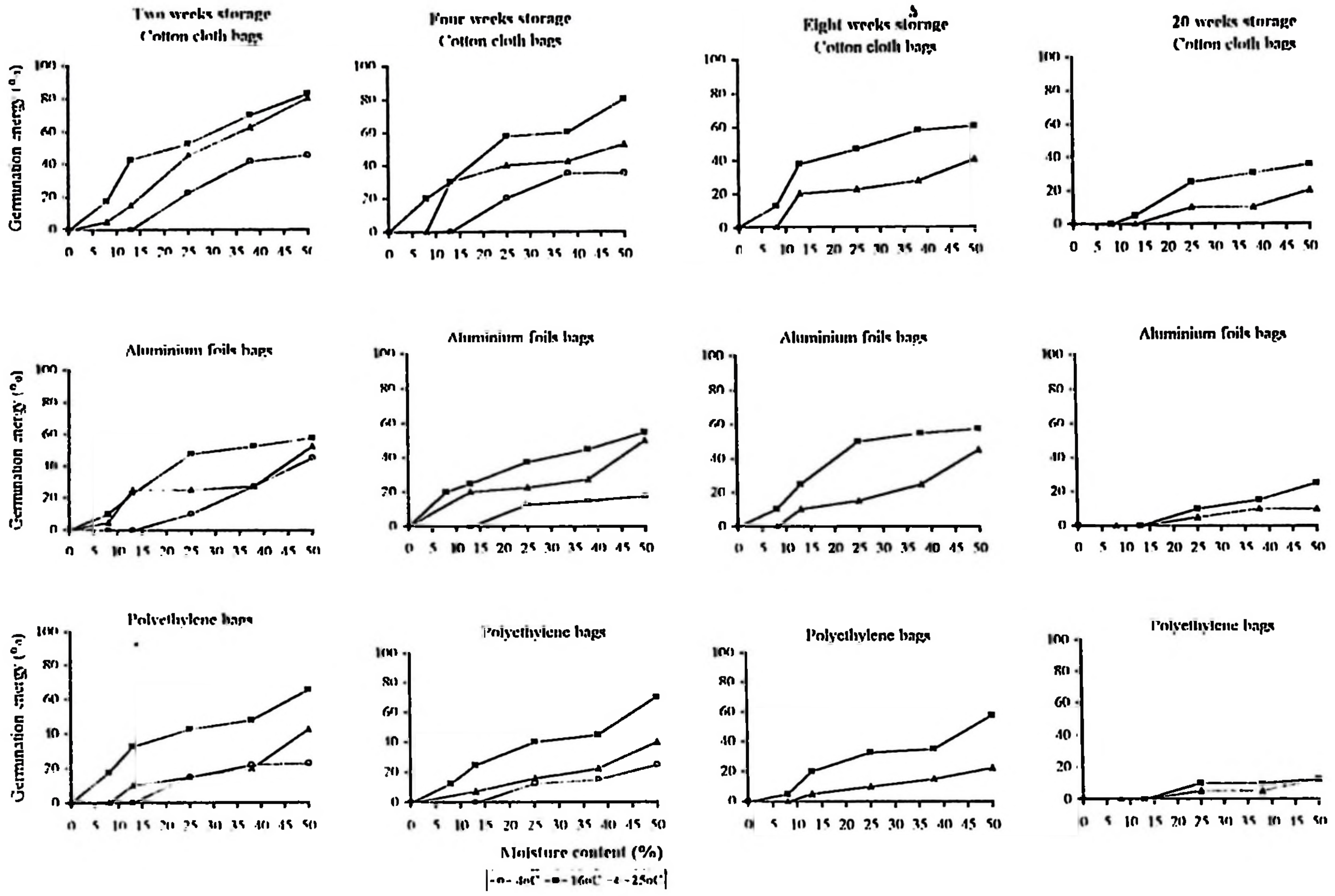


Figure 17: Effect of storage conditions on germination energy (%) of *C. africana* seeds after storage for 20 weeks.

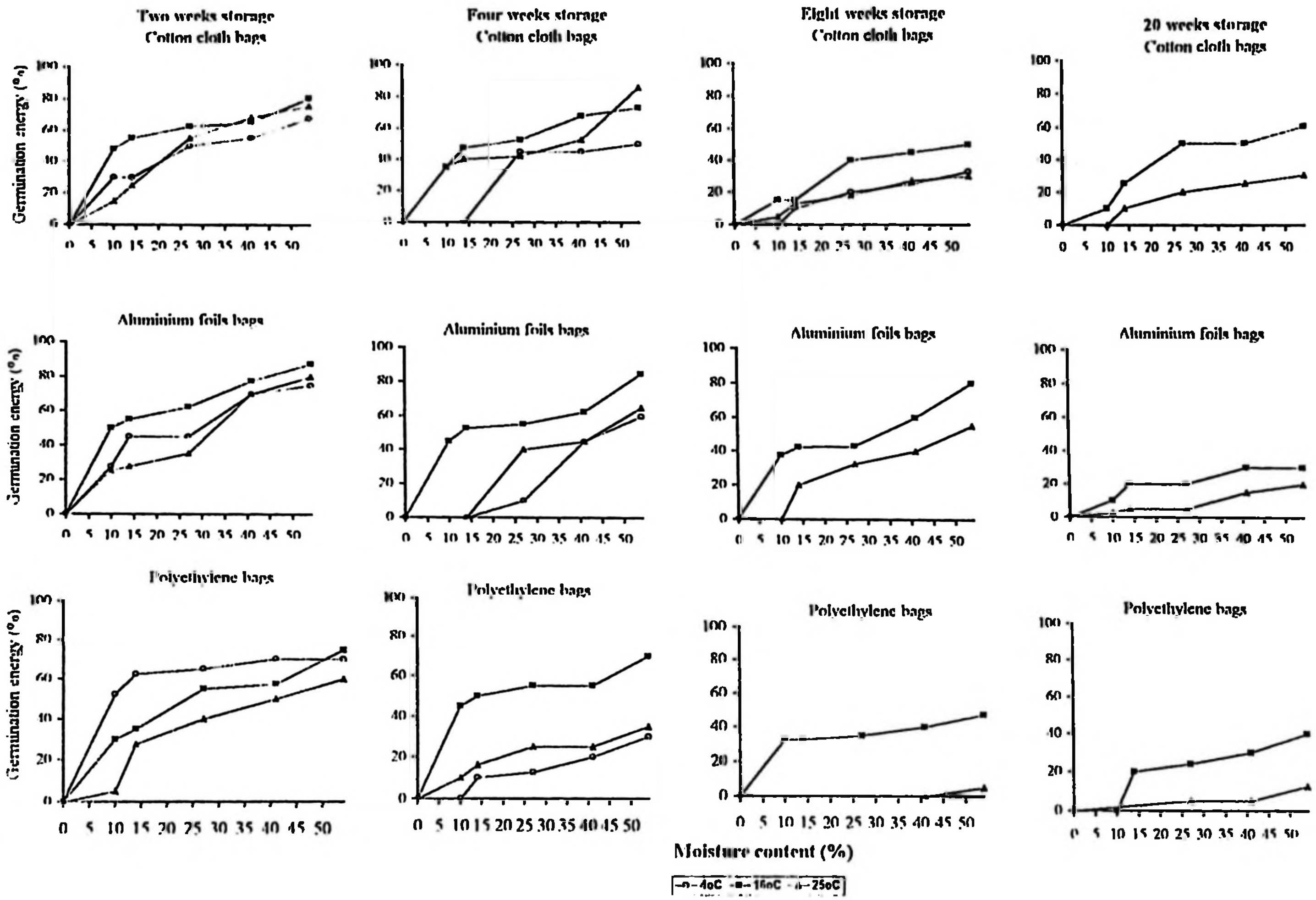


Figure 18: Effect of storage conditions on germination energy (%) of *C. densiflora* seeds after storage for 20 weeks.

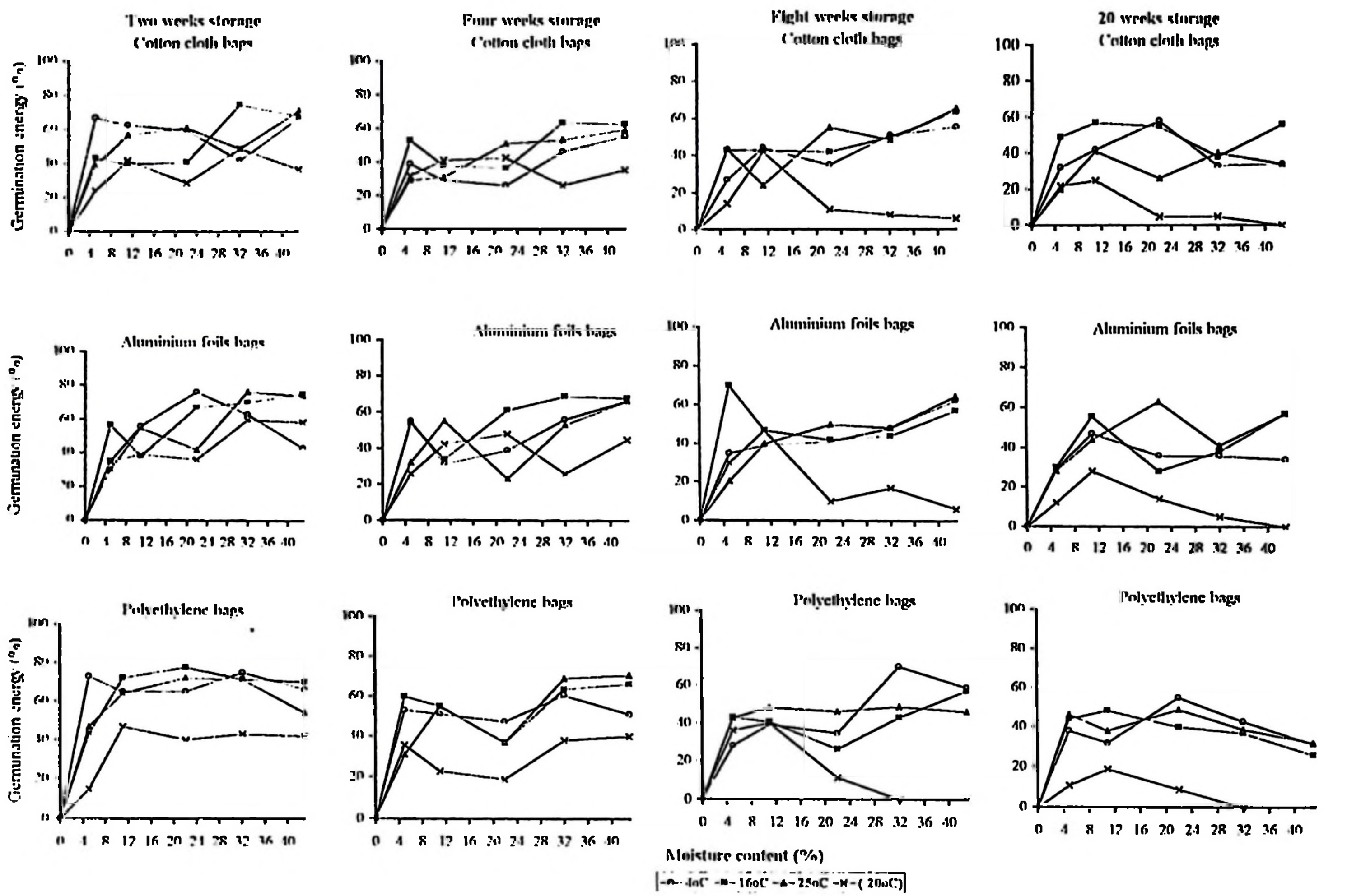


Figure 19: Effect of storage conditions on germination energy (%) of *S. cocculoides* seeds after storage for 20 weeks.

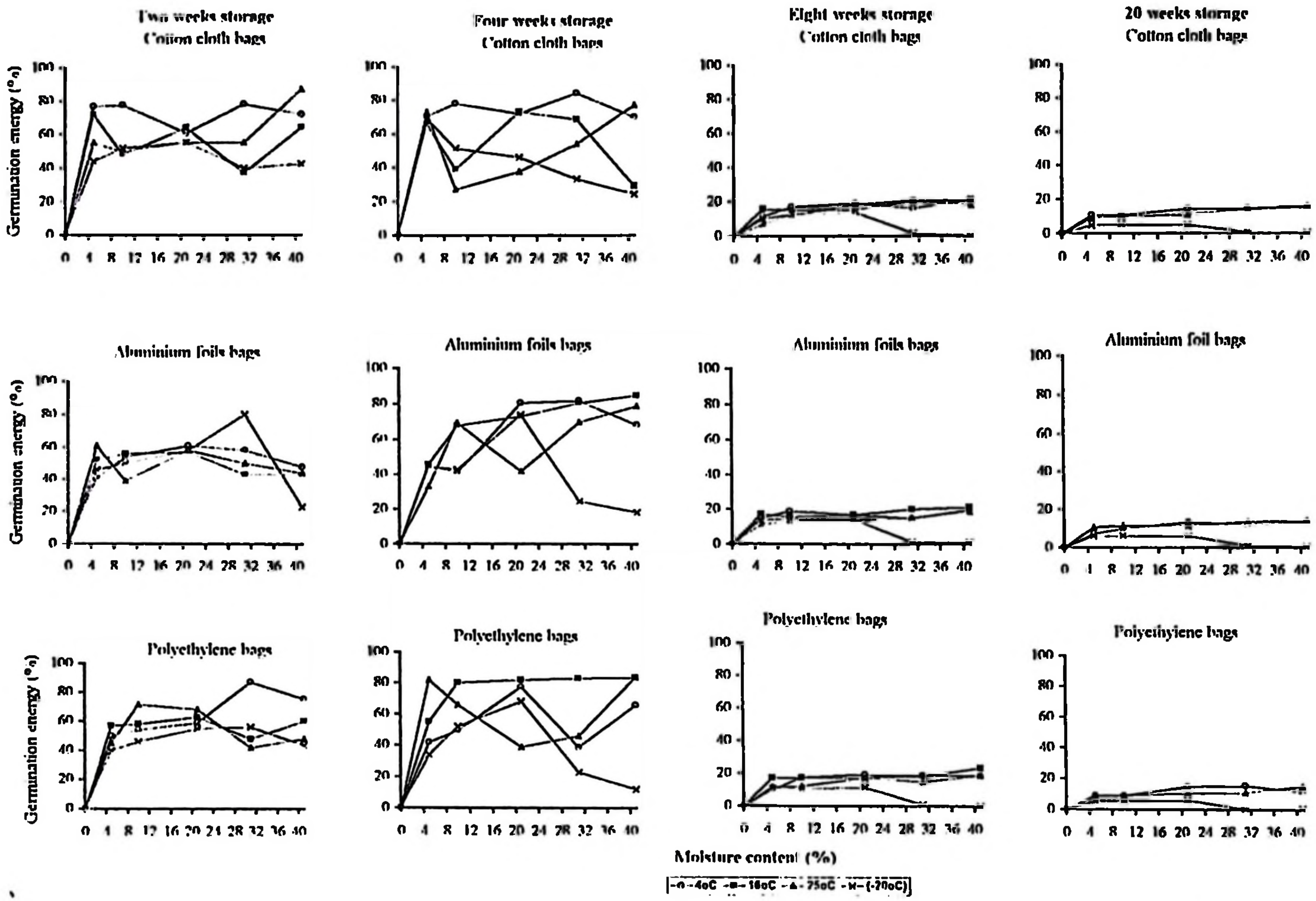


Figure 20: Effect of storage conditions on germination energy (%) of *S. spinosa* seeds after storage for 20 weeks.

Table 25 Effect of storage conditions on imbibition and total germination period for *C. africana* seed

SP	PM	GP	50%[1]				38%				25%				13%				8%			
			4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
2	C	T	40a	36b	38b	0	40a	36b	38b	0	40a	36b	38b	0	0	37b	39b	0	0	37b	39b	0
		I	17c	14c	16c	0	17c	14c	16c	0	17c	14c	16c	0	0	17c	18c	0	0	17c	18c	0
	A	T	40a	36b	38b	0	40a	36b	38b	0	40a	36b	38b	0	0	37b	39b	0	0	37b	39b	0
		I	17c	14c	16c	0	17c	14c	16c	0	17c	14c	16c	0	0	17c	18c	0	0	17c	18c	0
	P	T	40b	36b	38b	0	40a	36b	38b	0	40a	36b	38b	0	0	37b	39b	0	0	37b	39b	0
		I	17c	14c	16c	0	17c	14c	16c	0	17c	14c	16c	0	0	17c	18c	0	0	17c	18c	0
4	C	T	41a	37b	39b	0	41a	37b	39b	0	41	37b	39b	0	0	38b	40a	0	0	38b	40a	0
		I	18c	15c	17c	0	18c	15c	17c	0	18	15c	17c	0	0	19c	20b	0	0	19c	20b	0
	A	T	41a	37b	39c	0	41a	37b	39b	0	41	37b	39b	0	0	38b	40a	0	0	38b	40a	0
		I	18c	15c	17c	0	18c	15c	17c	0	18	15c	17c	0	0	19c	20b	0	0	19c	20b	0
	P	T	41a	37b	39b	0	41a	37b	39b	0	41	37b	39b	0	0	38b	40a	0	0	38b	40a	0
		I	18c	15c	17c	0	18c	15c	17c	0	18	15c	17c	0	0	19c	20b	0	0	19c	20c	0
8	C	T	0	37b	39b	0	0	37b	39b	0	0	37b	39b	0	0	38b	40a	0	0	38b	0	0
		I	0	15c	17c	0	0	15c	17c	0	0	15c	17c	0	0	19c	20b	0	0	19c	0	0
	A	T	0	37b	39b	0	0	37b	39b	0	0	37b	39b	0	0	38b	40a	0	0	38b	0	0
		I	0	15c	17c	0	0	15c	17c	0	0	15c	17c	0	0	19c	20b	0	0	19c	0	0
	P	T	0	37b	39b	0	0	37b	39b	0	0	37b	39b	0	0	38b	40a	0	0	38b	0	0
		I	0	15c	17c	0	0	15c	17c	0	0	15c	17c	0	0	19c	20b	0	0	19c	0	0
20	C	T	0	37b	39b	0	0	37b	39b	0	0	37b	39b	0	0	40a	0	0	0	0	0	0
		I	0	15c	17c	0	0	15c	17c	0	0	15c	17c	0	0	20b	0	0	0	0	0	0
	A	T	0	37b	39b	0	0	37b	39b	0	0	37b	39b	0	0	0	0	0	0	0	0	0
		I	0	15c	17c	0	0	15c	17c	0	0	15c	17c	0	0	0	0	0	0	0	0	0
	P	T	0	37b	39b	0	0	37b	39b	0	0	37b	39b	0	0	0	0	0	0	0	0	0
		I	0	15c	17c	0	0	15c	17c	0	0	15c	17c	0	0	0	0	0	0	0	0	0

SP: storage period (weeks); PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^0C) [a] Imbibition (I) – Number of days from sowing to commencement of germination; T- Total germination period (i.e. number of days from sowing to completion of germination)

Three means of the same storage day with the same letter within the column are not significantly different at $P < 0.05$

Table 26 Effect of storage conditions on imbibition and total germination period for *C. densiflora* seed

SP	PM	GP	54%[1]				41%				27%				14%				10%			
			4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
2	C	T	33b	26b	31b	0	33b	26b	31b	0	33b	26b	31b	0	33b	28b	33b	0	33b	30b	35b	0
		I	8d	6d	7d	0	8d	6d	7d	0	8d	6d	7d	0	8d	7d	8d	0	8d	7d	8d	0
	A	T	33b	26b	31b	0	33b	26b	31b	0	33b	26b	31b	0	33b	28b	33b	0	33b	28b	33b	0
		I	8d	6d	7d	0	8d	6d	7d	0	8d	6d	7d	0	8d	7d	8d	0	8d	7d	8d	0
	P	T	33b	26b	31b	0	33b	26b	31b	0	33b	26b	31b	0	33b	28b	33b	0	33b	28b	33b	0
		I	8d	6d	7d	0	8d	6d	7d	0	8d	6d	7d	0	8d	7d	8d	0	8d	7d	8d	0
4	C	T	35b	29b	33b	0	35b	29b	33b	0	35b	29b	33b	0	35b	29b	33b	0	0	29b	33b	0
		I	11c	8d	10c	0	11c	8d	10c	0	11c	8d	10c	0	11c	8d	10c	0	0	8d	10c	0
	A	T	35b	29b	33b	0	35b	29b	33b	0	35b	29b	33b	0	35b	29b	33b	0	0	29b	33b	0
		I	11c	8d	10d	0	11c	8d	10c	0	11c	8d	10c	0	0	8d	10c	0	0	8d	10c	0
	P	T	35b	29b	33b	0	35b	29b	33b	0	35b	29b	33b	0	0	29b	0	0	0	29b	0	0
		I	11c	8d	10d	0	11c	8d	10c	0	11c	8d	10c	0	11c	8d	10b	0	0	8d	10c	0
8	C	T	0	34b	36b	0	36b	34b	36b	0	36b	34b	36b	0	36b	34b	36b	0	0	35b	0	0
		I	0	9d	13c	0	13c	9d	13c	0	13c	9d	13c	0	13c	9d	13c	0	0	10c	0	0
	A	T	0	34b	36b	0	0	34b	36b	0	0	34b	36b	0	0	34b	36b	0	0	35b	0	0
		I	0	9d	13c	0	0	9d	13c	0	0	9d	13c	0	0	9d	13c	0	0	10c	0	0
	P	T	0	34b	36b	0	0	34	36b	0	0	34c	0	0	0	34b	0	0	0	35b	0	0
		I	0	9d	13c	0	0	9d	13c	0	0	9d	0	0	0	9d	0	0	0	10c	0	0
20	C	T	0	10c	12c	0	0	10c	12c	0	0	10c	12c	0	0	10c	12c	0	0	10c	0	0
		I	0	36b	38b	0	0	36b	38b	0	0	36b	38b	0	0	36b	38b	0	0	36b	0	0
	A	T	0	10c	12c	0	0	10c	12c	0	0	10c	12c	0	0	10c	12c	0	0	10c	0	0
		I	0	36b	38b	0	0	36b	38b	0	0	36b	38b	0	0	36b	38b	0	0	36b	0	0
	P	T	0	10c	12c	0	0	10c	12c	0	0	10c	12c	0	0	10c	12c	0	0	10c	0	0
		I	0	36b	38b	0	0	36b	38b	0	0	36b	38b	0	0	36b	38b	0	0	36b	0	0

SP: storage period (weeks); PM: packaging material; A: aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (°C) [a] Imbibition (I) Number of days from sowing to commencement of germination; T- Total germination period (i.e number of days from sowing to completion of germination)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table 27 Effect of storage conditions on imbibition and total germination period for *S. cocculoides* seed

SP	PM	GP	43%[1]				32%				22%				11%				5%			
			4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
2	C	T	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a
		I	17c	16c	18c	20b	17c	16c	18c	20b	17c	16c	18c	20b	19c	18c	20b	22b	19c	18c	20b	22b
	A	T	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a
		I	17c	16c	18c	20b	17c	16c	18c	20b	17c	16c	18c	20b	19b	18c	20b	22b	19c	18c	20b	22b
	P	T	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a
		I	17b	16c	18c	20b	17c	16c	18c	20b	17c	16c	18c	20c	19c	18c	20b	22b	19c	18c	20b	22b
4	C	T	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a
		I	18c	17c	19c	21b	18c	17c	19c	21b	18c	17c	19c	21b	20b	19c	21b	23b	20b	19c	21b	22b
	A	T	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a
		I	18c	17c	19c	21b	18c	17c	19c	21b	18c	17c	19c	21b	20a	19c	21b	23b	20b	19c	21b	22b
	P	T	41a	34b	38b	43a	41a	34b	38b	0	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a
		I	18c	17c	19c	21b	18a	17c	19c	0	18c	17c	19c	21c	20c	19c	21b	23b	20b	19c	21b	22b
8	C	T	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	36b	40a	45a
		I	18c	17c	19c	21b	18c	17c	19c	21b	18c	17c	19c	21b	20b	19c	21c	23b	20b	21b	23b	23b
	A	T	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	43a	36b	40a	45a
		I	18c	17c	19c	21b	18c	17c	19c	21c	18c	17c	19c	21b	20b	19c	21b	23b	22b	21b	23b	23b
	P	T	41a	34b	38b	0	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	43a	36b	40a	45a
		I	18c	17c	19c	0	18c	17c	19c	21c	18c	17c	19c	21b	20b	19c	21b	23b	22b	21b	23b	23b
20	C	T	41a	34b	38b	0	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	44a	41a	36b	40a	47a
		I	18c	17c	19c	0	18c	17c	19c	21c	18c	17c	19c	21b	20b	19c	21b	24b	20b	21b	23b	24b
	A	T	41a	34b	38b	0	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	44a	43a	36b	40a	47a
		I	18c	17c	19c	0	18c	17c	19c	21b	18c	17c	19c	21b	20b	19c	21b	24b	22b	21b	23b	23b
	P	T	41a	34b	38b	0	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	44a	43a	36b	40a	47a
		I	18c	17c	19c	0	18c	17c	19c	21c	18c	17c	19c	21b	20b	19c	21b	24b	22b	21b	23b	24b

SP: storage period (weeks); PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^{0}C) [a] Imbibition (I) – Number of days from sowing to commencement of germination; T- Total germination period (i.e. number of days from sowing to completion of germination)

Three means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

Table 28 Effect of storage conditions on imbibition and total germination period for *S. spinosa* seed

SP	PM	GP	41%[1]				31%				21%				10%				5%			
			4[2]	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20	4	16	25	-20
2	C	T	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a
		I	17c	16c	18c	20b	17c	16c	18c	20b	17c	16c	18c	20a	19c	18c	20b	22b	19c	18c	20b	22b
	A	T	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a
		I	17c	16c	18c	20b	17c	16c	18c	20b	17c	16c	18c	20b	19c	18c	20b	22b	19c	18c	20b	22b
	P	T	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a	40a	33b	37b	42a
		I	17c	16c	18c	20b	17c	16c	18c	20b	17c	16c	18c	20b	19c	18c	20b	22b	19c	18c	20b	22b
4	C	T	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a
		I	18c	17c	19c	21b	18c	17c	19c	21b	18c	17c	19c	21b	20b	19c	21b	23b	20b	19c	21b	22b
	A	T	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a
		I	18c	17c	19c	21b	18c	17c	19c	21b	18c	17c	19c	21b	20b	19c	21b	23b	20b	19c	21b	22b
	P	T	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a
		I	18c	17c	19c	21b	18c	17c	19c	21b	18c	17c	19c	21b	20b	19c	21b	23b	20b	19c	21b	22b
8	C	T	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	36b	40a	45a
		I	18c	17c	19c	21b	18c	17c	19c	21b	18c	17c	19c	21b	20b	19c	21b	23b	20b	21b	23b	23b
	A	T	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	43a	36b	40a	45a
		I	18c	17c	19c	21b	18c	17c	19c	21b	18c	17c	19c	21b	20b	19c	21b	23b	22b	21b	23b	23b
	P	T	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	43a	36b	40a	45a
		I	18c	17c	19c	21b	18c	17c	19c	21b	18c	17c	19c	21b	20b	19c	21b	23b	22b	21b	23b	23b
20	C	T	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	44a	41a	36b	40a	47a
		I	18c	17c	19c	21b	18c	17c	19c	21b	18c	17c	19c	21b	20b	19c	21b	24b	20b	21b	23b	24b
	A	T	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	44a	43a	36b	40a	47a
		I	18c	17c	19c	21b	18c	17c	19c	21b	18c	17c	19c	21b	20b	19c	21b	24b	22b	21b	23b	23b
	P	T	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	43a	41a	34b	38b	44a	43a	36b	40a	47a
		I	18c	17c	19c	21b	18c	17c	19c	21b	18c	17c	19c	21b	20b	19c	21b	24b	22b	21b	23b	24b

SP: storage period (weeks); PM: packaging material; A; aluminum foil bags; C; cotton bags; P: polyethylene bags; [1]: moisture content; [2]: temperature (^{0}C) ^{a} Imbibition (I) – Number of days from sowing to commencement of germination; T- Total germination period (i.e. number of days from sowing to completion of germination)

Six means of the same storage day with the same letter within the column are not significantly different at $P \leq 0.05$

4.4.4 Viability of un-germinated seeds

4.4.4.1 Un-stored seeds

Viability of all un-germinated seeds determined by cutting test for all species, showed all un germinated seeds to be non viable. Out of 1000 seeds sown for each species 37 seeds of *C. africana* did not germinate (3.7%) out of which 30 seeds were rotten (3%). 5 seeds were broken (0.5%) and 2 seeds were empty (0.2%) (Table 28a). Un germinated seeds for *C. densifora* were 40 seeds (4%) of which 32 seeds were rotten (3.2%), 5 seeds were broken (0.5%) and 3 were empty (0.3%) (Table 28a). 32 seeds of *S. cocculoides* (3.2%) did not germinate, out of which 25 seeds were rotten (2.5%), 4 were broken (0.4%) and 3 seeds were empty (0.3%) (Table 28a). Likewise for *S. spinosa*, 20 seeds (2%) did not germinate, from which 12 seeds were rotten (1.2%), 6 seeds were broken (0.6%) and 2 seeds were empty (0.2%) (Table 28a).

Table 29 a Seed status for un germinated seeds un stored seeds

Species	Viability (%)	Status of ungerminated seeds		
		Rotten %	Broken %	Empty %
C. africana	0	3	0.5	0.2
C. densiflora	0	3.2	0.5	0.3
S. cocculoides	0	2.5	0.4	0.3
S. spinosa	0	1.2	0.6	0.2

*Number of un-germinated seeds was very small therefore, all un-germinated seeds for all treatments were summed up to a single unit

4.4.4.1 Stored seeds

For stored seed out of 24,000 seeds sown for each species 808 seeds of *C. africana* did not germinate (3.4%) out of them 730 seeds were rotten (3%), 59 seeds were broken (0.24%) and 19 seeds were empty (0.08%) (Table 29b). Un germinated seeds for *C. densifora* were 712 seeds (2.96%) of which 600 seeds were rotten (2.5%), 62 seeds were broken (0.25%) and 50 were empty (0.2%) (Table 29b). Total of 422 seeds of *S. cocculoides* (1.76%) did not germinate, from which 350 seeds were rotten (1.45%), 4seeds were broken (0.16%) and 32 seeds were empty (0.13%) (Table 29b). Likewise for *S. spinosa*, 312 seeds (1.3%) did not germinate, from which 280 seeds were rotten (1.16%), 20 seeds were broken (0.08%) and 12 seeds were empty (0.05%) (Table 29b).

Table 29b Seed status for un-germinated seeds for stored seeds

Species	Viability (%)	*Status of un-germinated seeds		
		Rotten %	Broken %	Empty %
C. africana	0	3	0.24	0.08
C. densiflora	0	2.5	0.25	0.21
S. cocculoides	0	1.45	0.16	0.13
S. spinosa	0	1.16	0.08	0.05

*Number of un-germinated seeds was very small therefore, all un-germinated seeds for all treatments were summed up to a single unit

CHAPTER FIVE

5. DISCUSSION

5.1 Fruit and seed dimension

The mean width and height of fruit of *C. africana* of 3.6 and 4.5 cm, which is almost egg shaped (Table 4) are slightly higher than those given by Msanga (1998) as being 3 and 4 cm respectively. The seed mean width (1.8 cm) and height (2.7 cm) are slightly lower (2 and 3 cm.) than those given by Msanga (1998; Table 4). Number of seed per kilogram for *C. africana* was 240 fresh seed (Table 4). For *C. densiflora* the mean width and height were 4.5 and 5.5 cm, which is almost egg shaped (Table 4). Again slightly higher (5 long and 3 cm wide) than those given by Msanga (1998). The mean seed width and height of 2.2 cm and 3.6 cm (Table 4) are almost similar to those reported by Msanga (1998). Number of seed per kilogram for *C. densiflora* was 200 fresh seed (Table 4), These sizes of seeds of the two species falls into a large seed category (ISTA, 1993), which is among the characteristics of recalcitrant seed (Chin and Mohd, 1984).

The fruit of *S. cocculoides* is spherical with a mean diameter of 10 cm (Table 4) which is higher than that given by Msanga (1998) as 7 cm diameter. The mean seed width and height were 1.0 cm and 1.3 cm. Each fruit contains an average of 38 seeds while one kg contained 2,500 fresh clean seed. (Table 4). The number of seed per kilogram and seed per fruit is higher than that given by Msanga (1998) as being 1,800 seed per kilogram and 25 to 30 seeds per fruit. Fruit of *S. spinosa* is also spherical with a mean diameter 12 cm. This match exactly with that reported by Beentje (1994). The mean seed width and height were 0.9 cm and 1.1 cm. Each fruit contains an average of 60 seeds. While one kg contained 3,250 fresh clean seed, almost the same as that reported by Beentje (1994).

For each study species, observed difference in seed and fruit sizes could be due to differences in genetic constitution (Hong *et al.*, 1996), and probably due to difference in the stages of physiological maturity among the harvest, since previous study by Msanga (1998), did not state clearly the state of seed maturity, but in this study all were well matured. The other cause could be due to differences in ecological zones where fruit were collected (Nautiyal and Porohit, 1985).

5.2 Seed moisture content

5.2.1 Initial seed moisture content

Results of this study has indicated high initial seed moisture content of all seed components of 50, 54, 43 and 41% *for C. africana, C. densiflora, S. cocculoides* and *S. spinosa* respectively (Table 4). Higher moisture contents like these were also reported in seeds of *Suzygium cuminii, Hancornia speciosa* and *Warburgia salutaris* (Thomsen, 1998), *Euterpe edulis* (Martins *et al.*, 2000), *Sorindeia madagascariensis, Syzygium guineense* and *Uapaca kirkiana* (Msanga *et al.*, 1999a; 1999b and 2000). High initial moisture content is one of the characteristics of recalcitrant seeds. Seeds of ll four species showed a clear difference of water content between axes and storage tissue which is also another characteristic of recalcitrant seed (Berjak *et al.*, 1989).

5.2.2 Seed moisture content after storage

5.2.2.1 Un-desiccated seeds

For all storage conditions, little changes in moisture content occurred for un-desiccated seeds (50, 54, 43 and 41%) for *C. africana*, *C. densiflora*, *S. cocculoides* and *S. spinosa* respectively during the eight weeks of storage (Tables 6a, b, c and d). This may be related to stability of membrane and macromolecules due to their high initial embryo moisture content (Table 5) leading to stable sub-cellular water content (Martins *et al.*, 2000). The moisture content of seeds stored in polyethylene bags was more stable than that of seeds stored in cotton bags and aluminium foil bags (Tables 6 a, b, c and d). As expected, polyethylene bags are effective in resisting changes in moisture content (Copeland and McDonald, 1995).

5.2.3 Desiccated seeds

A remarkable reduction in moisture content for desiccated seeds under all storage conditions (Tables 6 a, b, c and d), observed for all species could be due to disturbance of cell structure during desiccation leading to imbalance of water potential of seed cells in relation to storage environment (Gillie and Joenje, 1991; MacDonald1999). Likewise, packaging materials and storage temperature could have an effect on changes of moisture content, since in this study seeds stored in cotton cloth bags at 25^{0}C had higher rates of moisture content reduction, while aluminium foil bags had almost stable moisture content percentage (Tables 6 a, b, c and d). As expected, cotton material allowed free moist exchange (Schmidt, 2000), which might have contributed to an increase in moisture content in earlier stages of storage. Slight changes in moisture content observed in aluminium foils might be due to loss through ventilation holes, whereas loosely sealed polyethylene bags reduced these changes in moisture contents.

5.3 Effect of seed desiccation on seed viability

5.3.1 Desiccation period

Longer desiccation period taken by both *C. africana* (22 days) and *C. densiflora* (18 days) to reach lowest moisture contents of 8 and 10% respectively (Table 7a) could be due to the large size of seeds (Table 4). Slow drying is a characteristic of large seed in many recalcitrant species. This may lead to a marked decrease in seed viability (Bilia *et al.*, 1999). On the other hand, it could be attributed to the large proportion of water in the embryo than in the seed coats (Table 5), which normally takes longer time to dry (Ellis *et al.*, 1998).

For *S. cocculoides* seeds, the shorter desiccation period (8 days) taken to reach lowest moisture content of 5% (Table 7b) could be due to their small size (Table 4). Rapid drying rate is a characteristic of orthodox seeds (Nkang *et al.*, 2000). Rapid drying of orthodox seed has an advantage of not allowing sufficient time for the process of the aqueous-based degenerative reactions that cause loss of seed viability to occur (Bilia *et al.*, 1999). Surprisingly, as noted earlier it was not possible to establish why seeds of *S. spinosa* took longer time (18 days) to be desiccated to lowest moisture content of

5% (Table 7b). Nevertheless, higher germination percentages maintained by this species at this lowest moisture content indicate it is not affected by slower drying (Berjak *et al.*, 1993).

Critical water content is reached after total loss of free cellular water and that would explain, partially the difference in the tolerance to desiccation among species (Frinch-Savage, 1992). In this study, critical moisture content levels of 13 and 10% attained by seeds of *C. africana* and *C. densiflora* respectively (Tables 6 a and b) is almost similar to that of seeds of *Syzygium guineense* and *Uapaca kirkiana* with critical moisture content of 15 and10% respectively (Msanga *et al.*, 1999a and b), but is much lower than that observed in other studies for recalcitrant species. For example, Hong and Ellis (1998) recorded critical moisture content of 20% for seeds of *Aglaia clarkii* and *Sandoricum koetjape*. They suggested that these seeds were very sensitive to desiccation. Likewise Msanga *et al.* (2000) recorded critical moisture content of 20% for seeds of *Sorindeia madagascariensis*.

5.3.2 Response of seed to desiccation

5.3.2.1 Daily germination and final cumulative percentage

For *C. africana* and *C. densiflora*, seed desiccationt significantly ($P<0.05$) affected daily and final cumulative germination percentages with un-desiccated seeds maintaining higher germination (Figure 1; Table 7a) while seed desiccation consistently had lower germination percentages. This could be caused by slow drying rates (Table 7a) which allow sufficient time for the progress of the aqueous –based degenerative reactions that might lower seed viability rate (Bilia *et al.*, 1999), or due to seed cell membrane deterioration upon dehydration as well as the apparent inability to repair such damage (Nautiyal and Porohit, 1985)

A remarkable drop in final cumulative germination observed for *C. africana* and *C. densiflora* from 95% at 50% and 54% moisture content to 50 and 65% at moisture content of 8 and 10% respectively (Table 7a) shows the two species are very sensitive to desiccation. This is typical characteristic of recalcitrant seeds (Chin, 1990). Surprisingly, desiccation has no significant (P>0.05) influence on both daily and final cumulative germination percentages of *S. cocculoides* and *S. spinosa* (Figure 1; Table 7b). Desiccation of seed of *S. cocculoides* and *S. spinosa* from 43 to 5% and 41 to 5% had slight effect on final cumulative germination percentages. For *S. cocculoides*, final cumulative germination percent was reduced from 89 to 75%, while for *S. spinosa* it was reduced from 97 to 90% (Tables 5c and d; Figures 2 and 3). This could be due to the rapid drying rate, which reduces chances of degenerative reactions which results in reduced viability (Bilia *et al.*, 1999) and probably due to the ability to withstand impact of cell damage by instant continuous cell repair (Martins *et al.*, 2000). This observation shows that these two species are less sensitive to desiccation, which is among the characteristic of orthodox seeds (Nkang *et al.*, 2000). Similar observation has been made for stones of *Melia azedarach* L. (Hong and Ellis, 1998).

5.3.2.2 Imbibition and total germination period

All study species (*C. africana, C. densiflora, S. cocculoides* and *S. spinosa*) had shortest imbibition and total germination period for seeds with higher initial moisture content (un-desiccated) whereas desiccation increased imbibition and total germination period (Table 7). This could probably be attributed by permeability of seed coat for un-desiccated seeds due to high moisture content, which keep seed coat moist and facilitates easier absorption of water. On the other hand, desiccation could results in hardening of seed coat reducing its permeability. This leads to delayed water absorption for imbibition (Bewley and Black, 1994).

5.3.2.3 Germination value and germination energy

Higher germination value observed for all species seeds with higher moisture content (Table 8) indicates that moisture content influences speed of germination. Since germination value is a measure of speed of germination and hence seed vigour (Djavanshir and Pourbeik, 1976), seed which gave higher germination value are therefore likely to have higher vigour. Since higher values recorded for seeds with higher moisture content, suggest that seed vigour increase with moisture content. Influence of moisture content on speed of germination could be due to contribution of moisture in increasing enzyme activity and hence increase in speed of germination (Bewley and Black, 1994).

5.3.2.4 Radicle elongation

For *C. africana* and *C. densiflora*, radicle elongation was significantly ($P<0.05$) influenced by moisture content (Table 8). There was a very strong positive linear relationship ($r=0.98$) between moisture content and radicle elongation (Figure 4). Faster radicle elongation indicates good vigour of seed. Higher moisture content may facilitate enzymatic activity, break down, translocation and use of food reserve. According to Bewley and Black (1994) the process of seed germination is achieved by elongation of radicle, which expands and penetrates the surrounding structures marking the completion of germination. Higher speed of radicle elongation for these species with higher moisture content suggest an increase in seed vigour with increase in moisture content. For both *S. cocculoides* and *S. spinosa*, moisture content did not have significant ($P>0.05$) influence on radicle elongation (Table 8). This suggests that these species are tolerant to desiccation and therefore their seed vigour is un-affected by desiccation.

5.4 Effect of seed storage on germination of stored seed

5.4.1 Daily germination percent

Storage condition significantly ($P<0.05$) influenced daily germination percent of all species. For *C. africana* and *C. densiflora*, the highest daily germination was recorded for seed stored with moisture content of 38%, followed by those stored with moisture content of 50% at 16^0C and seed with moisture content of 41% stored in cotton bags respectively. These results suggests that storage temperature of 16^0C is optimum for seeds which are to be stored with higher moisture content. While storage of seeds with lower moisture content at 4 and 25^0C lowered seed viability. These observations are almost similar to those of Msanga *et al.*, (1999a and b). Storage temperature of 16^0C, according to Chin (1990) does not cause freezing injury and probably can contribute to lowering of metabolic activity during storage. Additionally, little germination was recorded after storage beyond eight weeks and failure of seeds to survive at -20^0C, support the above argument, since recalcitrant seeds loose viability quickly and does not tolerate freezing injury (Chin, 1990). These observations are well supported by strong interactions noted between moisture content and temperature after storage for 20 weeks (Table 9). As suggested by Lews *et all.*, (1998), interaction between moisture content and temperature, occurs at the critical point where storage of seeds beyond these point lead to severe decline in seed quality.

For *S. cocculoides* and *S. spinosa*, storage temperature and seed moisture content significantly ($P < 0.05$) influenced daily germination percent (Tables 13 and 15). The highest germination recorded for *S. cocculoides* and *S. spinosa* seeds with 41% and 43% moisture content stored at 16^0C respectively could imply that these species are recalcitrant. These species also survived well at -20^0C for first four weeks of storage. This suggests that there was no severe cellular damage due to ice-crystal formation, which is expected to occur at $-8C^0$ or below for recalcitrant seeds (Boubriak *et al.*, 1997). Preliminary study by Uronu (2000) recorded similar observation for *S. cocculoides* seed. Therefore these species can be categorised as intermediate between orthodox and recalcitrant (Schmidt, 2000).

5.4.2 Final cumulative germination percent of stored seed

Storage conditions significantly ($P<0.05$) influenced final cumulative germination percent of seed of *C. africana* and *C. densiflora* (Table 17 and 18). Although it is well known that high moisture content is injurious during storage (Chin, 1990), higher final cumulative germination percent was noted for seeds stored with higher moisture content (Figures 5 and 6). This was achieved especially for seeds that were stored in cotton cloth bags, which according to Basu (1994) provides enough supply of oxygen and inhibit production of products of anaerobic respiration such as ethanol and acetaldehyde, which are toxic to seeds. Consequently storage temperature of 16^{0}C was the best storage temperature for these two species. On the other hand, final cumulative germination percent was very much reduced under all storage condition after the first eight weeks of storage. Very low germination was recorded for seeds stored at 16 and 25^{0}C only (Figures 5 and 6). This lower germination was probably caused by seed ageing, which is very common in recalcitrant seeds (Martins *et al.*, 2000).

In contrast, seeds of *S. cocculoides* and *S. spinosa* had higher germination even after 20 weeks of storage (Figures 7 and 8), indicating that they are not very much affected by seed aging which is a common phenomenon of orthodox seeds (Bourbriak *et al.*, 1997; Martins *et al.*, 2000). Since these two species had initially very high moisture content (Table 5), they cannot be categorised as orthodox (Roberts and King, 1980), but rather as intermediate between orthodox and recalcitrant (Robbins, 1998).

5.4.3 Seed vigour of stored seed

5.4.3.1 Radicle elongation

For all species, moisture content, temperature and packaging material significantly ($P<0.05$) affected radicle elongation (Tables 21, 22, 23 and 24; Figures 9, 10,11 and 12). Generally, storage of *C. africana* and *C. densiflora* seed with higher moisture content at 16^{0}C in cotton cloth bags resulted in higher cumulative radicle elongation, while other storage conditions gave intermediate results. Higher moisture content may have resulted in weakening of seed coat tissues surrounding the radicle tip and thus speeding up extension of radicle cells (Larsen *et al.*, 1998). However, there was no radicle elongation for seeds stored at –20^{0}C. Therefore freezing temperature reduced seed vigour of C. *africana* and *C. densiflora* while it did not affect seed vigour of *S. cocculoides* and *S. spinosa*.

5.4.3.2 Germination value and germination energy

Higher germination energy and germination value recorded for *C. africana* and *C. densiflora* seeds stored with their initial moisture content of respectively 50 and 54% at 16^{0}C in cotton bags (Figures 13 and 14) revealed that seeds stored with higher moisture maintained higher vigour. As suggested earlier, influence of moisture content on speed of germination could be due to the contribution of moisture in increasing enzyme activity and hence increase in speed of germination (Bewley and Black, 1994). As for germination percentages, storage temperature of 16^{0}C in cotton cloth bags maintained higher germination energy and germination value during the first eight weeks of storage (Figures 13, 14, 17 and 18). Since germination value and germination energy are products of daily and final cumulative germination percentages, they are therefore affected by all factors influencing germination capacity.

In this study, there was no clear trend of the effect of interaction of moisture content and packaging material on germination value and germination energy for *S. cocculoides* and *S. spinosa* seeds (Figures15, 16, 19 and 20). As suggested earlier, seed vigour of these species is not very much affected by storage conditions for the same reasons given for daily and final cumulative germination percentages.

5.4.4 Germination phases

For all species, storage conditions had significant (P< 0.05) on the germination phases. Seeds that were stored with their initial moisture content in cotton cloth bags at 16^{0}C had shortest imbibition period (the number of days from sowing to completion of germination). While longest imbibition period was recorded for seeds that were stored with lowest moisture content in polyethylene bags at 25^{0}C (Tables 25 and 26). As noted earlier, seed imbibition quicken recommencing of metabolism leading to increase in enzymatic activity, respiration and assimilation. Thus longer imbibition period will delay these processes leading to reduction of seed germination speed. Since these reactions are enzymatic controlled, suggest that optimum temperature and appropriate packaging material can contribute to improvement of seed germination speed.

Studies on *Sorindeia madagascariensis, Syzygium guineense* and *Uapaca kirkiana* (Msanga *et al.* 1999a, b and 2000) *Euterpe edulis* Berrie (1984), and on *Strychnos cocculoides* (Uronu, 2000) showed that seed with shorter imbibition period had higher germination speed (Berrie, 1984). In this study, longest total germination period of 40 days was attained by both *C. africana* and *C. densiflora* seeds stored at 4^{0}C, while those stored at 16^{0}C had shorter germination period of 36 and 26 respectively (Tables 25 and 26). The same trend was noted for seeds of *S. cocculoides* and *S. spinosa* (Tables 27 and 28).

5.4.5 Viability of un-germinated seeds

All un-stored and stored un-germinated seeds were not viable. The fact that all un-germinated seeds were found to be non-viable confirm that selected germination periods based on previous preliminary studies by (Msanga *et al.*, 1999a and b) and Uronu (2000) for all species were appropriate such that all seeds had enough time to complete germination.

CHAPTER 6

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the results obtained in this study, the following conclusions have been reached:

1. All species (*C. africana, C. densiflora, S. cocculoides* and *S. spinosa*) studied have initially high seed moisture content.
2. Although there were some minor insignificant results, generally seeds of *C. africana* and *C. densiflora* have proved to be recalcitrant, while those of *S. cocculoides* and *S. spinosa* have been proved beyond doubt to be intermediate between orthodox and recalcitrant.
3. Lower storage temperatures of 4^0C and below are fatal to seed of *C. africana* and *C. densiflora*, whilst 16^0C is the best storage temperature.
4. For *S. cocculoides* and *S. spinosa*, lower temperature did not have any effect on viability and vigour of seed, but freezing temperature (-20^0C) lowered seed viability and vigour for storage beyond eight weeks.
5. For *C. africana* and *C. densiflora*, moisture content had substantial influence on seed viability and vigour. Seed moisture content of $\geq$10 and $\geq$ 14 % were found to be detrimental to *C. africana* and *C. densiflora* seed respectively.
6. Moisture content had no strong influence on viability and vigour of seed of *S. cocculoides* and *S. spinosa*. Thus these seeds can be dried to 5% moisture

content and stored for up to 20 weeks without significant loss in viability.

7. For *C. africana* and *C. densiflora* seeds, cotton cloth bag was the best packaging material followed by aluminium foils, while polyethylene bags were not good for storage of beyond 2 weeks.
8. Although all packaging materials (cotton cloth bag, aluminium foil and polyethylene bags) were not significantly different in maintenance of seed viability and vigour, polyethylene bags were the best packaging material for *S. cocculoides* and *S. spinosa* seed.

6.2 Recommendations

The ultimate objective of this study was to investigate desiccation tolerance and storage conditions (temperature, moisture content and packaging material) that will maintain high germination and seedling vigour of seed of *C. africana*, *C. densiflora*, *S. cocculoides* and *S. spinosa*. The following are recommendations based on results of this study:

1. For maximum viability and vigour, seeds of *C. africana* and *C. densiflora* should be stored at 16^0C in cotton cloth bags for not more than eight weeks. *Cordyla africana* seed should be stored with moisture content between 25 and 50% that of *C. densiflora* seed should be between 27 and 54%.

2. For maximum viability and vigour, seeds of *S. cocculoides* and *S. spinosa* can be stored for more than to 20 weeks in polyethylene bags, with moisture content between 5 and 40% at temperatures of $\geq 4^0$C but not exceeding 25^0C

3. Since seed viability and vigour for *S. cocculoides* and *S. spinosa* were still high at the termination of the study (20 weeks after placement), further study should be conducted to determine their critical storage period.

4. Since the study has proved that seeds of *C. africana* and *C. densiflora* to be recalcitrant, further study should be conducted to determine rates of cell membrane disruption during desiccation.

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8. APPENDICES

Appendix 1 Calculation of germination value and germination energy

Appendix 1a Calculation of germination value

Germination value was calculated for all treatments using the formula of Djanshir and Poubeik (1976):

GV = ($\sum$DGS/N) GP/10

Where:

GV = Germination value
GP = Germination percent at the end of the test
DGS = Daily germination speed, obtained by dividing the cumulative germination percent (CG%) by the number of days since sowing (DSS)
$\sum$DGS = The total obtained by adding every DGS figure obtained from the daily germination counts
N = the number of daily counts, starting from the date of first germination
10 = Constant

For un-stored seeds of *C. africana* with initial moisture content of 50%, germination value was calculated as follows:

DSS	CG%	DGS	$\sum$DGS	Days	$\sum$DGS/N
6	35	5.83	5.83	1	5.83
11	65	5.91	11.74	2	5.87
16	78	4.88	16.62	3	5.54
21	93	4.43	21.05	4	5.26
26	93	3.58	24.62	5	4.92
31	95	3.06	27.69	6	**4.61**

$$GV = \frac{(\sum DGS/N)\ \text{Final CG\%}}{10}$$

$$= \frac{4.61 X 95}{10}$$

= **43.80**

All other germination values for all species and all treatments followed the same trend

Appendix 1b Calculation of germination Energy

Calculation of germination energy was done by taking energy period as that up to the day of peak germination, then summation of daily total germination was taken up to the point of peak germination as shown below.

For un-stored seeds of *C. africana* with initial moisture content of 50%, germination energy was calculated as follows:

DAS	Replicates				∑DGP
	I	II	III	IV	
6	40	40	30	30	**140**
11	20	30	30	40	120
16	20	10	0	20	50
21	10	20	30	0	60
26	0	0	0	0	0
31	10	0	0	0	10

$$\text{Germination energy \%} = \text{Maximum } \frac{\sum DGP}{400} \times 100$$

∑DGP = Daily total germination percent

DAS = Days after sowing

400 = Constant number for equating four replicates of 100 seeds

= (140 X 100)/ 400
= 35%

All other germination energies for all species and all treatments followed the same trend

APPENDIX 2 ANOVA TABLES FOR UN-STORED SEEDS

a) *C. africana* seed

i) Daily germination percent (DG%) and Final germination percent (FG%)

DAS	SOURCE	DF	MEAN SQURE		F-VALUE		Pr >F	
			DG%	FG%	DG%	FG%	DG%	FG%
6	Blk	3	98.33	120.00	0.77	0.97	0.5320	0.4403
	MC	4	287.50	267.50	2.25	2.15	0.1238	0.1364
11	Blk	3	298.33	98.33	0.86	0.45	0.4898	0.7228
	MC	4	745.00	182.50	2.14	0.83	0.1385	0.5298
16	Blk	3	91.25	544.58	1.22	2.89	0.3437	0.0793
	MC	4	51.25	845.00	0.69	4.49	0.6145	0.0190
21	Blk	3	234.67	132.22	1.91	0.82	0.1926	0.5087
	MC	4	181.23	1507.188	1.47	9.37	0.2817	0.0015
26	Blk	3	71.67	368.47	2.31	1.33	0.1381	0.3130
	MC	4	79.17	980.63	2.55	3.55	0.1045	0.0428
31	Blk	3	13.55	556.46	1.42	2.15	0.3056	0.1578
	MC	4	123.33	1256.41	13.45	4.85	0.0013	0.0196

ii) Radicle elongation (RE)

DAS	SOURCE	DF	MEAN SQURE	F-VALUE	Pr >F
4	Blk	3	49.27	1.17	0.3601
	MC	4	49.80	1.19	0.3652
6	Blk	3	5.60	1.17	0.3601
	MC	4	17.30	3.63	0.0368
8	Blk	3	0.267	0.06	0.9786
	MC	4	38.00	8.91	0.0014
12	Blk	3	2.044	0.26	0.8528
	MC	4	16.317	2.07	0.1529
16	Blk	3	5.918	0.54	0.6645
	MC	4	17.45	1.59	0.2445
20	Blk	3	15.56	0.56	0.6524
	MC	4	12.82	0.46	0.7619

DAS: Days after sowing; Blk: Block; MC: Moisture content (%)

APPENDIX 2 Continued

b) *C. densiflora* seed

i) Daily germination percent (DG%) and Final germination percent (FG%)

DAS	SOURCE	DF	MEAN SQURE		F-VALUE		Pr >F	
			DG%	FG%	DG%	FG%	DG%	FG%
8	Blk	3	34.40	34.40	2.39	2.39	0.1198	0.1198
	MC	4	30.00	30.00	2.08	2.08	0.1461	0.1461
13	Blk	3	76.27	24.20	0.36	2.95	0.7833	0.0756
	MC	4	342.50	95.80	1.61	11.68	0.2339	0.0004
18	Blk	3	125.0	108.27	0.45	0.78	0.7234	0.5260
	MC	4	382.50	1030.00	1.37	7.45	0.3015	0.0030
23	Blk	3	31.67	220.00	0.29	1.29	0.8348	0.3213
	MC	4	657.50	180.00	5.93	1.06	0.0072	0.4183
28	Blk	3	76.94	120.64	0.91	1.25	0.4786	0.3429
	MC	4	447.29	237.41	5.28	2.46	0.0222	0.1132
33	Blk	3	0	196.20	0	1.33	0	0.3242
	MC	4	0	237.91	0	1.86	0	0.2022

ii) Radicle elongation (RE)

DAS	SOURCE	DF	MEAN SQURE	F-VALUE	Pr >F
4	Blk	3	5.23	1.92	0.1852
	MC	4	28.45	10.44	0.0010
6	Blk	3	5.30	1.96	0.1882
	MC	4	30.45	11.48	0.0012
8	Blk	3	26.40	1.75	0.2097
	MC	4	128.80	8.55	0.0017
12	Blk	3	41.47	2.51	0.1081
	MC	4	235.88	14.29	0.0002
16	Blk	3	150.77	2.52	0.1170
	MC	4	519.33	8.69	0.0027
20	Blk	3	202.304	3.89	0.0492
	MC	4	596.73	11.47	0.0014

DAS: Days after sowing; Blk: Block; MC: Moisture content (%)

APPENDIX 2 Continued

c) *S. cocculoides* seed

i) Daily germination percent (DG%) and Final germination percent (FG%)

DAS	SOURCE	DF	MEAN SQURE		F-VALUE		Pr >F	
			DG%	FG%	DG%	FG%	DG%	FG%
19	Blk	3	34.40	34.40	2.39	2.39	0.1198	0.1198
	MC	4	30.00	30.00	2.08	2.08	0.1461	0.1461
24	Blk	3	76.27	24.20	0.36	2.95	0.7833	0.0756
	MC	4	342.50	95.80	1.61	11.68	0.2339	0.0004
29	Blk	3	125.0	108.27	0.45	0.78	0.7234	0.5260
	MC	4	382.50	1030.00	1.37	7.45	0.3015	0.0030
34	Blk	3	31.67	220.00	0.29	1.29	0.8348	0.3213
	MC	4	657.50	180.00	5.93	1.06	0.0072	0.4183
39	Blk	3	76.94	150.77	0.91	2.52	0.4786	0.1170
	MC	4	447.29	519.33	5.28	8.69	0.0222	0.0027
44	Blk	3	0	202.30	0	3.89	0	0.0492
	MC	4	0	596.73	0	11.47	0	0.0014

ii) Radicle elongation (RE)

DAS	SOURCE	DF	MEAN SQURE	F-VALUE	Pr >F
8	Blk	3	10.18	0.04	0.9869
	MC	4	468.75	2.04	0.1519
12	Blk	3	10.20	0.06	0.9800
	MC	4	452.60	3.02	0.1628
16	Blk	3	26.40	1.75	0.2097
	MC	4	128.80	8.55	0.0017
20	Blk	3	41.47	2.51	0.1081
	MC	4	235.87	14.29	0.0002
24	Blk	3	120.64	1.25	0.3429
	MC	4	237.41	2.64	0.1132
28	Blk	3	196.20	1.33	0.3242
	MC	4	273.91	1.86	0.2022

DAS: Days after sowing; Blk: Block; MC: Moisture content (%)

APPENDIX 2 ANOVA Continued

d) *S. spinosa* seed

i) Daily germination percent (DG%) and Final germination percent (FG%)

DAS	SOURCE	DF	MEAN SQURE		F-VALUE		Pr >F	
			DG%	FG%	DG%	FG%	DG%	FG%
21	Blk	3	34.40	34.40	2.40	2.39	0.1199	0.1198
	MC	4	30.00	30.00	2.08	2.08	0.1461	0.1461
26	Blk	3	76.28	24.20	0.37	2.95	0.7834	0.0756
	MC	4	342.50	95.80	1.61	11.68	0.2339	0.0004
31	Blk	3	126.0	108.27	0.46	0.78	0.7235	0.5260
	MC	4	382.50	1030.00	1.37	7.45	0.3015	0.0030
36	Blk	3	31.68	220.00	0.30	1.29	0.8349	0.3213
	MC	4	657.50	180.00	5.93	1.06	0.0072	0.4183
41	Blk	3	76.95	120.64	0.92	1.25	0.4787	0.3429
	MC	4	447.29	237.41	5.28	2.46	0.0222	0.1132
46	Blk	3	0	202.30	0	3.89	0	0.0492
	MC	4	0	596.73	0	11.47	0	0.0014

ii) Radicle elongation (RE)

DAS	SOURCE	DF	MEAN SQURE	F-VALUE	Pr >F
8	Blk	3	5.23	1.92	0.1852
	MC	4	28.45	10.44	0.0010
12	Blk	3	6.24	2.68	0.1960
	MC	4	30.72	11.52	0.0020
16	Blk	3	26.40	1.75	0.2097
	MC	4		8.55	0.0017
20	Blk	3	41.47	2.51	0.1081
	MC	4	235.87	14.29	0.0002
24	Blk	3	150.77	2.52	0.1170
	MC	4	519.33	8.69	0.0027
28	Blk	3	196.20	1.33	0.3242
	MC	4	273.91	1.86	0.2022

DAS: Days after sowing; Blk: Block; MC: Moisture content (%)

APPENDIX 3 ANOVA TABLES

Appendix 3a ANOVA tables for Daily germination percent for *C. africana* seeds for storage trial

SP	DAS	Source	DF	Mean square	F Value	Pr > F
2	15	BLK	3	171.99	2.36	0.0735
		MC	4	485.17	6.65	0.0001
		TEMP	3	1735.9	23.78	0.0001
		PM	2	163.68	2.24	0.1092
		MC*TEMP	12	154.10	2.11	0.0183
		MC*PM	8	169.36	2.32	0.0216
		TEMP*PM	6	28.04	0.38	0.8885
		MC*TEMP*PM	24	121.81	1.67	0.0324
	20	BLK	3	78.34	1.18	0.3186
		MC	4	1197.1	18.04	0.0001
		TEMP	3	4370.2	65.86	0.0001
		PM	2	174.34	2.63	0.0745
		MC*TEMP	12	217.32	3.28	0.0003
		MC*PM	8	16.61	0.25	0.9802
		TEMP*PM	6	71.15	1.07	0.3809
		MC*TEMP*PM	24	28.89	0.44	0.9905
	25	BLK	3	10.15	0.12	0.9488
		MC	4	1381.2	16.19	0.0001
		TEMP	3	5430.8	63.67	0.0001
		PM	2	97.89	1.15	0.3197
		MC*TEMP	12	276.10	3.24	0.0003
		MC*PM	8	80.92	0.95	0.4779
		TEMP*PM	6	66.83	0.78	0.5839
		MC*TEMP*PM	24	73.52	0.86	0.6531
	30	BLK	3	87.55	0.96	0.4110
		MC	4	1516.28	16.70	0.0001
		TEMP	3	3317.11	36.53	0.0001
		PM	2	190.27	2.10	0.1261
		MC*TEMP	12	194.71	2.14	0.0164
		MC*PM	8	54.68	0.60	0.7753
		TEMP*PM	6	98.84	1.09	0.3711
		MC*TEMP*PM	24	74.13	0.82	0.7130
	35	BLK	3	235.94	3.15	0.0165
		MC	4	669.85	9.96	0.0001
		TEMP	3	1165.50	17.33	0.0001
		PM	2	11.06	0.16	0.8483
		MC*TEMP	12	153.95	2.29	0.0099
		MC*PM	8	29.55	0.44	0.8960
		TEMP*PM	6	34.66	0.52	0.7961
		MC*TEMP*PM	24	45.80	0.68	0.8656
	40	BLK	3	7.10	0.39	0.7597
		MC	4	584.93	32.20	0.0001
		TEMP	3	71.33	3.93	0.0096
		PM	2	42.78	2.36	0.0979
		MC*TEMP	12	71.33	3.93	0.0001
		MC*PM	8	42.78	2.36	0.0198
		TEMP*PM	6	16.25	0.89	0.5001
		MC*TEMP*PM	24	16.25	0.89	0.6092
4	16	BLK	3	171.99	2.36	0.0735
		MC	4	485.17	6.65	0.0001
		TEMP	3	1735.9	23.78	0.0001
		PM	2	163.68	2.24	0.1092
		MC*TEMP	12	154.11	2.11	0.0183
		MC*PM	8	169.36	2.32	0.0216
		TEMP*PM	6	28.04	0.38	0.8885
		MC*TEMP*PM	24	121.81	1.67	0.0324
	21	BLK	3	78.35	1.18	0.3186
		MC	4	1197	18.04	0.0001
		TEMP	3	4370.2	65.86	0.0001
		PM	2	174.84	2.63	0.0745
		MC*TEMP	12	217.82	3.28	0.0003
		MC*PM	8	16.61	0.25	0.9802
		TEMP*PM	6	71.15	1.07	0.3809
		MC*TEMP*PM	24	28.89	0.44	0.9905

Appendix 3a continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	26	BLK	3	10.15	0.12	0.9488
		MC	4	1381.2	16.19	0.0001
		TEMP	3	5430.8	63.67	0.0001
		PM	2	97.89	1.15	0.3197
		MC*TEMP	12	276.10	3.24	0.0003
		MC*PM	8	80.93	0.95	0.4779
		TEMP*PM	6	66.33	0.78	0.5839
		MC*TEMP*PM	24	73.52	0.86	0.6531
	31	BLK	3	87.55	0.96	0.4110
		MC	4	1516.28	16.70	0.0001
		TEMP	3	3317.11	36.53	0.0001
		PM	2	190.27	2.10	0.1261
		MC*TEMP	12	194.72	2.14	0.0164
		MC*PM	8	54.68	0.60	0.7753
		TEMP*PM	6	98.35	1.09	0.3711
		MC*TEMP*PM	24	74.13	0.82	0.7130
	36	BLK	3	235.94	3.51	0.0165
		MC	4	669.85	9.96	0.0001
		TEMP	3	1165.5	17.33	0.0001
		PM	2	11.07	0.16	0.8483
		MC*TEMP	12	153.96	2.29	0.0099
		MC*PM	8	29.55	0.44	0.8960
		TEMP*PM	6	34.66	0.52	0.7961
		MC*TEMP*PM	24	45.81	0.68	0.8656
	41	BLK	3	7.10	0.39	0.7597
		MC	4	584.94	32.20	0.0001
		TEMP	3	71.33	3.93	0.0096
		PM	2	42.78	2.36	0.0979
		MC*TEMP	12	71.33	3.93	0.0001
		MC*PM	8	42.78	2.36	0.0198
		TEMP*PM	6	16.25	0.89	0.5001
		MC*TEMP*PM	24	16.25	0.89	0.6092
8	18	BLK	3	4.09	0.07	0.9754
		MC	4	228.89	3.96	0.0042
		TEMP	3	1395.3	24.17	0.0001
		PM	2	613.99	10.67	0.0001
		MC*TEMP	12	105.19	1.82	0.0477
		MC*PM	8	94.37	1.63	0.1179
		TEMP*PM	6	357.25	6.19	0.0001
		MC*TEMP*PM	24	78.96	1.37	0.1286
	23	BLK	3	66.18	1.37	0.2607
		MC	4	1101.4	22.42	0.0001
		TEMP	3	7042.5	143.36	0.0001
		PM	2	411.74	8.38	0.0003
		MC*TEMP	12	402.94	8.20	0.0001
		MC*PM	8	73.58	1.50	0.1609
		TEMP*PM	6	234.66	4.78	0.0002
		MC*TEMP*PM	24	86.73	1.77	0.0200
	28	BLK	3	84.13	1.74	0.1602
		MC	4	620.38	12.84	0.0001
		TEMP	3	3227.2	66.81	0.0001
		PM	2	133.88	2.77	0.0653
		MC*TEMP	12	300.02	6.21	0.0001
		MC*PM	8	17.20	0.36	0.9420
		TEMP*PM	6	76.97	1.59	0.1515
		MC*TEMP*PM	24	39.83	0.82	0.7022
	33	BLK	3	157.31	2.09	0.1038
		MC	4	234.13	3.10	0.0169
		TEMP	3	2338.08	30.99	0.0001
		PM	2	41.46	0.55	0.5782
		MC*TEMP	12	110.33	1.46	0.1422
		MC*PM	8	42.85	0.57	0.8031
		TEMP*PM	6	23.04	0.31	0.9335
		MC*TEMP*PM	24	44.28	0.59	0.9375

Appendix 3a continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	38	BLK	3	151.38	4.14	0.0073
		MC	4	90.02	2.45	0.0476
		TEMP	3	386.73	10.54	0.0001
		PM	2	28.22	0.77	0.4650
		MC*TEMP	12	44.55	1.21	0.2763
		MC*PM	3	21.38	0.58	0.7912
		TEMP*PM	6	18.50	0.50	0.8046
		MC*TEMP*PM	24	27.05	0.74	0.8081
	43	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-
20	20	BLK	3	0.24	1.00	0.3942
		MC	4	59.62	242.68	0.0001
		TEMP	3	59.62	242.68	0.0001
		PM	2	59.62	242.68	0.0001
		MC*TEMP	12	59.62	242.68	0.0001
		MC*PM	8	59.62	242.68	0.0001
		TEMP*PM	6	59.62	242.68	0.0001
		MC*TEMP*PM	24	59.62	242.68	0.0001
	25	BLK	3	13.32	0.42	0.7413
		MC	4	569.72	17.81	0.0001
		TEMP	3	1401.9	43.84	0.0001
		PM	2	112.14	3.51	0.0321
		MC*TEMP	12	225.43	7.05	0.0001
		MC*PM	8	82.83	2.59	0.0106
		TEMP*PM	6	44.51	1.39	0.2202
		MC*TEMP*PM	24	71.50	2.24	0.0016
	30	BLK	3	23.17	1.34	0.2635
		MC	4	561.32	32.42	0.0001
		TEMP	3	1012.2	58.47	0.0001
		PM	2	147.39	8.51	0.0003
		MC*TEMP	12	219.04	12.65	0.0001
		MC*PM	8	36.43	2.10	0.0376
		TEMP*PM	6	116.55	6.73	0.0001
		MC*TEMP*PM	24	47.34	2.73	0.0001
	35	BLK	3	57.40	4.75	0.0033
		MC	4	57.40	4.75	0.0012
		TEMP	3	24.41	2.02	0.1127
		PM	2	4.86	0.40	0.6696
		MC*TEMP	12	24.41	2.02	0.0248
		MC*PM	8	4.86	0.40	0.9183
		TEMP*PM	6	2.28	0.19	0.9797
		MC*TEMP*PM	24	2.28	0.19	1.0000
	40	BLK	3	50.07	4.81	0.0030
		MC	4	50.07	4.81	0.0011
		TEMP	3	22.79	2.91	0.0910
		PM	2	0.68	0.07	0.9364
		MC*TEMP	12	22.79	2.19	0.0140
		MC*PM	8	0.68	0.07	0.9998
		TEMP*PM	6	2.18	0.21	0.9735
		MC*TEMP*PM	24	2.18	0.21	1.0000
	45	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-

Appendix 3b ANOVA tables for Final cumulative germination percent for *C. africana* seeds For storage trial

SP	DAS	Source	DF	Mean square	F Value	Pr > F
2	15	BLK	3	171.99	2.36	0.0735
		MC	4	485.16	6.65	0.0001
		TEMP	3	1735.9	23.78	0.0001
		PM	2	163.68	2.24	0.1092
		MC*TEMP	12	154.10	2.11	0.0183
		MC*PM	8	169.36	2.32	0.0216
		TEMP*PM	6	28.04	0.38	0.8885
		MC*TEMP*PM	24	121.31	1.68	0.0324
	20	BLK	3	199.93	2.60	0.0534
		MC	4	1970.5	25.67	0.0001
		TEMP	3	7750.4	100.97	0.0001
		PM	2	180.49	0.098	0.0982
		MC*TEMP	12	417.56	5.44	0.0001
		MC*PM	8	72.876	0.95	0.4774
		TEMP*PM	6	65.69	0.36	0.5287
		MC*TEMP*PM	24	63.06	0.82	0.7061
	25	BLK	3	98.98	2.04	0.1106
		MC	4	3762.7	77.38	0.0001
		TEMP	3	17036	350.35	0.0001
		PM	2	264.07	5.43	0.0051
		MC*TEMP	12	757.52	15.58	0.0001
		MC*PM	8	17.46	0.36	0.9406
		TEMP*PM	6	70.21	1.44	0.2003
		MC*TEMP*PM	24	22.03	0.45	0.9875
	30	BLK	3	47.25	0.85	0.4689
		MC	4	6323.07	113.60	0.0001
		TEMP	3	25184.7	452.47	0.0001
		PM	2	532.16	9.56	0.0001
		MC*TEMP	12	1059.45	19.03	0.0001
		MC*PM	8	21.65	0.39	0.9255
		TEMP*PM	6	176.66	3.17	0.0055
		MC*TEMP*PM	24	28.24	0.51	0.9737
	35	BLK	3	136.31	2.31	0.0776
		MC	4	8123.67	137.89	0.0001
		TEMP	3	29812.67	506.03	0.0001
		PM	2	693.66	11.77	0.0001
		MC*TEMP	12	1227.66	20.84	0.0001
		MC*PM	8	39.65	0.67	0.7148
		TEMP*PM	6	173.21	2.98	0.0093
		MC*TEMP*PM	24	28.47	0.48	0.9808
	40	BLK	3	110.03	1.67	0.1787
		MC	4	9086.03	136.58	0.0001
		TEMP	3	31259.99	469.91	0.0001
		PM	2	819.61	12.32	0.0001
		MC*TEMP	12	1329.67	19.99	0.0001
		MC*PM	8	40.87	0.61	0.7650
		TEMP*PM	6	185.98	2.80	0.0127
		MC*TEMP*PM	24	27.40	0.41	0.9936
4	16	BLK	3	171.99	2.63	0.0735
		MC	4	485.17	6.65	0.0001
		TEMP	3	1735.9	23.78	0.0001
		PM	2	163.68	2.24	0.1092
		MC*TEMP	12	154.10	2.11	0.0183
		MC*PM	8	169.36	2.32	0.0216
		TEMP*PM	6	28.04	0.38	0.8885
		MC*TEMP*PM	24	121.31	1.67	0.0324
	21	BLK	3	199.93	2.60	0.0534
		MC	4	1970.5	25.67	0.0001
		TEMP	3	7750.4	100.97	0.0001
		PM	2	180.49	2.35	0.0982
		MC*TEMP	12	417.56	5.44	0.0001
		MC*PM	8	72.87	0.98	0.4774
		TEMP*PM	6	65.69	0.86	0.5287
		MC*TEMP*PM	24	63.06	0.82	0.7061

Appendix 3b continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	26	BLK	3	98.98	2.04	0.1106
		MC	4	3762.7	77.38	0.0001
		TEMP	3	17036	350.35	0.0001
		PM	2	264.07	5.43	0.0051
		MC*TEMP	12	757.5	15.58	0.0001
		MC*PM	8	17.47	0.36	0.9406
		TEMP*PM	6	70.21	1.44	0.2003
		MC*TEMP*PM	24	22.03	0.45	0.9875
	31	BLK	3	47.25	0.85	0.4689
		MC	4	6323.07	113.60	0.0001
		TEMP	3	25184.7	452.47	0.0001
		PM	2	532.16	9.56	0.0001
		MC*TEMP	12	1059.45	19.03	0.0001
		MC*PM	8	21.65	0.39	0.9255
		TEMP*PM	6	176.66	3.17	0.0055
		MC*TEMP*PM	24	28.24	0.51	0.9737
	36	BLK	3	136.31	2.31	0.0776
		MC	4	8123.67	137.89	0.0001
		TEMP	3	29812.67	506.03	0.0001
		PM	2	693.66	11.77	0.0001
		MC*TEMP	12	1227.66	20.84	0.0001
		MC*PM	8	39.65	0.67	0.7148
		TEMP*PM	6	173.21	2.94	0.0093
		MC*TEMP*PM	24	28.47	0.48	0.9808
	41	BLK	3	110.03	1.65	0.1787
		MC	4	9086.03	136.58	0.0001
		TEMP	3	31259.99	469.91	0.0001
		PM	2	819.61	12.32	0.0001
		MC*TEMP	12	1329.67	19.99	0.0001
		MC*PM	8	40.87	0.61	0.7650
		TEMP*PM	6	185.98	2.80	0.0127
		MC*TEMP*PM	24	27.40	0.41	0.9936
8	18	BLK	3	4.10	0.07	0.9754
		MC	4	228.89	3.96	0.0042
		TEMP	3	1395.3	24.17	0.0001
		PM	2	613.99	10.64	0.0001
		MC*TEMP	12	105.19	1.82	0.0477
		MC*PM	8	94.37	1.63	0.1179
		TEMP*PM	6	357.25	6.19	0.0001
		MC*TEMP*PM	24	78.96	1.37	0.1286
	23	BLK	3	30.26	0.42	0.7360
		MC	4	1734.4	24.30	0.0001
		TEMP	3	10806	151.43	0.0001
		PM	2	775.31	10.86	0.0001
		MC*TEMP	12	600.95	8.42	0.0001
		MC*PM	8	48.13	0.67	0.7135
		TEMP*PM	6	289.46	4.06	0.0008
		MC*TEMP*PM	24	55.04	0.77	0.7689
	28	BLK	3	78.18	1.56	0.2006
		MC	4	2365.2	47.21	0.0001
		TEMP	3	17857	356.46	0.0001
		PM	2	1093	21.82	0.0001
		MC*TEMP	12	813.11	16.23	0.0001
		MC*PM	8	17.56	0.35	0.9446
		TEMP*PM	6	391.03	7.81	0.0001
		MC*TEMP*PM	24	59.38	1.19	0.2608
	33	BLK	3	166.97	3.56	0.0154
		MC	4	3058	65.27	0.0001
		TEMP	3	24438.42	521.57	0.0001
		PM	2	1167.87	24.93	0.0001
		MC*TEMP	12	1038.17	22.16	0.0001
		MC*PM	8	34.54	0.74	0.6584
		TEMP*PM	6	403.28	8.61	0.0001
		MC*TEMP*PM	24	67.50	1.44	0.0941

Appendix 3b continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	38	BLK	3	57.37	1.09	0.3532
		MC	4	3353	63.92	0.0001
		TEMP	3	27421.86	522.78	0.0001
		PM	2	1200.13	22.88	0.0001
		MC*TEMP	12	1141.99	21.77	0.0001
		MC*PM	8	35.82	0.68	0.7062
		TEMP*PM	6	416.14	7.93	0.0001
		MC*TEMP*PM	24	52.67	1.00	0.4636
	43	BLK	3	57.37	1.09	0.3532
		MC	4	3353	63.92	0.0001
		TEMP	3	27421.86	522.78	0.0001
		PM	2	1200.13	22.88	0.0001
		MC*TEMP	12	1141.99	21.77	0.0001
		MC*PM	8	35.82	0.68	0.7062
		TEMP*PM	6	416.14	7.93	0.0001
		MC*TEMP*PM	24	52.67	1.00	0.4636
20	20	BLK	3	0.24	1.00	0.3942
		MC	4	59.62	242.68	0.0001
		TEMP	3	59.62	242.68	0.0001
		PM	2	59.62	242.68	0.0001
		MC*TEMP	12	59.62	242.68	0.0001
		MC*PM	8	59.62	242.68	0.0001
		TEMP*PM	6	59.62	242.68	0.0001
		MC*TEMP*PM	24	59.62	242.68	0.0001
	25	BLK	3	12.19	0.38	0.7690
		MC	4	693.13	21.49	0.0001
		TEMP	3	1917.7	59.46	0.0001
		PM	2	284.72	8.83	0.0002
		MC*TEMP	12	263.60	8.17	0.0001
		MC*PM	8	81.09	2.51	0.0130
		TEMP*PM	6	112.33	3.48	0.0028
		MC*TEMP*PM	24	43.24	1.34	0.1438
	30	BLK	3	45.00	1.33	0.2660
		MC	4	1538.3	45.48	0.0001
		TEMP	3	3666.9	108.41	0.0001
		PM	2	424.72	12.56	0.0001
		MC*TEMP	12	565.88	16.73	0.0001
		MC*PM	8	49.86	1.47	0.1696
		TEMP*PM	6	199.01	5.88	0.0001
		MC*TEMP*PM	24	23.97	0.71	0.8387
	35	BLK	3	49.02	1.45	0.2304
		MC	4	1582.75	46.77	0.0001
		TEMP	3	3787.60	111.92	0.0001
		PM	2	452.18	13.36	0.0001
		MC*TEMP	12	583.52	17.24	0.0001
		MC*PM	8	51.12	1.51	0.1563
		TEMP*PM	6	216.67	6.40	0.0001
		MC*TEMP*PM	24	25.13	0.74	0.8023
	40	BLK	3	49.02	1.45	0.2304
		MC	4	1582.75	46.77	0.0001
		TEMP	3	3787.61	111.92	0.0001
		PM	2	452.18	13.36	0.0001
		MC*TEMP	12	583.52	17.24	0.0001
		MC*PM	8	51.12	1.51	0.1563
		TEMP*PM	6	216.67	6.40	0.0001
		MC*TEMP*PM	24	25.13	0.74	0.8023
	45	BLK	3	49.02	1.45	0.2304
		MC	4	1582.75	46.77	0.0001
		TEMP	3	3787.61	111.92	0.0001
		PM	2	452.18	13.36	0.0001
		MC*TEMP	12	583.52	17.24	0.0001
		MC*PM	8	51.12	1.51	0.1563
		TEMP*PM	6	216.67	6.40	0.0001
		MC*TEMP*PM	24	25.13	0.74	0.8023

Appendix 3c ANOVA tables for radicle elongation for *C. africana* seeds for storage trial

SP	DAS	Source	DF	Mean square	F Value	Pr > F
2	15	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-
	20	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-
	25	BLK	3	2.7	4.60	0.0040
		MC	4	36.10	61.50	0.0001
		TEMP	3	74.48	126.90	0.0001
		PM	2	12.86	21.92	0.0001
		MC*TEMP	12	5.87	10.01	0.0001
		MC*PM	8	0.45	0.77	0.6326
		TEMP*PM	6	5.48	9.35	0.0001
		MC*TEMP*PM	24	0.62	1.07	0.3830
	30	BLK	3	5.61	5.67	0.0010
		MC	4	131.56	132.94	0.0001
		TEMP	3	396.35	400.50	0.0001
		PM	2	39.46	39.88	0.0001
		MC*TEMP	12	21.30	21.52	0.0001
		MC*PM	8	1.96	1.99	0.0505
		TEMP*PM	6	5.69	5.75	0.0001
		MC*TEMP*PM	24	0.97	0.98	0.4990
	35	BLK	3	5.41	4.65	0.0037
		MC	4	247.43	212.84	0.0001
		TEMP	3	680.53	585.39	0.0001
		PM	2	60.47	52.01	0.0001
		MC*TEMP	12	38.81	33.39	0.0001
		MC*PM	8	2.38	2.05	0.0431
		TEMP*PM	6	7.13	6.14	0.0001
		MC*TEMP*PM	24	1.49	1.29	0.1794
	40	BLK	3	4.04	2.98	0.0327
		MC	4	600.93	443.43	0.0001
		TEMP	3	2121.67	1565.60	0.0001
		PM	2	110.63	81.63	0.0001
		MC*TEMP	12	110.72	81.71	0.0001
		MC*PM	8	2.16	1.60	0.1283
		TEMP*PM	6	13.64	10.07	0.0001
		MC*TEMP*PM	24	2.92	2.15	0.0025
4	16	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-
	21	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-

Appendix 3c continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	26	BLK	3	2.7	4.60	0.0040
		MC	4	36.10	61.50	0.0001
		TEMP	3	74.49	126.90	0.0001
		PM	2	12.87	21.92	0.0001
		MC*TEMP	12	5.88	10.01	0.0001
		MC*PM	8	0.45	0.77	0.6326
		TEMP*PM	6	5.49	9.35	0.0001
		MC*TEMP*PM	24	0.62	1.07	0.3830
	31	BLK	3	5.61	5.67	0.0010
		MC	4	131.57	132.94	0.0001
		TEMP	3	396.35	400.50	0.0001
		PM	2	39.47	39.88	0.0001
		MC*TEMP	12	21.30	21.52	0.0001
		MC*PM	8	1.97	1.99	0.0505
		TEMP*PM	6	5.69	5.75	0.0001
		MC*TEMP*PM	24	0.97	0.98	0.4990
	36	BLK	3	5.41	4.65	0.0037
		MC	4	247.43	212.84	0.0001
		TEMP	3	680.53	585.39	0.0001
		PM	2	60.47	52.01	0.0001
		MC*TEMP	12	38.31	33.39	0.0001
		MC*PM	8	2.38	2.05	0.0431
		TEMP*PM	6	7.13	6.14	0.0001
		MC*TEMP*PM	24	1.49	1.29	0.1794
	41	BLK	3	4.04	2.98	0.0327
		MC	4	600.93	443.43	0.0001
		TEMP	3	2121.67	1565.60	0.0001
		PM	2	110.63	81.63	0.0001
		MC*TEMP	12	110.72	81.71	0.0001
		MC*PM	8	2.16	1.60	0.1283
		TEMP*PM	6	13.64	10.07	0.0001
		MC*TEMP*PM	24	2.92	2.15	0.0025
8	18	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-
	23	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-
	28	BLK	3	0.00	0	0.0001
		MC	4	0.50	0	0.0001
		TEMP	3	1.67	0	0.0001
		PM	2	0.87	0	0.0001
		MC*TEMP	12	0.50	0	0.0001
		MC*PM	8	0.20	0	0.0001
		TEMP*PM	6	0.87	0	0.0001
		MC*TEMP*PM	24	0.20	0	0.0001
	33	BLK	3	1.01	2.45	0.0649
		MC	4	25.90	62.83	0.0001
		TEMP	3	179.73	435.99	0.0001
		PM	2	8.47	20.54	0.0001
		MC*TEMP	12	10.57	25.63	0.0001
		MC*PM	8	0.80	1.94	0.0567
		TEMP*PM	6	2.87	6.95	0.0001
		MC*TEMP*PM	24	0.87	2.10	0.0033

Appendix 3c continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	38	BLK	3	2.95	4.01	0.0086
		MC	4	53.57	72.85	0.0001
		TEMP	3	452.06	614.79	0.0001
		PM	2	10.85	14.76	0.0001
		MC*TEMP	12	20.92	28.45	0.0001
		MC*PM	8	0.77	1.04	0.4059
		TEMP*PM	6	3.69	5.02	0.0001
		MC*TEMP*PM	24	1.22	1.66	0.0335
	43	BLK	3	4.38	5.35	0.0015
		MC	4	143.07	174.80	0.0001
		TEMP	3	1309.76	1600.28	0.0001
		PM	2	34.07	41.62	0.0001
		MC*TEMP	12	48.98	59.84	0.0001
		MC*PM	8	2.07	2.53	0.0126
		TEMP*PM	6	16.56	20.23	0.0001
		MC*TEMP*PM	24	1.78	2.17	0.0022
20	20	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-
	25	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-
	30	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-
	35	BLK	3	0.08	0.19	0.9054
		MC	4	9.43	22.63	0.0001
		TEMP	3	42.91	102.96	0.0001
		PM	2	11.40	27.35	0.0001
		MC*TEMP	12	7.30	17.52	0.0001
		MC*PM	8	1.23	2.96	0.0039
		TEMP*PM	6	5.18	12.42	0.0001
		MC*TEMP*PM	24	1.23	2.96	0.0001
	40	BLK	3	0.67	1.18	0.3188
		MC	4	39.07	69.15	0.0001
		TEMP	3	173.07	306.33	0.0001
		PM	2	14.87	26.31	0.0001
		MC*TEMP	12	17.29	30.60	0.0001
		MC*PM	8	2.12	3.75	0.0004
		TEMP*PM	6	6.87	12.15	0.0001
		MC*TEMP*PM	24	1.00	1.78	0.0185
	45	BLK	3	1.01	1.64	0.1813
		MC	4	81.17	131.84	0.0001
		TEMP	3	440.18	715.00	0.0001
		PM	2	24.20	39.31	0.0001
		MC*TEMP	12	38.45	62.47	0.0001
		MC*PM	8	1.62	2.63	0.0097
		TEMP*PM	6	10.24	16.64	0.0001
		MC*TEMP*PM	24	0.77	1.25	0.2023

Appendix 3d ANOVA tables for Daily germination percent for *C. densiflora* seeds for storage trial

SP	DAS	Source	DF	Mean square	F Value	Pr > F
2	15	BLK	3	137.19	2.85	0.0391
		MC	4	501.19	10.37	0.0001
		TEMP	3	3577.3	74.04	0.0001
		PM	2	551.65	11.42	0.0001
		MC*TEMP	12	360.32	7.46	0.0001
		MC*PM	8	183.51	3.80	0.0004
		TEMP*PM	6	255.59	5.29	0.0001
		MC*TEMP*PM	24	180.97	3.75	0.0001
	20	BLK	3	75.77	1.32	0.2708
		MC	4	1528.1	26.54	0.0001
		TEMP	3	8722.7	151.47	0.0001
		PM	2	135.59	2.35	0.0979
		MC*TEMP	12	291.68	5.07	0.0001
		MC*PM	8	327.53	5.69	0.0001
		TEMP*PM	6	422.38	7.33	0.0001
		MC*TEMP*PM	24	243.38	4.23	0.0001
	25	BLK	3	123.28	1.96	0.1215
		MC	4	569.75	9.06	0.0001
		TEMP	3	9580.4	152.41	0.0001
		PM	2	277.47	4.41	0.0135
		MC*TEMP	12	260.39	4.41	0.0001
		MC*PM	8	70.09	1.12	0.3552
		TEMP*PM	6	117.79	1.87	0.0877
		MC*TEMP*PM	24	107.45	1.71	0.0265
	30	BLK	3	77.15	0.94	0.4249
		MC	4	188.05	2.28	0.0626
		TEMP	3	5090.5	61.70	0.0001
		PM	2	41.97	0.51	0.6021
		MC*TEMP	12	438.12	5.31	0.0001
		MC*PM	8	204.98	2.48	0.0141
		TEMP*PM	6	95.35	1.16	0.3323
		MC*TEMP*PM	24	80.78	0.98	0.4960
	35	BLK	3	36.20	0.63	0.5983
		MC	4	1500.5	26.00	0.0001
		TEMP	3	3154.86	54.67	0.0001
		PM	2	171.40	2.97	0.0539
		MC*TEMP	12	543.39	9.42	0.0001
		MC*PM	8	176.93	3.07	0.0029
		TEMP*PM	6	134.76	2.34	0.0340
		MC*TEMP*PM	24	178.93	3.10	0.0001
	40	BLK	3	5.19	0.24	0.8715
		MC	4	294.28	13.34	0.0001
		TEMP	3	601.98	27.28	0.0001
		PM	2	130.12	5.90	0.0033
		MC*TEMP	12	491.6	22.28	0.0001
		MC*PM	8	57.95	2.63	0.0096
		TEMP*PM	6	177.6	8.05	0.0001
		MC*TEMP*PM	24	229.26	10.39	0.0001
4	16	BLK	3	24.62	1.19	0.3146
		MC	4	865.23	41.86	0.0001
		TEMP	3	2515.1	121.68	0.0001
		PM	2	792.61	38.35	0.0001
		MC*TEMP	12	260.06	12.58	0.0001
		MC*PM	8	274.11	13.26	0.0001
		TEMP*PM	6	145.30	7.03	0.0001
		MC*TEMP*PM	24	79.06	3.82	0.0001
	21	BLK	3	29.32	0.76	0.5156
		MC	4	1650.8	43.02	0.0001
		TEMP	3	7007.2	182.60	0.0001
		PM	2	121.66	3.17	0.0444
		MC*TEMP	12	363.38	9.47	0.0001
		MC*PM	8	151.15	3.94	0.0003
		TEMP*PM	6	353.51	9.21	0.0001
		MC*TEMP*PM	24	235.36	6.13	0.0001

Appendix 3d continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	26	BLK	3	28.49	0.77	0.5146
		MC	4	1095.4	29.44	0.0001
		TEMP	3	6004.2	161.36	0.0001
		PM	2	374.37	10.07	0.0001
		MC*TEMP	12	256.36	6.90	0.0001
		MC*PM	8	124.24	3.34	0.0014
		TEMP*PM	6	275.61	7.41	0.0001
		MC*TEMP*PM	24	71.39	1.92	0.0090
	31	BLK	3	23.34	0.67	0.5690
		MC	4	708.33	20.03	0.0001
		TEMP	3	5319.49	150.40	0.0001
		PM	2	503.32	14.23	0.0001
		MC*TEMP	12	631.46	17.85	0.0001
		MC*PM	8	226.24	6.40	0.0001
		TEMP*PM	6	279.86	7.91	0.0001
		MC*TEMP*PM	24	166.36	4.70	0.0001
	36	BLK	3	26.80	0.62	0.6022
		MC	4	967.59	22.42	0.0001
		TEMP	3	1818.64	42.14	0.0001
		PM	2	406.35	9.42	0.0001
		MC*TEMP	12	359.66	8.33	0.0001
		MC*PM	8	92.57	2.15	0.0339
		TEMP*PM	6	192.21	4.45	0.0003
		MC*TEMP*PM	24	203.99	4.73	0.0001
	41	BLK	3	0.39	0.03	0.9919
		MC	4	172.07	14.59	0.0001
		TEMP	3	254.60	21.58	0.0001
		PM	2	72.42	6.14	0.0026
		MC*TEMP	12	188.09	15.95	0.0001
		MC*PM	8	30.42	2.58	0.0109
		TEMP*PM	6	101.36	8.59	0.0001
		MC*TEMP*PM	24	31.09	2.64	0.0002
8	18	BLK	3	33.92	2.15	0.0959
		MC	4	247.05	15.64	0.0001
		TEMP	3	790.60	50.06	0.0001
		PM	2	113.51	7.19	0.0010
		MC*TEMP	12	99.54	6.30	0.0001
		MC*PM	8	170.88	10.82	0.0001
		TEMP*PM	6	44.73	2.83	0.0117
		MC*TEMP*PM	24	148.11	9.38	0.0001
	23	BLK	3	1.66	0.05	0.9859
		MC	4	443.43	12.91	0.0001
		TEMP	3	5016.6	146.03	0.0001
		PM	2	551.16	16.04	0.0001
		MC*TEMP	12	204.07	5.94	0.0001
		MC*PM	8	81.43	2.37	0.0190
		TEMP*PM	6	286.95	8.35	0.0001
		MC*TEMP*PM	24	89.29	2.60	0.0002
	28	BLK	3	7.12	0.33	0.8006
		MC	4	288.60	13.54	0.0001
		TEMP	3	6031	282.90	0.0001
		PM	2	529.10	24.82	0.0001
		MC*TEMP	12	170.86	8.01	0.0001
		MC*PM	8	72.61	3.41	0.0012
		TEMP*PM	6	566.23	26.56	0.0001
		MC*TEMP*PM	24	85.07	3.99	0.0001
	33	BLK	3	67.38	2.16	0.0939
		MC	4	227.10	7.30	0.0001
		TEMP	3	5711.67	183.50	0.0001
		PM	2	514.69	16.54	0.0001
		MC*TEMP	12	197.42	6.34	0.0001
		MC*PM	8	215.01	6.91	0.0001
		TEMP*PM	6	340.99	10.96	0.0001
		MC*TEMP*PM	24	72.35	2.32	0.0009

Appendix 3d continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	38	BLK	3	10.61	0.30	0.8244
		MC	4	111.74	3.18	0.0150
		TEMP	3	2313.35	65.74	0.0001
		PM	2	74.58	2.12	0.1232
		MC*TEMP	12	110.25	3.13	0.0005
		MC*PM	8	111.04	3.16	0.0023
		TEMP*PM	6	264.73	7.52	0.0001
		MC*TEMP*PM	24	124.89	3.55	0.0001
	43	BLK	3	9.27	0.32	0.8083
		MC	4	36.57	1.28	0.2808
		TEMP	3	1335.31	46.63	0.0001
		PM	2	114.62	4.00	0.0200
		MC*TEMP	12	48.91	1.71	0.0684
		MC*PM	8	33.81	1.18	0.3132
		TEMP*PM	6	39.39	1.38	0.2269
		MC*TEMP*PM	24	142.74	4.98	0.0001
20	20	BLK	3	30.19	1.06	0.3678
		MC	4	205.90	7.22	0.0001
		TEMP	3	1599.9	56.13	0.0001
		PM	2	78.53	2.76	0.0663
		MC*TEMP	12	166.55	5.84	0.0001
		MC*PM	8	42.45	1.49	0.1639
		TEMP*PM	6	34.57	1.21	0.3017
		MC*TEMP*PM	24	33.80	1.19	0.2602
	25	BLK	3	73.17	2.54	0.0579
		MC	4	378.17	13.14	0.0001
		TEMP	3	4639.9	161.18	0.0001
		PM	2	236.67	8.22	0.0004
		MC*TEMP	12	187.96	6.53	0.0001
		MC*PM	8	28.56	0.99	0.4439
		TEMP*PM	6	117.96	4.10	0.0007
		MC*TEMP*PM	24	34.91	1.21	0.2363
	30	BLK	3	191.80	4.83	0.0029
		MC	4	461.79	11.64	0.0001
		TEMP	3	3973.4	100.16	0.0001
		PM	2	132.45	3.34	0.0377
		MC*TEMP	12	190.65	4.81	0.0001
		MC*PM	8	72.62	1.83	0.0741
		TEMP*PM	6	83.60	2.11	0.0546
		MC*TEMP*PM	24	59.24	1.49	0.0744
	35	BLK	3	8.14	0.61	0.6109
		MC	4	59.78	4.46	0.0019
		TEMP	3	380.67	28.41	0.0001
		PM	2	34.51	2.58	0.0790
		MC*TEMP	12	59.78	4.46	0.0001
		MC*PM	8	37.76	2.82	0.0058
		TEMP*PM	6	34.51	2.58	0.0204
		MC*TEMP*PM	24	37.76	2.82	0.0001
	40	BLK	3	0.06	0.01	0.9983
		MC	4	18.65	3.59	0.0077
		TEMP	3	37.59	7.24	0.0001
		PM	2	14.86	2.86	0.0599
		MC*TEMP	12	18.65	3.59	0.0001
		MC*PM	8	24.33	4.68	0.0001
		TEMP*PM	6	14.86	2.86	0.0110
		MC*TEMP*PM	24	24.33	4.68	0.0001
	45	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-

Appendix 3e ANOVA tables for Cumulative germination percent for *C. densiflora* seeds for storage trial

SP	DAS	Source	DF	Mean square	F Value	Pr > F
2	15	BLK	3	137.49	2.85	0.0391
		MC	4	501.19	10.37	0.0001
		TEMP	3	3577.3	74.04	0.0001
		PM	2	551.66	11.42	0.0001
		MC*TEMP	12	360.32	7.46	0.0001
		MC*PM	8	183.51	3.80	0.0004
		TEMP*PM	6	255.59	5.29	0.0001
		MC*TEMP*PM	24	180.97	3.75	0.0001
	20	BLK	3	49.97	0.95	0.4156
		MC	4	2464.8	47.08	0.0001
		TEMP	3	14761	281.95	0.0001
		PM	2	270	5.16	0.0067
		MC*TEMP	12	518.04	9.89	0.0001
		MC*PM	8	296.24	5.66	0.0001
		TEMP*PM	6	285.75	5.46	0.0001
		MC*TEMP*PM	24	197.53	3.77	0.0001
	25	BLK	3	78.35	1.13	0.3374
		MC	4	2724.8	39.38	0.0001
		TEMP	3	30582	442.03	0.0001
		PM	2	697.84	10.09	0.0001
		MC*TEMP	12	511.49	7.39	0.0001
		MC*PM	8	222.42	3.21	0.0020
		TEMP*PM	6	440.07	6.36	0.0001
		MC*TEMP*PM	24	121.85	1.76	0.0204
	30	BLK	3	17.94	0.29	0.8342
		MC	4	3376.6	54.17	0.0001
		TEMP	3	41250	661.78	0.0001
		PM	2	664.97	10.67	0.0001
		MC*TEMP	12	690.03	11.07	0.0001
		MC*PM	8	86.12	1.38	0.2073
		TEMP*PM	6	303.21	4.86	0.0001
		MC*TEMP*PM	24	132.26	2.12	0.0030
	35	BLK	3	26.87	0.61	0.6073
		MC	4	2306.89	52.63	0.0001
		TEMP	3	51643.30	117.21	0.0001
		PM	2	322.11	7.35	0.0009
		MC*TEMP	12	388.43	8.86	0.0001
		MC*PM	8	47.09	1.07	0.3831
		TEMP*PM	6	212.60	4.85	0.0001
		MC*TEMP*PM	24	103.09	2.35	0.0008
	40	BLK	3	23.41	0.46	0.7131
		MC	4	2017.37	39.33	0.0001
		TEMP	3	56255.35	1096.80	0.0001
		PM	2	212.47	4.14	0.0174
		MC*TEMP	12	302.54	5.90	0.0001
		MC*PM	8	30.09	0.59	0.7880
		TEMP*PM	6	115.63	2.29	0.0403
		MC*TEMP*PM	24	27.88	0.54	0.9599
4	16	BLK	3	24.62	1.19	0.3146
		MC	4	865.23	41.86	0.0001
		TEMP	3	2515	121.68	0.0001
		PM	2	792.61	38.35	0.0001
		MC*TEMP	12	260.05	12.58	0.0001
		MC*PM	8	274.10	13.26	0.0001
		TEMP*PM	6	145.30	7.03	0.0001
		MC*TEMP*PM	24	79.05	3.82	0.0001
	21	BLK	3	26.09	0.63	0.5972
		MC	4	3023.4	72.88	0.0001
		TEMP	3	11358	373.78	0.0001
		PM	2	464.95	11.21	0.0001
		MC*TEMP	12	503.24	12.13	0.0001
		MC*PM	8	412.76	9.95	0.0001
		TEMP*PM	6	383.89	9.95	0.0001
		MC*TEMP*PM	24	252.19	6.08	0.0001

Appendix 3e continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	26	BLK	3	11.41	0.39	0.7591
		MC	4	4987.8	171.18	0.0001
		TEMP	3	20596	706.87	0.0001
		PM	2	893.56	30.67	0.0001
		MC*TEMP	12	617.92	21.21	0.0001
		MC*PM	8	578.35	19.85	0.0001
		TEMP*PM	6	504.75	17.32	0.0001
		MC*TEMP*PM	24	230.03	7.89	0.0001
	31	BLK	3	52.83	1.86	0.1381
		MC	4	6696.64	235.75	0.0001
		TEMP	3	31342.12	1103.36	0.0001
		PM	2	1062.54	37.41	0.0001
		MC*TEMP	12	963.92	33.93	0.0001
		MC*PM	8	605.76	21.33	0.0001
		TEMP*PM	6	675.36	23.78	0.0001
		MC*TEMP*PM	24	303.81	10.70	0.0001
	36	BLK	3	31.77	1.08	0.3584
		MC	4	7344.34	249.99	0.0001
		TEMP	3	36630.47	1246.86	0.0001
		PM	2	1020.88	34.75	0.0001
		MC*TEMP	12	1192.01	40.57	0.0001
		MC*PM	8	591.44	20.13	0.0001
		TEMP*PM	6	610.11	20.77	0.0001
		MC*TEMP*PM	24	287.80	9.80	0.0001
	41	BLK	3	31.03	1.05	0.3704
		MC	4	6671.38	226.47	0.0001
		TEMP	3	38361.65	1302.23	0.0001
		PM	2	1204.43	40.89	0.0001
		MC*TEMP	12	1156.86	39.27	0.0001
		MC*PM	8	620.29	21.06	0.0001
		TEMP*PM	6	794.88	26.98	0.0001
		MC*TEMP*PM	24	321.39	10.91	0.0001
8	18	BLK	3	33.92	2.15	0.0959
		MC	4	247.05	15.64	0.0001
		TEMP	3	790.61	50.06	0.0001
		PM	2	113.51	7.19	0.0010
		MC*TEMP	12	99.54	6.30	0.0001
		MC*PM	8	170.87	10.82	0.0001
		TEMP*PM	6	44.73	2.83	0.0117
		MC*TEMP*PM	24	148.12	9.38	0.0001
	23	BLK	3	9.98	0.29	0.8350
		MC	4	784.19	22.52	0.0001
		TEMP	3	7131.6	204.76	0.0001
		PM	2	748.25	21.48	0.0001
		MC*TEMP	12	303.60	8.72	0.0001
		MC*PM	8	177.92	5.11	0.0001
		TEMP*PM	6	359.82	10.33	0.0001
		MC*TEMP*PM	24	111.38	3.20	0.0001
	28	BLK	3	12.92	0.46	0.7077
		MC	4	1184.4	42.54	0.0001
		TEMP	3	15228	546.95	0.0001
		PM	2	1645	59.09	0.0001
		MC*TEMP	12	471.59	16.94	0.0001
		MC*PM	8	219.41	7.88	0.0001
		TEMP*PM	6	995.39	35.75	0.0001
		MC*TEMP*PM	24	165.24	5.93	0.0001
	33	BLK	3	52.22	1.68	0.1739
		MC	4	1422.94	45.66	0.0001
		TEMP	3	24112.99	773.73	0.0001
		PM	2	2666.80	85.57	0.0001
		MC*TEMP	12	661.08	21.21	0.0001
		MC*PM	8	416.38	14.80	0.0001
		TEMP*PM	6	1546.44	49.62	0.0001
		MC*TEMP*PM	24	193.01	6.19	0.0001

Appendix 3e continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	38	BLK	3	65.02	2.05	0.1089
		MC	4	1588.90	50.04	0.0001
		TEMP	3	29891.71	941.44	0.0001
		PM	2	3067.67	96.62	0.0001
		MC*TEMP	12	754.94	23.78	0.0001
		MC*PM	8	491.93	15.49	0.0001
		TEMP*PM	6	1986.46	62.56	0.0001
		MC*TEMP*PM	24	219.59	6.92	0.0001
	43	BLK	3	83.44	3.01	0.0317
		MC	4	1584.10	57.10	0.0001
		TEMP	3	35094.10	1264.99	0.0001
		PM	2	3571.22	128.73	0.0001
		MC*TEMP	12	794.41	28.64	0.0001
		MC*PM	8	441.50	15.91	0.0001
		TEMP*PM	6	2021.85	72.38	0.0001
		MC*TEMP*PM	24	257.04	9.27	0.0001
20	20	BLK	3	30.19	1.06	0.3678
		MC	4	205.91	7.22	0.0001
		TEMP	3	1599.9	56.13	0.0001
		PM	2	78.53	2.76	0.0663
		MC*TEMP	12	166.55	5.84	0.0001
		MC*PM	8	42.45	1.49	0.1639
		TEMP*PM	6	34.57	1.21	0.3017
		MC*TEMP*PM	24	33.80	1.19	0.2602
	25	BLK	3	85.13	2.65	0.0502
		MC	4	698.60	21.77	0.0001
		TEMP	3	7703.2	240.01	0.0001
		PM	2	421.48	13.13	0.0001
		MC*TEMP	12	344.80	10.74	0.0001
		MC*PM	8	53.79	1.68	0.1071
		TEMP*PM	6	162.65	5.07	0.0001
		MC*TEMP*PM	24	31.34	0.98	0.4994
	30	BLK	3	265.93	7.41	0.0001
		MC	4	1330	37.05	0.0001
		TEMP	3	13772	383.69	0.0001
		PM	2	676.18	18.84	0.0001
		MC*TEMP	12	525.98	14.65	0.0001
		MC*PM	8	81.40	2.27	0.0248
		TEMP*PM	6	266.11	7.41	0.0001
		MC*TEMP*PM	24	69.79	1.94	0.0078
	35	BLK	3	246.57	7.38	0.0001
		MC	4	1482.29	44.36	0.0001
		TEMP	3	15417.97	416.44	0.0001
		PM	2	752.90	22.53	0.0001
		MC*TEMP	12	578.01	17.30	0.0001
		MC*PM	8	54.43	1.63	0.1194
		TEMP*PM	6	279.83	8.38	0.0001
		MC*TEMP*PM	24	52.83	1.58	0.0495
	40	BLK	3	231.73	7.23	0.0001
		MC	4	1557.45	48.60	0.0001
		TEMP	3	16137.19	503.53	0.0001
		PM	2	863.53	26.94	0.0001
		MC*TEMP	12	602.99	18.82	0.0001
		MC*PM	8	46.80	1.46	0.1748
		TEMP*PM	6	301.72	9.41	0.0001
		MC*TEMP*PM	24	43.76	1.37	0.1298
	45	BLK	3	231.73	7.23	0.0001
		MC	4	1557.45	48.60	0.0001
		TEMP	3	16137.19	503.53	0.0001
		PM	2	863.54	26.94	0.0001
		MC*TEMP	12	602.99	18.82	0.0001
		MC*PM	8	46.80	1.46	0.1748
		TEMP*PM	6	301.72	9.41	0.0001
		MC*TEMP*PM	24	43.76	1.37	0.1298

Appendix 3f ANOVA tables for Radicle elongation *Cordyla densiflora* seeds for storage trial

SP	DAS	Source	DF	Mean square	F Value	Pr > F
2	15	BLK	3	1.57	1.40	0.2433
		MC	4	31.27	27.95	0.0001
		TEMP	3	78.89	70.51	0.0001
		PM	2	2.55	2.28	0.1050
		MC*TEMP	12	10.67	9.54	0.0001
		MC*PM	8	2.28	2.04	0.0442
		TEMP*PM	6	1.81	1.62	0.1447
		MC*TEMP*PM	24	0.98	0.88	0.6304
	20	BLK	3	0.23	0.17	0.9185
		MC	4	170.43	121.98	0.0001
		TEMP	3	584.24	418.16	0.0001
		PM	2	12.60	9.02	0.0002
		MC*TEMP	12	29.19	20.89	0.0001
		MC*PM	8	2.43	1.74	0.0917
		TEMP*PM	6	2.11	1.51	0.1770
		MC*TEMP*PM	24	0.72	0.52	0.9705
	25	BLK	3	0.54	0.28	0.8433
		MC	4	431.57	218.02	0.0001
		TEMP	3	2320	1172.03	0.0001
		PM	2	38.60	19.50	0.0001
		MC*TEMP	12	72.05	36.40	0.0001
		MC*PM	8	5.52	2.79	0.0063
		TEMP*PM	6	7.93	4.01	0.0009
		MC*TEMP*PM	24	2.07	1.05	0.4101
	30	BLK	3	0.80	0.35	0.7860
		MC	4	899.60	398.47	0.0001
		TEMP	3	4532.27	2007.54	0.0001
		PM	2	70.47	31.21	0.0001
		MC*TEMP	12	114.71	50.81	0.0001
		MC*PM	8	3.05	1.35	0.2213
		TEMP*PM	6	11.27	4.99	0.0001
		MC*TEMP*PM	24	2.63	1.16	0.2812
	35	BLK	3	1.08	0.43	0.7312
		MC	4	1806.77	722.27	0.0001
		TEMP	3	9312.24	3722.65	0.0001
		PM	2	53.60	21.43	0.0001
		MC*TEMP	12	263.97	105.52	0.0001
		MC*PM	8	10.77	4.30	0.0001
		TEMP*PM	6	8.18	3.27	0.0045
		MC*TEMP*PM	24	2.23	0.89	0.6117
	40	BLK	3	1.05	0.48	0.6939
		MC	4	1740.54	803.11	0.0001
		TEMP	3	12167.61	5614.30	0.0001
		PM	2	130.59	60.25	0.0001
		MC*TEMP	12	285.60	131.78	0.0001
		MC*PM	8	16.36	7.55	0.0001
		TEMP*PM	6	18.16	8.38	0.0001
		MC*TEMP*PM	24	4.96	2.29	0.0001
4	16	BLK	3	0.11	0.34	0.7957
		MC	4	26.57	81.54	0.0001
		TEMP	3	50.13	153.88	0.0001
		PM	2	0.07	0.20	0.8151
		MC*TEMP	12	9.85	30.25	0.0001
		MC*PM	8	1.32	4.04	0.0002
		TEMP*PM	6	0.60	1.84	0.0935
		MC*TEMP*PM	24	0.74	2.27	0.0013
	21	BLK	3	0.95	1.15	0.3301
		MC	4	123.67	150.03	0.0001
		TEMP	3	368.25	446.73	0.0001
		PM	2	10.05	12.20	0.0001
		MC*TEMP	12	32.30	39.19	0.0001
		MC*PM	8	4.41	5.35	0.0001
		TEMP*PM	6	3.90	4.73	0.0002
		MC*TEMP*PM	24	1.56	1.89	0.0104

Appendix 3f continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	26	BLK	3	2.81	1.69	0.1702
		MC	4	417.04	250.32	0.0001
		TEMP	3	2136.8	1285.13	0.0001
		PM	2	35.80	21.53	0.0001
		MC*TEMP	12	101.81	61.23	0.0001
		MC*PM	8	6.59	3.97	0.0002
		TEMP*PM	6	7.83	4.71	0.0002
		MC*TEMP*PM	24	4.23	2.54	0.0003
	31	BLK	3	2.98	1.43	0.2362
		MC	4	733.73	351.89	0.0001
		TEMP	3	3908.00	1874.23	0.0001
		PM	2	72.20	34.63	0.0001
		MC*TEMP	12	132.22	63.41	0.0001
		MC*PM	8	11.78	5.65	0.0001
		TEMP*PM	6	14.07	6.75	0.0001
		MC*TEMP*PM	24	7.20	3.46	0.0001
	36	BLK	3	3.28	1.44	0.2341
		MC	4	1852.77	811.40	0.0001
		TEMP	3	7702.31	3373.14	0.0001
		PM	2	62.07	27.18	0.0001
		MC*TEMP	12	312.81	136.99	0.0001
		MC*PM	8	10.07	4.41	0.0001
		TEMP*PM	6	14.78	6.47	0.0001
		MC*TEMP*PM	24	6.44	2.82	0.0001
	41	BLK	3	4.10	1.91	0.1298
		MC	4	2340.73	1088.33	0.0001
		TEMP	3	9842.28	4576.20	0.0001
		PM	2	82.02	38.13	0.0001
		MC*TEMP	12	366.09	170.21	0.0001
		MC*PM	8	23.31	10.84	0.0001
		TEMP*PM	6	23.09	10.73	0.0001
		MC*TEMP*PM	24	11.93	5.55	0.0001
8	18	BLK	3	0.57	3.11	0.0279
		MC	4	5.67	31.05	0.0001
		TEMP	3	15.00	82.20	0.0001
		PM	2	0.00	0.00	1.0000
		MC*TEMP	12	5.67	31.05	0.0001
		MC*PM	8	0.17	0.91	0.5067
		TEMP*PM	6	0.00	0.00	1.0000
		MC*TEMP*PM	24	0.17	0.91	0.5839
	23	BLK	3	1.13	2.77	0.0430
		MC	4	24.97	61.37	0.0001
		TEMP	3	100.30	246.50	0.0001
		PM	2	3.59	8.83	0.0002
		MC*TEMP	12	23.93	58.82	0.0001
		MC*PM	8	1.16	2.85	0.0054
		TEMP*PM	6	1.35	3.32	0.00040
		MC*TEMP*PM	24	0.78	1.91	0.00093
	28	BLK	3	1.41	1.65	0.1805
		MC	4	159.27	185.75	0.0001
		TEMP	3	608.78	710.00	0.0001
		PM	2	48.20	56.21	0.0001
		MC*TEMP	12	85.44	99.65	0.0001
		MC*PM	8	10.87	12.67	0.0001
		TEMP*PM	6	10.24	11.95	0.0001
		MC*TEMP*PM	24	5.24	6.12	0.0001
	33	BLK	3	1.44	1.06	0.3683
		MC	4	431.77	317.85	0.0001
		TEMP	3	1950.00	1435.51	0.0001
		PM	2	182.64	134.45	0.0001
		MC*TEMP	12	192.61	141.80	0.0001
		MC*PM	8	37.78	27.81	0.0001
		TEMP*PM	6	54.57	40.17	0.0001
		MC*TEMP*PM	24	19.16	14.11	0.0001

Appendix 3f continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	38	BLK	3	1.63	1.13	0.3371
		MC	4	766.43	531.79	0.0001
		TEMP	3	4403.80	3055.56	0.0001
		PM	2	312.47	216.30	0.0001
		MC*TEMP	12	297.85	206.67	0.0001
		MC*PM	8	51.88	36.00	0.0001
		TEMP*PM	6	91.13	63.23	0.0001
		MC*TEMP*PM	24	33.10	22.97	0.0001
	43	BLK	3	1.14	0.84	0.4730
		MC	4	1045.34	773.44	0.0001
		TEMP	3	6281.60	4645.51	0.0001
		PM	2	480.05	355.02	0.0001
		MC*TEMP	12	398.21	294.50	0.0001
		MC*PM	8	48.82	36.11	0.0001
		TEMP*PM	6	161.92	119.75	0.0001
		MC*TEMP*PM	24	34.97	25.86	0.0001
20	20	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-
	25	BLK	3	0.14	1.88	0.1339
		MC	4	5.57	72.63	0.0001
		TEMP	3	13.07	170.48	0.0001
		PM	2	0.87	11.31	0.0001
		MC*TEMP	12	5.57	72.63	0.0001
		MC*PM	8	0.37	4.78	0.0001
		TEMP*PM	6	0.87	11.31	0.0001
		MC*TEMP*PM	24	0.37	4.78	0.0001
	30	BLK	3	0.63	2.80	0.0417
		MC	4	43.83	193.48	0.0001
		TEMP	3	154.40	681.52	0.0001
		PM	2	15.27	67.39	0.0001
		MC*TEMP	12	34.23	151.10	0.0001
		MC*PM	8	4.18	18.47	0.0001
		TEMP*PM	6	5.67	25.01	0.0001
		MC*TEMP*PM	24	2.25	9.93	0.0001
	35	BLK	3	0.93	2.26	0.0835
		MC	4	195.43	472.56	0.0001
		TEMP	3	953.49	2305.57	0.0001
		PM	2	66.47	160.72	0.0001
		MC*TEMP	12	135.21	326.94	0.0001
		MC*PM	8	18.13	43.85	0.0001
		TEMP*PM	6	29.76	71.95	0.0001
		MC*TEMP*PM	24	12.64	30.57	0.0001
	40	BLK	3	7.80	4.98	0.0024
		MC	4	283.98	181.08	0.0001
		TEMP	3	2560.55	1632.73	0.0001
		PM	2	64.52	41.14	0.0001
		MC*TEMP	12	107.94	68.83	0.0001
		MC*PM	8	21.06	13.43	0.0001
		TEMP*PM	6	26.65	16.99	0.0001
		MC*TEMP*PM	24	12.91	8.23	0.0001
	45	BLK	3	5.15	4.67	0.0037
		MC	4	422.25	382.67	0.0001
		TEMP	3	4076.70	3694.63	0.0001
		PM	2	86.05	77.99	0.0001
		MC*TEMP	12	162.36	147.14	0.0001
		MC*PM	8	14.78	13.40	0.0001
		TEMP*PM	6	36.32	32.92	0.0001
		MC*TEMP*PM	24	10.41	9.44	0.0001

Appendix 3g ANOVA tables for Daily germination percent for *S. cocculoides* seeds for storage trial

SP	DAS	Source	DF	Mean square	F Value	Pr > F
2	15	BLK	3	54.47	1.31	0.2739
		MC	4	201.09	4.79	0.0011
		TEMP	3	511.71	12.18	0.0001
		PM	2	33.33	0.79	0.4538
		MC*TEMP	12	315.93	7.52	0.0001
		MC*PM	8	63.15	1.50	0.1587
		TEMP*PM	6	102.37	2.44	0.0274
		MC*TEMP*PM	24	109.95	2.62	0.0002
	20	BLK	3	29.17	0.95	0.4193
		MC	4	534.78	17.35	0.0001
		TEMP	3	2327	75.51	0.0001
		PM	2	19.95	0.65	0.5247
		MC*TEMP	12	684.47	22.21	0.0001
		MC*PM	8	90.21	2.93	0.0043
		TEMP*PM	6	159.95	5.19	0.0001
		MC*TEMP*PM	24	75.30	2.44	0.0005
	25	BLK	3	50.70	0.40	0.2456
		MC	4	1503.7	41.40	0.0001
		TEMP	3	1065	29.33	0.0001
		PM	2	152.64	4.20	0.0165
		MC*TEMP	12	577.88	15.91	0.0001
		MC*PM	8	79.49	2.19	0.0304
		TEMP*PM	6	225.44	6.21	0.0001
		MC*TEMP*PM	24	161.61	4.45	0.0001
	30	BLK	3	53.97	0.86	0.4619
		MC	4	504.12	8.05	0.0001
		TEMP	3	345.26	5.52	0.0012
		PM	2	211.58	3.38	0.0363
		MC*TEMP	12	320.82	5.12	0.0001
		MC*PM	8	51.20	0.82	0.5877
		TEMP*PM	6	163.04	2.60	0.0192
		MC*TEMP*PM	24	125.06	2.00	0.0059
	35	BLK	3	11.22	0.27	0.8473
		MC	4	448.81	10.79	0.0001
		TEMP	3	360.70	8.67	0.0001
		PM	2	89.84	2.16	0.1184
		MC*TEMP	12	506.59	12.18	0.0001
		MC*PM	8	73.87	1.78	0.0846
		TEMP*PM	6	159.20	3.83	0.0013
		MC*TEMP*PM	24	70.85	1.70	0.0274
	40	BLK	3	4.85	0.14	0.9331
		MC	4	163.15	4.86	0.0010
		TEMP	3	262.86	7.83	0.0001
		PM	2	212.57	6.33	0.002
		MC*TEMP	12	327.64	9.76	0.0001
		MC*PM	8	59.80	1.78	0.0834
		TEMP*PM	6	20.05	0.60	0.7322
		MC*TEMP*PM	24	56.71	1.69	0.0293
4	16	BLK	3	15.84	0.37	0.7754
		MC	4	310.80	7.24	0.0001
		TEMP	3	1576.6	36.73	0.0001
		PM	2	25.71	0.60	0.5505
		MC*TEMP	12	192.95	4.49	0.0001
		MC*PM	8	50.32	1.17	0.3183
		TEMP*PM	6	55.86	1.30	0.2588
		MC*TEMP*PM	24	39.86	0.93	0.5634
	21	BLK	3	89.27	1.99	0.1178
		MC	4	224.32	4.99	0.0008
		TEMP	3	1552.2	34.53	0.0001
		PM	2	353.09	7.85	0.0005
		MC*TEMP	12	454.28	10.10	0.0001
		MC*PM	8	39.40	0.88	0.5374
		TEMP*PM	6	128.60	2.86	0.0110
		MC*TEMP*PM	24	89.85	2.00	0.0058

Appendix 3g continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	26	BLK	3	75.62	1.27	0.2857
		MC	4	1138.6	19.15	0.0001
		TEMP	3	2155	36.24	0.0001
		PM	2	469.55	7.90	0.0005
		MC*TEMP	12	389.13	6.54	0.0001
		MC*PM	8	142.22	2.39	0.0180
		TEMP*PM	6	62.26	1.05	0.3966
		MC*TEMP*PM	24	89.91	1.51	0.0684
	31	BLK	3	23.08	0.31	0.8185
		MC	4	1235.09	16.56	0.0001
		TEMP	3	508.77	6.82	0.0002
		PM	2	103.98	1.39	0.2507
		MC*TEMP	12	288.81	3.87	0.0001
		MC*PM	8	70.51	0.95	0.4805
		TEMP*PM	6	136.77	1.83	0.0949
		MC*TEMP*PM	24	126.90	1.70	0.0275
	36	BLK	3	29.34	0.69	0.5601
		MC	4	480.41	11.27	0.0001
		TEMP	3	273.84	6.43	0.0004
		PM	2	0.44	0.01	0.9897
		MC*TEMP	12	203.23	4.77	0.0001
		MC*PM	8	42.64	1.00	0.4374
		TEMP*PM	6	121.99	2.86	0.0110
		MC*TEMP*PM	24	141.06	3.31	0.0001
	41	BLK	3	6.89	0.74	0.5313
		MC	4	108.95	11.65	0.0001
		TEMP	3	20.39	2.18	0.0920
		PM	2	22.70	2.43	0.0913
		MC*TEMP	12	168.97	18.07	0.0001
		MC*PM	8	14.13	1.51	0.1563
		TEMP*PM	6	13.69	1.46	0.1930
		MC*TEMP*PM	24	16.55	1.77	0.0196
8	18	BLK	3	38.18	1.12	0.3431
		MC	4	709.44	20.78	0.0001
		TEMP	3	3303.2	96.76	0.0001
		PM	2	210.59	6.17	0.0026
		MC*TEMP	12	356.97	10.46	0.0001
		MC*PM	8	23.50	0.69	0.7014
		TEMP*PM	6	73.29	2.15	0.0503
		MC*TEMP*PM	24	86.07	2.52	0.0003
	23	BLK	3	29.76	1.16	0.3259
		MC	4	1379.4	53.84	0.0001
		TEMP	3	8152.9	318.23	0.0001
		PM	2	155.19	6.06	0.0029
		MC*TEMP	12	608.65	23.76	0.0001
		MC*PM	8	19.61	0.77	0.6335
		TEMP*PM	6	117.14	4.57	0.0002
		MC*TEMP*PM	24	39.28	1.53	0.0619
	28	BLK	3	27.73	0.54	0.6572
		MC	4	1079.8	20.93	0.0001
		TEMP	3	1534.7	29.75	0.0001
		PM	2	104.24	2.02	0.1356
		MC*TEMP	12	350.95	6.80	0.0001
		MC*PM	8	154.24	2.99	0.0036
		TEMP*PM	6	92.98	1.80	0.1011
		MC*TEMP*PM	24	107.10	2.08	0.0038
	33	BLK	3	40.29	0.69	0.5587
		MC	4	1008.7	17.30	0.0001
		TEMP	3	937.08	16.07	0.0001
		PM	2	25.48	0.44	0.6466
		MC*TEMP	12	1154.27	19.80	0.0001
		MC*PM	8	104.84	1.80	0.0801
		TEMP*PM	6	79.14	1.36	0.2343
		MC*TEMP*PM	24	87.79	1.31	0.0703

Appendix 3g continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	38	BLK	3	6.12	0.16	0.9246
		MC	4	645.32	16.62	0.0001
		TEMP	3	735.37	18.96	0.0001
		PM	2	221.83	5.71	0.0039
		MC*TEMP	12	587.49	15.13	0.0001
		MC*PM	8	36.73	0.95	0.4800
		TEMP*PM	6	130.96	3.37	0.0036
		MC*TEMP*PM	24	61.80	1.59	0.0470
	43	BLK	3	1.7137	1.00	0.3942
		MC	4	1.7137	1.00	0.4090
		TEMP	3	1.7137	1.00	0.3942
		PM	2	1.7137	1.00	0.3699
		MC*TEMP	12	1.7137	1.00	0.4509
		MC*PM	8	1.7137	1.00	0.4378
		TEMP*PM	6	1.7137	1.00	0.4269
		MC*TEMP*PM	24	1.7137	1.00	0.4688
20	20	BLK	3	15.84	0.37	0.7754
		MC	4	310.81	7.24	0.0001
		TEMP	3	1576.6	36.73	0.0001
		PM	2	25.71	0.60	0.5505
		MC*TEMP	12	192.95	4.49	0.0001
		MC*PM	8	50.32	1.17	0.3183
		TEMP*PM	6	55.86	1.30	0.2588
		MC*TEMP*PM	24	39.86	0.93	0.5634
	25	BLK	3	17.40	0.84	0.4754
		MC	4	97.50	4.69	0.0013
		TEMP	3	5528.6	265.88	0.0001
		PM	2	509.09	24.48	0.0001
		MC*TEMP	12	297.64	14.31	0.0001
		MC*PM	8	174.98	8.41	0.0001
		TEMP*PM	6	40.99	1.97	0.0721
		MC*TEMP*PM	24	39.53	1.90	0.0098
	30	BLK	3	70.45	2.83	0.0398
		MC	4	477.20	19.19	0.0001
		TEMP	3	3716	149.42	0.0001
		PM	2	7.21	0.29	0.7487
		MC*TEMP	12	271.67	10.92	0.0001
		MC*PM	8	81.70	3.29	0.0016
		TEMP*PM	6	78.23	3.15	0.0059
		MC*TEMP*PM	24	76.42	3.07	0.0001
	35	BLK	3	42.72	1.40	0.2457
		MC	4	941.43	30.76	0.0001
		TEMP	3	867.73	28.35	0.0001
		PM	2	78.44	2.56	0.0799
		MC*TEMP	12	259.48	8.48	0.0001
		MC*PM	8	68.70	2.24	0.0263
		TEMP*PM	6	21.89	0.72	0.6377
		MC*TEMP*PM	24	64.08	2.09	0.0034
	40	BLK	3	18.94	0.72	0.5397
		MC	4	313.49	11.96	0.0001
		TEMP	3	404.59	15.43	0.0001
		PM	2	66.18	2.52	0.0830
		MC*TEMP	12	164.62	6.28	0.0001
		MC*PM	8	130.71	4.99	0.0001
		TEMP*PM	6	106.63	4.07	0.0008
		MC*TEMP*PM	24	54.22	2.07	0.0040
	45	BLK	3	26.53	1.21	0.3071
		MC	4	217.73	9.94	0.0001
		TEMP	3	571.14	26.08	0.0001
		PM	2	28.17	1.29	0.2789
		MC*TEMP	12	247.69	11.31	0.0001
		MC*PM	8	33.58	1.53	0.1486
		TEMP*PM	6	32.36	1.48	0.1884
		MC*TEMP*PM	24	41.73	1.91	0.0096

Appendix 3h ANOVA tables for Cumulative germination percent for *S. cocculoides* seeds
For storage trial

SP	DAS	Source	DF	Mean square	F Value	Pr > F
2	15	BLK	3	54.87	1.31	0.2739
		MC	4	201.69	4.79	0.0011
		TEMP	3	511.71	12.18	0.0001
		PM	2	33.33	0.79	0.4538
		MC*TEMP	12	315.93	7.52	0.0001
		MC*PM	8	63.15	1.50	0.1587
		TEMP*PM	6	102.37	2.44	0.0274
		MC*TEMP*PM	24	109 95	2.62	0.0002
	20	BLK	3	28.51	0.79	0.5014
		MC	4	740.69	20.51	0.0001
		TEMP	3	3223	89.23	0.0001
		PM	2	11.27	0.31	0.7324
		MC*TEMP	12	894.36	24.76	0.0001
		MC*PM	8	65.08	1.80	0.0795
		TEMP*PM	6	181.34	5.02	0.0001
		MC*TEMP*PM	24	94.13	2.61	0.0002
	25	BLK	3	33.91	0.99	0.3996
		MC	4	1475	42.98	0.0001
		TEMP	3	4398	128.17	0.0001
		PM	2	219.98	6.41	0.0021
		MC*TEMP	12	543.69	15.84	0.0001
		MC*PM	8	81.64	2.38	0.0186
		TEMP*PM	6	378.78	11.04	0.0001
		MC*TEMP*PM	24	81.81	2.38	0.0007
	30	BLK	3	3.39	0.12	0.9477
		MC	4	1407.54	50.14	0.0001
		TEMP	3	3427.05	122.09	0.0001
		PM	2	136.08	4.85	0.0089
		MC*TEMP	12	264 06	9.41	0.0001
		MC*PM	8	73.30	2.61	0.0101
		TEMP*PM	6	170.78	6.08	0.0001
		MC*TEMP*PM	24	47.36	1.69	0.0296
	35	BLK	3	11.64	0.39	0.7582
		MC	4	1044.73	35.27	0.0001
		TEMP	3	3343.80	112.88	0.0001
		PM	2	125.43	4.23	0.0160
		MC*TEMP	12	164.64	5.56	0.0001
		MC*PM	8	43.42	1.47	0.1728
		TEMP*PM	6	117.64	3.97	0.0009
		MC*TEMP*PM	24	22.40	0.76	0.7868
	40	BLK	3	14.62	0.57	0.6322
		MC	4	1235.83	48.62	0.0001
		TEMP	3	2803.45	110.28	0.0001
		PM	2	221.02	8.69	0.0003
		MC*TEMP	12	123.25	4.85	0.0001
		MC*PM	8	36.28	1.43	0.1879
		TEMP*PM	6	87.98	3.46	0.0029
		MC*TEMP*PM	24	24.69	0.97	0.5065
4	16	BLK	3	15.84	0.37	0.7754
		MC	4	310.81	7.24	0.0001
		TEMP	3	1576.6	36.73	0.0001
		PM	2	25.71	0.60	0.5505
		MC*TEMP	12	192.95	4.49	0.0001
		MC*PM	8	50.32	1.17	0.3183
		TEMP*PM	6	55.86	1.30	0.2588
		MC*TEMP*PM	24	39.86	0.93	0.5634
	21	BLK	3	90.11	1.61	0.1898
		MC	4	366.81	6.54	0.0001
		TEMP	3	3213.6	57.26	0.0001
		PM	2	425.38	7.58	0.0007
		MC*TEMP	12	555.27	9.89	0.0001
		MC*PM	8	66.87	1.19	0.3066
		TEMP*PM	6	126.32	2.25	0.0406
		MC*TEMP*PM	24	119.27	2.13	0.0029

Appendix 3h continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	26	BLK	3	20.74	0.51	0.6763
		MC	4	909.53	22.34	0.0001
		TEMP	3	4992.8	122.64	0.0001
		PM	2	124.05	3.05	0.0500
		MC*TEMP	12	123.03	3.02	0.0007
		MC*PM	8	60.79	1.49	0.1625
		TEMP*PM	6	54.76	1.35	0.2295
		MC*TEMP*PM	24	92.67	2.28	0.0012
	31	BLK	3	12.88	0.46	0.7124
		MC	4	1824.82	64.81	0.0001
		TEMP	3	3880.74	137.83	0.0001
		PM	2	15.73	0.56	0.5730
		MC*TEMP	12	68.52	2.43	0.0060
		MC*PM	8	12.21	0.43	0.8997
		TEMP*PM	6	60.99	2.17	0.0484
		MC*TEMP*PM	24	44.89	1.59	0.0465
	36	BLK	3	3.42	0.15	0.9285
		MC	4	1731.28	76.57	0.0001
		TEMP	3	3323.07	147.16	0.0001
		PM	2	19.16	0.85	0.4298
		MC*TEMP	12	67.39	2.98	0.0008
		MC*PM	8	14.80	0.66	0.7303
		TEMP*PM	6	73.26	3.24	0.0048
		MC*TEMP*PM	24	20.46	0.91	0.5937
	41	BLK	3	5.49	0.23	0.8742
		MC	4	1605.85	67.72	0.0001
		TEMP	3	3210.44	135.40	0.0001
		PM	2	11.69	0.49	0.6115
		MC*TEMP	12	56.36	2.38	0.0073
		MC*PM	8	12.81	0.54	0.8250
		TEMP*PM	6	72.90	3.07	0.0069
		MC*TEMP*PM	24	17.87	0.75	0.7896
8	18	BLK	3	38.18	1.12	0.3431
		MC	4	709.44	20.78	0.0001
		TEMP	3	3303.2	96.76	0.0001
		PM	2	210.59	6.17	0.0026
		MC*TEMP	12	356.97	10.46	0.0001
		MC*PM	8	23.50	0.69	0.7014
		TEMP*PM	6	73.29	2.15	0.0503
		MC*TEMP*PM	24	86.07	2.52	0.0003
	23	BLK	3	19.11	0.61	0.6085
		MC	4	2165.8	69.27	0.0001
		TEMP	3	12514	400.22	0.0001
		PM	2	336.51	10.76	0.0001
		MC*TEMP	12	875.65	28.00	0.0001
		MC*PM	8	20.61	0.66	0.7269
		TEMP*PM	6	152.96	4.89	0.0001
		MC*TEMP*PM	24	61.64	1.97	0.0067
	28	BLK	3	15.41	0.63	0.5989
		MC	4	620.29	25.21	0.0001
		TEMP	3	12294	499.75	0.0001
		PM	2	525.20	21.35	0.0001
		MC*TEMP	12	663.69	26.98	0.0001
		MC*PM	8	63.80	2.59	0.0105
		TEMP*PM	6	25.80	1.05	0.3955
		MC*TEMP*PM	24	71.87	2.92	0.0001
	33	BLK	3	39.04	1.75	0.1587
		MC	4	601.80	26.96	0.0001
		TEMP	3	12758	571.57	0.0001
		PM	2	211.21	13.94	0.0001
		MC*TEMP	12	919.97	41.21	0.0001
		MC*PM	8	38.77	1.74	0.0927
		TEMP*PM	6	68.11	3.05	0.0073
		MC*TEMP*PM	24	64.29	2.88	0.0001

Appendix 3h continued

SP	DAS	Source	DF	Mean square	F Value	Pr F
	38	BLK	3	22.29	1.21	0.3087
		MC	4	184.76	10.01	0.0001
		TEMP	3	12872.06	697.19	0.0001
		PM	2	439.32	23.79	0.0001
		MC*TEMP	12	929.05	50.32	0.0001
		MC*PM	8	24.55	1.33	0.2313
		TEMP*PM	6	56.45	3.06	0.0072
		MC*TEMP*PM	24	50.18	2.72	0.0001
	43	BLK	3	19.36	1.08	0.3575
		MC	4	175.97	9.85	0.0001
		TEMP	3	12940.36	724.25	0.0001
		PM	2	433.99	24.29	0.0001
		MC*TEMP	12	928.95	51.99	0.0001
		MC*PM	8	25.76	1.44	0.1820
		TEMP*PM	6	55.13	3.09	0.0067
		MC*TEMP*PM	24	49.75	2.78	0.0001
20	20	BLK	3	15.84	0.37	0.7754
		MC	4	310.31	7.24	0.0001
		TEMP	3	1576.6	36.73	0.0001
		PM	2	25.71	0.60	0.5505
		MC*TEMP	12	192.95	4.49	0.0001
		MC*PM	8	50.32	1.17	0.3183
		TEMP*PM	6	55.86	1.30	0.2588
		MC*TEMP*PM	24	39.86	0.93	0.5634
	25	BLK	3	41.65	1.51	0.2140
		MC	4	98.17	3.56	0.0081
		TEMP	3	8357.4	302.67	0.0001
		PM	2	663.45	24.03	0.0001
		MC*TEMP	12	341.16	12.36	0.0001
		MC*PM	8	158.27	5.73	0.0001
		TEMP*PM	6	54.80	1.98	0.0702
		MC*TEMP*PM	24	40.24	1.46	0.0874
	30	BLK	3	3.90	0.17	0.9139
		MC	4	298.30	13.31	0.0001
		TEMP	3	12383	552.38	0.0001
		PM	2	357.87	15.96	0.0001
		MC*TEMP	12	550.40	24.55	0.0001
		MC*PM	8	78.94	3.52	0.0008
		TEMP*PM	6	48.70	2.17	0.0477
		MC*TEMP*PM	24	39.51	1.76	0.0203
	35	BLK	3	13.18	0.55	0.6492
		MC	4	339.43	14.15	0.0001
		TEMP	3	13232.69	551.74	0.0001
		PM	2	457.03	19.06	0.0001
		MC*TEMP	12	683.44	28.50	0.0001
		MC*PM	8	28.86	1.20	0.2996
		TEMP*PM	6	37.19	1.55	0.1642
		MC*TEMP*PM	24	20.63	0.86	0.6556
	40	BLK	3	1.59	0.11	0.9542
		MC	4	388.17	26.88	0.0001
		TEMP	3	14233	985.64	0.0001
		PM	2	391.99	27.14	0.0001
		MC*TEMP	12	729.09	50.49	0.0001
		MC*PM	8	36.46	2.52	0.0126
		TEMP*PM	6	19.33	1.34	0.2423
		MC*TEMP*PM	24	14.11	0.98	0.4985
	45	BLK	3	4.79	0.30	0.8257
		MC	4	430.96	26.94	0.0001
		TEMP	3	15662	979.04	0.0001
		PM	2	439.32	27.46	0.0001
		MC*TEMP	12	809.62	50.61	0.0001
		MC*PM	8	29.33	1.83	0.0736
		TEMP*PM	6	15.82	0.99	0.4345
		MC*TEMP*PM	24	18.18	1.14	0.3087

Appendix 3i ANOVA tables for Radicle elongation for *S. cocculoides seeds*
For storage trial

SP	DAS	Source	DF	Mean square	F Value	Pr > F
2	15	BLK	3	0.05	0.07	0.9781
		MC	4	126.27	169.32	0.0001
		TEMP	3	40.37	54.30	0.0001
		PM	2	14.30	19.24	0.0001
		MC*TEMP	12	2.88	3.87	0.0001
		MC*PM	8	0.30	0.41	0.9143
		TEMP*PM	6	10.77	14.49	0.0001
		MC*TEMP*PM	24	0.63	0.85	0.6691
	20	BLK	3	0.99	0.83	0.4811
		MC	4	256.41	213.30	0.0001
		TEMP	3	206.81	172.05	0.0001
		PM	2	32.79	27.28	0.0001
		MC*TEMP	12	1.02	0.85	0.5974
		MC*PM	8	0.26	0.21	0.9883
		TEMP*PM	6	17.16	14.28	0.0001
		MC*TEMP*PM	24	0.26	0.22	1.0000
	25	BLK	3	2.74	1.22	0.3027
		MC	4	990.46	442.66	0.0001
		TEMP	3	609.49	272.40	0.0001
		PM	2	68.26	30.51	0.0001
		MC*TEMP	12	15.32	6.85	0.0001
		MC*PM	8	0.56	0.25	0.9797
		TEMP*PM	6	24.08	10.76	0.0001
		MC*TEMP*PM	24	1.07	0.48	0.9824
	30	BLK	3	3.37	1.19	0.3166
		MC	4	1021.89	359.49	0.0001
		TEMP	3	1336.07	470.02	0.0001
		PM	2	129.80	45.66	0.0001
		MC*TEMP	12	17.92	6.31	0.0001
		MC*PM	8	1.26	0.44	0.8943
		TEMP*PM	6	93.94	33.05	0.0001
		MC*TEMP*PM	24	1.58	0.56	0.9546
	35	BLK	3	0.88	0.57	0.6338
		MC	4	978.40	638.17	0.0001
		TEMP	3	712.78	414.91	0.0001
		PM	2	58.47	38.14	0.0001
		MC*TEMP	12	16.00	10.44	0.0001
		MC*PM	8	0.30	0.20	0.9912
		TEMP*PM	6	34.91	22.77	0.0001
		MC*TEMP*PM	24	0.30	0.20	1.0000
	40	BLK	3	0.88	0.57	0.6338
		MC	4	1001.07	652.95	0.0001
		TEMP	3	540.69	352.67	0.0001
		PM	2	115.27	75.18	0.0001
		MC*TEMP	12	14.58	9.51	0.0001
		MC*PM	8	0.27	0.17	0.9941
		TEMP*PM	6	39.09	25.50	0.0001
		MC*TEMP*PM	24	0.98	0.64	0.9028
4	16	BLK	3	0.92	1.08	0.3605
		MC	4	112.90	132.78	0.0001
		TEMP	3	29.88	35.14	0.0001
		PM	2	9.04	10.63	0.0001
		MC*TEMP	12	2.12	2.50	0.0047
		MC*PM	8	1.05	1.24	0.2791
		TEMP*PM	6	12.55	14.76	0.0001
		MC*TEMP*PM	24	0.97	1.15	0.2996
	21	BLK	3	0.72	0.74	0.5322
		MC	4	247.60	252.11	0.0001
		TEMP	3	166.64	169.68	0.0001
		PM	2	24.27	24.71	0.0001
		MC*TEMP	12	1.64	1.67	0.0759
		MC*PM	8	1.60	1.63	0.1194
		TEMP*PM	6	9.51	9.68	0.0001
		MC*TEMP*PM	24	0.84	0.86	0.6560

Appendix 3i continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	26	BLK	3	1.37	1.02	0.3866
		MC	4	1398.9	1040.30	0.0001
		TEMP	3	514.31	382.65	0.0001
		PM	2	100.07	74.45	0.0001
		MC*TEMP	12	6.37	4.74	0.0001
		MC*PM	8	0.90	0.67	0.7178
		TEMP*PM	6	19.98	14.86	0.0001
		MC*TEMP*PM	24	0.37	0.27	0.9998
	31	BLK	3	1.58	0.86	0.4622
		MC	4	1873.84	1020.51	0.0001
		TEMP	3	1511.08	822.95	0.0001
		PM	2	191.29	104.18	0.0001
		MC*TEMP	12	46.91	25.55	0.0001
		MC*PM	8	5.29	2.88	0.0049
		TEMP*PM	6	99.99	54.46	0.0001
		MC*TEMP*PM	24	1.33	0.73	0.8212
	36	BLK	3	2.36	1.16	0.3261
		MC	4	1819.15	894.62	0.0001
		TEMP	3	910.10	447.57	0.0001
		PM	2	61.12	30.06	0.0001
		MC*TEMP	12	48.10	23.66	0.0001
		MC*PM	8	0.70	0.34	0.9475
		TEMP*PM	6	34.27	16.85	0.0001
		MC*TEMP*PM	24	0.85	0.42	0.9926
	41	BLK	3	1.28	0.84	0.4718
		MC	4	1912.77	1262.50	0.0001
		TEMP	3	791.11	522.16	0.0001
		PM	2	135.27	89.28	0.0001
		MC*TEMP	12	49.39	32.60	0.0001
		MC*PM	8	1.27	0.84	0.5720
		TEMP*PM	6	51.18	33.78	0.0001
		MC*TEMP*PM	24	1.95	1.29	0.1758
8	18	BLK	3	1.26	2.64	0.0511
		MC	4	74.60	156.76	0.0001
		TEMP	3	47.53	99.88	0.0001
		PM	2	8.87	18.63	0.0001
		MC*TEMP	12	3.75	7.89	0.0001
		MC*PM	8	0.20	0.42	0.9078
		TEMP*PM	6	10.73	22.55	0.0001
		MC*TEMP*PM	24	2.62	5.51	0.0001
	23	BLK	3	0.97	1.73	0.1632
		MC	4	213.17	380.73	0.0001
		TEMP	3	104.98	187.50	0.0001
		PM	2	21.60	38.58	0.0001
		MC*TEMP	12	5.03	8.99	0.0001
		MC*PM	8	1.77	3.16	0.0023
		TEMP*PM	6	9.51	16.99	0.0001
		MC*TEMP*PM	24	0.90	1.61	0.0437
	28	BLK	3	0.52	0.41	0.7473
		MC	4	1214.4	949.28	0.0001
		TEMP	3	1192.4	932.10	0.0001
		PM	2	92.07	71.97	0.0001
		MC*TEMP	12	68.09	53.22	0.0001
		MC*PM	8	2.40	1.88	0.0664
		TEMP*PM	6	11.35	8.88	0.0001
		MC*TEMP*PM	24	3.02	2.36	0.0008
	33	BLK	3	2.57	1.19	0.3133
		MC	4	1956.39	910.55	0.0001
		TEMP	3	2275.87	1059.24	0.0001
		PM	2	81.12	37.75	0.0001
		MC*TEMP	12	46.38	21.59	0.0001
		MC*PM	8	6.05	2.82	0.0058
		TEMP*PM	6	61.45	28.60	0.0001
		MC*TEMP*PM	24	10.19	4.74	0.0001

Appendix 3i continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	38	BLK	3	1.41	0.90	0.4428
		MC	4	2341.10	1491.31	0.0001
		TEMP	3	2333.58	1487.02	0.0001
		PM	2	53.07	33.82	0.0001
		MC*TEMP	12	169.41	27.97	0.0001
		MC*PM	8	2.90	1.85	0.0001
		TEMP*PM	6	49.78	31.72	0.0001
		MC*TEMP*PM	24	4.28	2.73	0.0001
	43	BLK	3	1.55	0.98	0.4041
		MC	4	2512.89	1587.92	0.0001
		TEMP	3	2375.20	1500.91	0.0001
		PM	2	129.24	81.67	0.0001
		MC*TEMP	12	238.55	150.74	0.0001
		MC*PM	8	1.88	1.19	0.3074
		TEMP*PM	6	57.30	36.21	0.0001
		MC*TEMP*PM	24	1.92	1.21	0.2347
20	20	BLK	3	0.91	1.08	0.3605
		MC	4	112.90	132.78	0.0001
		TEMP	3	29.88	35.14	0.0001
		PM	2	9.03	10.63	0.0001
		MC*TEMP	12	2.12	2.50	0.0047
		MC*PM	8	1.05	1.24	0.2791
		TEMP*PM	6	12.55	14.76	0.0001
		MC*TEMP*PM	24	0.97	1.15	0.2996
	25	BLK	3	0.34	0.58	0.6283
		MC	4	158.00	266.43	0.0001
		TEMP	3	72.24	121.82	0.0001
		PM	2	13.27	22.37	0.0001
		MC*TEMP	12	4.80	8.09	0.0001
		MC*PM	8	1.10	1.85	0.0699
		TEMP*PM	6	3.84	6.48	0.0001
		MC*TEMP*PM	24	1.57	2.64	0.0001
	30	BLK	3	0.34	0.22	0.8837
		MC	4	258.75	167.31	0.0001
		TEMP	3	364.21	235.50	0.0001
		PM	2	87.15	56.35	0.0001
		MC*TEMP	12	26.85	17.36	0.0001
		MC*PM	8	1.78	1.15	0.3320
		TEMP*PM	6	9.73	6.29	0.0001
		MC*TEMP*PM	24	3.41	2.21	0.0018
	35	BLK	3	2.14	0.73	0.5379
		MC	4	819.32	278.17	0.0001
		TEMP	3	2438.58	827.93	0.0001
		PM	2	40.63	13.79	0.0001
		MC*TEMP	12	60.17	20.43	0.0001
		MC*PM	8	21.75	7.39	0.0001
		TEMP*PM	6	36.80	12.50	0.0001
		MC*TEMP*PM	24	9.88	3.35	0.0001
	40	BLK	3	0.83	0.33	0.8050
		MC	4	1347.18	534.03	0.0001
		TEMP	3	4758.82	1886.40	0.0001
		PM	2	35.52	14.08	0.0001
		MC*TEMP	12	123.32	48.88	0.0001
		MC*PM	8	7.18	2.85	0.0053
		TEMP*PM	6	38.32	15.19	0.0001
		MC*TEMP*PM	24	4.32	1.71	0.0263
	45	BLK	3	1.28	0.48	0.6939
		MC	4	1913.65	722.36	0.0001
		TEMP	3	6791.11	2563.48	0.0001
		PM	2	59.95	22.63	0.0001
		MC*TEMP	12	43.32	16.35	0.0001
		MC*PM	8	3.51	1.32	0.2345
		TEMP*PM	6	30.90	11.66	0.0001
		MC*TEMP*PM	24	1.76	0.66	0.8820

Appendix 3j ANOVA tables for Daily germination percent for *S. spinosa* seeds
For storage trial

SP	DAS	Source	DF	Mean square	F Value	Pr > F
2	15	BLK	3	106.28	2.70	0.0471
		MC	4	2661.3	67.64	0.0001
		TEMP	3	197.46	5.02	0.0023
		PM	2	640.16	16.27	0.0001
		MC*TEMP	12	568.21	14.44	0.0001
		MC*PM	8	84.97	2.16	0.0327
		TEMP*PM	6	242.38	6.16	0.0001
		MC*TEMP*PM	24	39.57	2.28	0.0012
	20	BLK	3	56.69	1.49	0.2184
		MC	4	1004	26.42	0.0001
		TEMP	3	103.21	2.72	0.0463
		PM	2	133.46	3.51	0.0320
		MC*TEMP	12	135.05	3.55	0.0001
		MC*PM	8	68.83	1.81	0.0777
		TEMP*PM	6	296.98	7.81	0.0001
		MC*TEMP*PM	24	69.29	1.82	0.0148
	25	BLK	3	67.29	1.11	0.3471
		MC	4	190.22	3.13	0.0161
		TEMP	3	70.08	1.15	0.3286
		PM	2	244.62	4.03	0.0194
		MC*TEMP	12	109.72	1.81	0.0499
		MC*PM	8	88.34	1.46	0.1767
		TEMP*PM	6	145.93	2.40	0.0294
		MC*TEMP*PM	24	128.37	2.11	0.0031
	30	BLK	3	27.83	0.56	0.6444
		MC	4	594.69	11.89	0.0001
		TEMP	3	244.45	4.89	0.0027
		PM	2	27.18	0.54	0.5816
		MC*TEMP	12	211.89	4.24	0.0001
		MC*PM	8	112.74	2.25	0.0256
		TEMP*PM	6	87.98	1.76	0.1099
		MC*TEMP*PM	24	74.76	1.50	0.0738
	35	BLK	3	34.07	1.51	0.2146
		MC	4	1433.61	63.38	0.0001
		TEMP	3	325.41	14.39	0.0001
		PM	2	50.73	2.24	0.1092
		MC*TEMP	12	262.88	11.62	0.0001
		MC*PM	8	24.43	1.08	0.3793
		TEMP*PM	6	39.02	1.72	0.1176
		MC*TEMP*PM	24	62.63	2.77	0.0001
	40	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-
4	16	BLK	3	1.52	0.04	0.9898
		MC	4	208.83	5.34	0.0004
		TEMP	3	880.63	22.51	0.0001
		PM	2	206.76	5.29	0.0059
		MC*TEMP	12	661.68	16.91	0.0001
		MC*PM	8	96.32	2.46	0.0149
		TEMP*PM	6	9.92	0.25	0.9573
		MC*TEMP*PM	24	63.30	1.62	0.0415
	21	BLK	3	32.94	1.08	0.3591
		MC	4	2495.3	81.77	0.0001
		TEMP	3	1709.5	56.02	0.0001
		PM	2	82.91	2.72	0.0688
		MC*TEMP	12	789.57	24.87	0.0001
		MC*PM	8	36.48	1.20	0.3041
		TEMP*PM	6	161.33	5.29	0.0001
		MC*TEMP*PM	24	35.19	1.15	0.2919

Appendix 3j continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	26	BLK	3	3.58	0.09	0.9648
		MC	4	967.16	24.63	0.0001
		TEMP	3	1628.2	41.46	0.0001
		PM	2	165.32	4.21	0.0164
		MC*TEMP	12	1132	28.83	0.0001
		MC*PM	8	175.27	4.46	0.0001
		TEMP*PM	6	19.36	0.49	0.8131
		MC*TEMP*PM	24	62.19	1.58	0.0490
	31	BLK	3	52.25	1.34	0.2622
		MC	4	126.93	3.26	0.0131
		TEMP	3	7.97	0.20	0.8930
		PM	2	153.07	3.93	0.0213
		MC*TEMP	12	567.60	14.58	0.0001
		MC*PM	8	179.65	4.62	0.0001
		TEMP*PM	6	128.61	3.30	0.0042
		MC*TEMP*PM	24	192.13	4.94	0.0001
	36	BLK	3	60.18	1.87	0.1372
		MC	4	1376.15	42.66	0.0001
		TEMP	3	390.39	12.10	0.0001
		PM	2	59.42	1.84	0.1615
		MC*TEMP	12	213.54	6.62	0.0001
		MC*PM	8	30.94	0.96	0.4697
		TEMP*PM	6	78.11	2.42	0.0283
		MC*TEMP*PM	24	70.97	2.20	0.0019
	41	BLK	3	1.71	1.00	0.3942
		MC	4	1.71	1.00	0.4090
		TEMP	3	1.71	1.00	0.3942
		PM	2	1.71	1.00	0.3699
		MC*TEMP	12	1.71	1.00	0.4509
		MC*PM	8	1.71	1.00	0.4378
		TEMP*PM	6	1.71	1.00	0.4269
		MC*TEMP*PM	24	1.71	1.00	0.4688
8	18	BLK	3	1.25	0.03	0.9928
		MC	4	350.96	8.59	0.0001
		TEMP	3	2336.6	57.22	0.0001
		PM	2	29.35	0.72	0.4888
		MC*TEMP	12	1222.4	29.93	0.0001
		MC*PM	8	182.24	4.46	0.0001
		TEMP*PM	6	111.42	2.73	0.0147
		MC*TEMP*PM	24	81.56	2.00	0.0059
	23	BLK	3	77.90	1.56	0.2011
		MC	4	265.12	5.30	0.0005
		TEMP	3	1652.1	33.05	0.0001
		PM	2	38.92	0.78	0.4606
		MC*TEMP	12	695.76	13.92	0.0001
		MC*PM	8	156.26	3.13	0.0025
		TEMP*PM	6	92.35	1.85	0.0924
		MC*TEMP*PM	24	79.79	1.60	0.0461
	28	BLK	3	111.30	1.95	0.1234
		MC	4	771.93	13.52	0.0001
		TEMP	3	428.63	7.51	0.0001
		PM	2	428.23	7.67	0.0006
		MC*TEMP	12	1498	26.23	0.0001
		MC*PM	8	89.56	1.57	0.1373
		TEMP*PM	6	102.83	1.80	0.1014
		MC*TEMP*PM	24	121.09	2.12	0.0030
	33	BLK	3	39.81	0.86	0.4623
		MC	4	245.26	5.31	0.0005
		TEMP	3	140.27	3.04	0.0306
		PM	2	383.32	8.30	0.0004
		MC*TEMP	12	516.83	11.18	0.0001
		MC*PM	8	146.25	3.16	0.0022
		TEMP*PM	6	35.37	0.77	0.5980
		MC*TEMP*PM	24	221.51	4.79	0.0001

Appendix 3j continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	38	BLK	3	31.68	1.39	0.2474
		MC	4	80.09	3.51	0.0087
		TEMP	3	346.74	15.21	0.0001
		PM	2	102.98	4.52	0.0122
		MC*TEMP	12	113.69	4.99	0.0001
		MC*PM	8	132.91	5.83	0.0001
		TEMP*PM	6	97.24	4.27	0.0005
		MC*TEMP*PM	24	38.62	3.39	0.0001
	43	BLK	3	0	0	-
		MC	4	0	0	-
		TEMP	3	0	0	-
		PM	2	0	0	-
		MC*TEMP	12	0	0	-
		MC*PM	8	0	0	-
		TEMP*PM	6	0	0	-
		MC*TEMP*PM	24	0	0	-
20	20	BLK	3	9.79	0.38	0.7708
		MC	4	202.27	7.75	0.0001
		TEMP	3	2867.9	109.92	0.0001
		PM	2	29.29	1.12	0.3276
		MC*TEMP	12	242.73	9.30	0.0001
		MC*PM	8	32.54	1.25	0.2743
		TEMP*PM	6	100.47	3.85	0.0012
		MC*TEMP*PM	24	35.05	1.34	0.1422
	25	BLK	3	16.17	0.52	0.6716
		MC	4	723.78	23.11	0.0001
		TEMP	3	1637.5	52.29	0.0001
		PM	2	69.99	2.24	0.1100
		MC*TEMP	12	486.64	15.54	0.0001
		MC*PM	8	52.65	1.68	0.1058
		TEMP*PM	6	72.45	2.31	0.0356
		MC*TEMP*PM	24	70.72	2.26	0.0014
	30	BLK	3	40.67	1.14	0.3363
		MC	4	752.09	20.99	0.0001
		TEMP	3	697.60	19.47	0.0001
		PM	2	35.52	0.99	0.3731
		MC*TEMP	12	113.47	3.17	0.0004
		MC*PM	8	35.06	0.98	0.4544
		TEMP*PM	6	74.46	2.08	0.0580
		MC*TEMP*PM	24	88.23	2.46	0.004
	35	BLK	3	10.21	0.36	0.7801
		MC	4	429.25	15.24	0.0001
		TEMP	3	599.23	21.28	0.0001
		PM	2	55.33	1.96	0.1432
		MC*TEMP	12	69.25	2.46	0.0054
		MC*PM	8	61.65	2.19	0.0303
		TEMP*PM	6	122.04	4.33	0.0004
		MC*TEMP*PM	24	100.51	3.57	0.0004
	40	BLK	3	24.70	1.04	0.3743
		MC	4	211.68	8.95	0.0001
		TEMP	3	240.85	10.18	0.0001
		PM	2	268.83	11.37	0.0001
		MC*TEMP	12	136.59	5.78	0.0001
		MC*PM	8	96.17	4.07	0.0002
		TEMP*PM	6	61.94	2.62	0.0186
		MC*TEMP*PM	24	70.03	2.96	0.0001
	45	BLK	3	12.88	1.48	0.2210
		MC	4	324.68	37.38	0.0001
		TEMP	3	133.14	15.33	0.0001
		PM	2	39.51	4.55	0.0118
		MC*TEMP	12	48.80	5.62	0.0001
		MC*PM	8	38.34	4.41	0.0001
		TEMP*PM	6	12.54	1.44	0.2005
		MC*TEMP*PM	24	22.56	2.60	0.0002

Appendix 3k ANOVA tables for Cumulative germination percent for *S.spinosa* seeds
For storage trial

SP	DAS	Source	DF	Mean square	F Value	Pr > F
2	15	BLK	3	106.28	2.70	0.0471
		MC	4	2661.3	67.64	0.0001
		TEMP	3	197.46	5.02	0.0023
		PM	2	640.16	16.27	0.0001
		MC*TEMP	12	568.21	14.44	0.0001
		MC*PM	8	84.97	2.16	0.0327
		TEMP*PM	6	242.38	6.16	0.0001
		MC*TEMP*PM	24	89.57	2.28	0.0012
	20	BLK	3	17.11	0.52	0.6711
		MC	4	605.14	18.28	0.0001
		TEMP	3	345.07	10.43	0.0001
		PM	2	115.25	3.48	0.0329
		MC*TEMP	12	213.24	6.44	0.0001
		MC*PM	8	32.26	0.97	0.4573
		TEMP*PM	6	188.32	5.70	0.0001
		MC*TEMP*PM	24	131.56	3.97	0.0001
	25	BLK	3	74.76	2.51	0.0607
		MC	4	770.99	25.83	0.0001
		TEMP	3	590.26	19.78	0.0001
		PM	2	12.24	0.41	0.6643
		MC*TEMP	12	335.90	11.26	0.0001
		MC*PM	8	25.21	0.84	0.5645
		TEMP*PM	6	69.11	2.32	0.0354
		MC*TEMP*PM	24	46.89	1.57	0.0519
	30	BLK	3	43.10	2.14	0.0964
		MC	4	346.99	17.26	0.0001
		TEMP	3	295.74	14.71	0.0001
		PM	2	37.73	1.88	0.1562
		MC*TEMP	12	158.66	7.89	0.0001
		MC*PM	8	13.31	0.66	0.7245
		TEMP*PM	6	41.43	2.06	0.0601
		MC*TEMP*PM	24	29.89	1.49	0.0767
	35	BLK	3	29.73	0.93	0.4254
		MC	4	75.02	2.36	0.0554
		TEMP	3	214.42	6.74	0.0002
		PM	2	6.64	0.21	0.8118
		MC*TEMP	12	127.68	4.01	0.0001
		MC*PM	8	33.86	1.06	0.3904
		TEMP*PM	6	68.51	2.15	0.0497
		MC*TEMP*PM	24	20.54	0.65	0.8966
	40	BLK	3	31.22	0.98	0.4043
		MC	4	75.04	2.35	0.0559
		TEMP	3	212.76	6.67	0.0003
		PM	2	6.44	0.20	0.8175
		MC*TEMP	12	127.26	3.99	0.0001
		MC*PM	8	34.07	1.07	0.3878
		TEMP*PM	6	69.96	2.19	0.0458
		MC*TEMP*PM	24	20.08	0.63	0.9094
4	16	BLK	3	1.52	0.04	0.9898
		MC	4	208.83	5.34	0.0004
		TEMP	3	880.63	22.51	0.0001
		PM	2	206.76	5.29	0.0059
		MC*TEMP	12	661.68	16.91	0.0001
		MC*PM	8	96.32	2.46	0.0149
		TEMP*PM	6	9.92	0.25	0.9573
		MC*TEMP*PM	24	63.30	1.62	0.0415
	21	BLK	3	36.43	1.07	0.3643
		MC	4	1897.2	55.60	0.0001
		TEMP	3	2803.7	82.17	0.0001
		PM	2	194.98	5.71	0.0039
		MC*TEMP	12	973.16	28.52	0.0001
		MC*PM	8	78.10	2.29	0.0234
		TEMP*PM	6	148.53	4.35	0.0004
		MC*TEMP*PM	24	40.35	1.18	0.2633

Appendix 3k continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	26	BLK	3	42.81	1.40	0.2445
		MC	4	2575.9	84.23	0.0001
		TEMP	3	5114.5	167.25	0.0001
		PM	2	18.07	0.59	0.5549
		MC*TEMP	12	2016.9	65.95	0.0001
		MC*PM	8	108.99	3.56	0.0007
		TEMP*PM	6	103.77	3.39	0.0034
		MC*TEMP*PM	24	76.57	2.50	0.0003
	31	BLK	3	45.58	1.33	0.2656
		MC	4	1392.74	40.69	0.0001
		TEMP	3	4194.63	122.55	0.0001
		PM	2	29.94	0.87	0.4187
		MC*TEMP	12	1606.92	46.95	0.0001
		MC*PM	8	57.63	1.68	0.1051
		TEMP*PM	6	60.74	1.77	0.1067
		MC*TEMP*PM	24	23.30	0.68	0.8659
	36	BLK	3	4.55	0.15	0.9313
		MC	4	583.71	18.39	0.0001
		TEMP	3	3135.73	101.50	0.0001
		PM	2	1.09	0.04	0.9651
		MC*TEMP	12	1386.08	44.87	0.0001
		MC*PM	8	39.71	1.29	0.2538
		TEMP*PM	6	24.38	0.79	0.5795
		MC*TEMP*PM	24	34.85	1.13	0.3176
	41	BLK	3	4.93	0.16	0.9241
		MC	4	587.68	18.88	0.0001
		TEMP	3	3130.16	100.58	0.001
		PM	2	0.76	0.02	0.9758
		MC*TEMP	12	1386.22	44.54	0.0001
		MC*PM	8	39.95	1.28	0.2547
		TEMP*PM	6	23.73	0.76	0.6004
		MC*TEMP*PM	24	34.73	1.12	0.3306
8	18	BLK	3	1.25	0.03	0.9928
		MC	4	350.96	8.59	0.0001
		TEMP	3	2336.6	57.22	0.0001
		PM	2	29.35	0.72	0.4888
		MC*TEMP	12	1222.4	29.93	0.0001
		MC*PM	8	182.24	4.46	0.0001
		TEMP*PM	6	111.42	2.73	0.0147
		MC*TEMP*PM	24	81.56	2.00	0.0059
	23	BLK	3	39.71	0.90	0.4445
		MC	4	233.78	5.27	0.0005
		TEMP	3	4457.7	100.56	0.0001
		PM	2	12.33	0.28	0.7574
		MC*TEMP	12	1970.7	44.46	0.0001
		MC*PM	8	241.5	5.45	0.0001
		TEMP*PM	6	113.32	2.56	0.0213
		MC*TEMP*PM	24	123.51	2.79	0.0001
	28	BLK	3	32.55	1.07	0.3624
		MC	4	804.86	26.51	0.0001
		TEMP	3	4956.4	163.23	0.0001
		PM	2	271.18	8.93	0.0002
		MC*TEMP	12	1931.7	63.62	0.0001
		MC*PM	8	105.28	3.47	0.0010
		TEMP*PM	6	21.18	0.70	0.6518
		MC*TEMP*PM	24	99.62	3.28	0.0001
	33	BLK	3	13.03	0.46	0.7071
		MC	4	499.24	17.81	0.0001
		TEMP	3	4916.6	175.37	0.0001
		PM	2	34.09	1.22	0.2989
		MC*TEMP	12	1355.27	48.34	0.0001
		MC*PM	8	36.41	1.30	0.2469
		TEMP*PM	6	27.81	0.99	0.4321
		MC*TEMP*PM	24	52.45	1.87	0.0116

Appendix 3k continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	38	BLK	3	52.17	1.02	0.2864
		MC	4	1443.90	14.35	0.0001
		TEMP	3	11031.53	160.73	0.0001
		PM	2	93.07	1.35	0.1069
		MC*TEMP	12	3114.25	43.67	0.0001
		MC*PM	8	65.40	0.92	0.1302
		TEMP*PM	6	72.27	1.54	0.1101
		MC*TEMP*PM	24	50.15	1.03	0.2297
	43	BLK	3	29.34	1.02	0.3847
		MC	4	419.41	14.35	0.0001
		TEMP	3	4697.52	160.73	0.0001
		PM	2	53.98	1.35	0.1607
		MC*TEMP	12	1276.28	43.67	0.0001
		MC*PM	8	26.96	0.92	0.4993
		TEMP*PM	6	45.08	1.54	0.1669
		MC*TEMP*PM	24	30.02	1.03	0.4344
20	20	BLK	3	9.79	0.38	0.7708
		MC	4	202.27	7.75	0.0001
		TEMP	3	2867.9	109.92	0.0001
		PM	2	29.29	1.12	0.3276
		MC*TEMP	12	242.73	9.30	0.0001
		MC*PM	8	32.54	1.25	0.2743
		TEMP*PM	6	100.47	3.85	0.0012
		MC*TEMP*PM	24	35.05	1.34	0.1422
	25	BLK	3	6.07	0.14	0.9363
		MC	4	484.85	11.15	0.0001
		TEMP	3	4320.2	99.31	0.0001
		PM	2	126.18	2.90	0.0576
		MC*TEMP	12	718.36	16.51	0.0001
		MC*PM	8	64.08	1.47	0.1700
		TEMP*PM	6	120.94	2.78	0.0131
		MC*TEMP*PM	24	92.55	2.13	0.0029
	30	BLK	3	22.00	0.87	0.4596
		MC	4	51.12	2.01	0.0946
		TEMP	3	5474.6	215.60	0.0001
		PM	2	92.69	3.65	0.0280
		MC*TEMP	12	690.72	27.20	0.0001
		MC*PM	8	26.36	1.04	0.4092
		TEMP*PM	6	91.99	3.62	0.0020
		MC*TEMP*PM	24	40.59	1.60	0.0456
	35	BLK	3	17.43	0.88	0.4535
		MC	4	184.88	9.31	0.0001
		TEMP	3	6844.18	344.83	0.0001
		PM	2	72.33	3.64	0.0281
		MC*TEMP	12	602.23	30.34	0.0001
		MC*PM	8	12.47	0.63	0.7535
		TEMP*PM	6	36.39	1.83	0.0951
		MC*TEMP*PM	24	15.42	0.78	0.7620
	40	BLK	3	32.17	1.99	0.1166
		MC	4	292.95	18.15	0.0001
		TEMP	3	7659.29	474.62	0.0001
		PM	2	1.85	0.89	0.8917
		MC*TEMP	12	669.19	41.47	0.0001
		MC*PM	8	10.80	0.67	0.7182
		TEMP*PM	6	40.22	2.49	0.0244
		MC*TEMP*PM	24	18.68	1.16	0.2871
	45	BLK	3	24.82	1.55	0.2027
		MC	4	276.91	17.32	0.0001
		TEMP	3	8058.21	503.94	0.0001
		PM	2	0.55	0.03	0.9661
		MC*TEMP	12	734.18	45.91	0.0001
		MC*PM	8	15.13	0.95	0.4800
		TEMP*PM	6	45.44	2.84	0.0115
		MC*TEMP*PM	24	23.56	1.47	0.0813

Appendix 31 ANOVA tables for Radicle elongation for *S. spinosa* seeds for storage trial

SP	DAS	Source	DF	Mean square	F Value	Pr > F
2	15	BLK	3	0.55	0.55	0.6457
		MC	4	42.33	42.79	0.0001
		TEMP	3	40.84	41.28	0.0001
		PM	2	12.19	12.32	0.0001
		MC*TEMP	12	1.18	1.20	0.2880
		MC*PM	8	0.60	0.61	0.7681
		TEMP*PM	6	11.99	12.12	0.0001
		MC*TEMP*PM	24	0.54	0.55	0.9575
	20	BLK	3	0.03	0.03	0.9944
		MC	4	213.77	166.02	0.0001
		TEMP	3	138.38	107.47	0.0001
		PM	2	3.80	2.95	0.0549
		MC*TEMP	12	7.99	6.20	0.0001
		MC*PM	8	2.22	1.72	0.0962
		TEMP*PM	6	12.51	9.72	0.0001
		MC*TEMP*PM	24	3.04	2.36	0.0008
	25	BLK	3	0.58	0.28	0.8388
		MC	4	390.36	188.78	0.0001
		TEMP	3	146.29	70.75	0.0001
		PM	2	8.13	3.93	0.0214
		MC*TEMP	12	36.06	17.44	0.0001
		MC*PM	8	9.70	4.69	0.0001
		TEMP*PM	6	33.52	16.21	0.0001
		MC*TEMP*PM	24	10.38	5.02	0.0001
	30	BLK	3	0.03	0.03	0.9946
		MC	4	899.75	601.79	0.0001
		TEMP	3	1336.44	893.86	0.0001
		PM	2	67.59	45.21	0.0001
		MC*TEMP	12	50.80	33.98	0.0001
		MC*PM	8	3.82	2.55	0.0117
		TEMP*PM	6	86.39	57.78	0.0001
		MC*TEMP*PM	24	11.39	7.62	0.0001
	35	BLK	3	0.43	0.21	0.8890
		MC	4	1045.93	514.66	0.0001
		TEMP	3	1598.99	786.79	0.0001
		PM	2	58.55	28.81	0.0001
		MC*TEMP	12	49.13	24.18	0.0001
		MC*PM	8	3.01	1.48	0.1673
		TEMP*PM	6	68.99	33.95	0.0001
		MC*TEMP*PM	24	1.84	0.91	0.5935
	40	BLK	3	0.37	0.16	0.9244
		MC	4	820.19	353.31	0.0001
		TEMP	3	1727.42	744.11	0.0001
		PM	2	71.82	30.94	0.0001
		MC*TEMP	12	55.38	23.86	0.0001
		MC*PM	8	2.00	0.86	0.5486
		TEMP*PM	6	90.37	38.93	0.0001
		MC*TEMP*PM	24	1.31	0.56	0.9501
4	16	BLK	3	0.45	0.63	0.5986
		MC	4	38.67	53.21	0.0001
		TEMP	3	28.98	39.87	0.0001
		PM	2	17.27	23.76	0.0001
		MC*TEMP	12	2.09	2.87	0.0012
		MC*PM	8	1.52	2.09	0.0393
		TEMP*PM	6	9.44	13.00	0.0001
		MC*TEMP*PM	24	0.47	0.65	0.8932
	21	BLK	3	0.48	0.43	0.7347
		MC	4	240.83	214.68	0.0001
		TEMP	3	120.98	107.84	0.0001
		PM	2	8.87	7.90	0.0005
		MC*TEMP	12	4.92	4.39	0.0001
		MC*PM	8	1.53	1.37	0.2140
		TEMP*PM	6	13.31	11.87	0.0001
		MC*TEMP*PM	24	1.09	0.97	0.5071

Appendix 31 continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	26	BLK	3	0.39	0.30	0.8257
		MC	4	493.90	378.72	0.0001
		TEMP	3	264.60	202.39	0.0001
		PM	2	6.07	4.65	0.0107
		MC*TEMP	12	33.54	25.72	0.0001
		MC*PM	8	3.40	2.61	0.0102
		TEMP*PM	6	36.47	27.96	0.0001
		MC*TEMP*PM	24	2.58	1.98	0.0066
	31	BLK	3	0.69	0.40	0.7509
		MC	4	1030.6	598.25	0.0001
		TEMP	3	885.70	514.14	0.0001
		PM	2	109.95	63.82	0.0001
		MC*TEMP	12	46.95	27.26	0.0001
		MC*PM	8	7.57	4.40	0.0001
		TEMP*PM	6	88.70	51.49	0.0001
		MC*TEMP*PM	24	13.33	7.74	0.0001
	36	BLK	3	0.72	0.39	0.7604
		MC	4	1314.97	709.97	0.0001
		TEMP	3	1670.35	901.84	0.0001
		PM	2	38.47	20.77	0.0001
		MC*TEMP	12	77.67	41.94	0.0001
		MC*PM	8	13.80	7.45	0.0001
		TEMP*PM	6	109.22	58.97	0.0001
		MC*TEMP*PM	24	7.33	3.96	0.0001
	41	BLK	3	0.37	0.28	0.8408
		MC	4	1072.23	814.88	0.0001
		TEMP	3	1780.97	1353.51	0.0001
		PM	2	29.60	22.50	0.0001
		MC*TEMP	12	99.92	75.94	0.0001
		MC*PM	8	11.18	8.50	0.0001
		TEMP*PM	6	142.31	108.15	0.0001
		MC*TEMP*PM	24	7.34	5.58	0.0001
8	18	BLK	3	0.34	0.73	0.5370
		MC	4	35.39	77.02	0.0001
		TEMP	3	15.79	33.89	0.0001
		PM	2	11.75	25.22	0.0001
		MC*TEMP	12	1.70	3.65	0.0001
		MC*PM	8	1.59	3.42	0.0001
		TEMP*PM	6	6.40	13.73	0.0001
		MC*TEMP*PM	24	0.90	1.94	0.0080
	23	BLK	3	0.14	0.20	0.8932
		MC	4	213.78	302.56	0.0001
		TEMP	3	199.57	282.44	0.0001
		PM	2	7.91	11.20	0.0001
		MC*TEMP	12	3.77	5.34	0.0001
		MC*PM	8	0.59	0.84	0.5671
		TEMP*PM	6	11.13	15.75	0.0001
		MC*TEMP*PM	24	1.07	1.51	0.0683
	28	BLK	3	0.08	0.08	0.9692
		MC	4	615.07	656.75	0.0001
		TEMP	3	480.80	513.38	0.0001
		PM	2	16.20	17.30	0.0001
		MC*TEMP	12	48.35	51.63	0.0001
		MC*PM	8	7.12	7.60	0.0001
		TEMP*PM	6	57.53	61.43	0.0001
		MC*TEMP*PM	24	2.00	2.14	0.0026
	33	BLK	3	0.34	0.23	0.8736
		MC	4	891.22	611.46	0.0001
		TEMP	3	1387.66	952.06	0.0001
		PM	2	61.12	41.93	0.0001
		MC*TEMP	12	64.15	44.01	0.0001
		MC*PM	8	3.57	2.45	0.0153
		TEMP*PM	6	65.96	45.26	0.0001
		MC*TEMP*PM	24	4.86	3.34	0.0001

Appendix 31 continued

SP	DAS	Source	DF	Mean square	F Value	Pr > F
	38	BLK	3	0.19	0.19	0.9056
		MC	4	1043.57	1029.41	0.0001
		TEMP	3	2670.40	2634.19	0.0001
		PM	2	54.07	53.33	0.0001
		MC*TEMP	12	68.01	67.09	0.0001
		MC*PM	8	2.82	2.78	0.0064
		TEMP*PM	6	81.00	79.90	0.0001
		MC*TEMP*PM	24	2.86	2.82	0.0001
	43	BLK	3	0.22	0.22	0.8846
		MC	4	955.83	932.99	0.0001
		TEMP	3	2885.40	2816.45	0.0001
		PM	2	42.47	41.45	0.0001
		MC*TEMP	12	83.12	81.14	0.0001
		MC*PM	8	4.88	4.77	0.0001
		TEMP*PM	6	88.07	85.96	0.0001
		MC*TEMP*PM	24	3.04	2.97	0.0001
20	20	BLK	3	0.04	1.00	0.3942
		MC	4	5.17	116.25	0.0001
		TEMP	3	3.80	85.50	0.0001
		PM	2	1.40	31.50	0.0001
		MC*TEMP	12	1.97	44.25	0.0001
		MC*PM	8	0.57	12.75	0.0001
		TEMP*PM	6	0.87	19.50	0.0001
		MC*TEMP*PM	24	0.37	8.25	0.0001
	25	BLK	3	1.67	0.85	0.4708
		MC	4	814.27	309.72	0.0001
		TEMP	3	329.80	167.26	0.0001
		PM	2	43.33	32.97	0.0001
		MC*TEMP	12	81.20	10.30	0.0001
		MC*PM	8	25.33	4.82	0.0001
		TEMP*PM	6	328.40	83.28	0.0001
		MC*TEMP*PM	24	53.60	3.40	0.0001
	30	BLK	3	0.144	0.12	0.9504
		MC	4	394.77	318.23	0.0001
		TEMP	3	312.24	251.71	0.0001
		PM	2	76.07	61.32	0.0001
		MC*TEMP	12	17.30	13.95	0.0001
		MC*PM	8	7.07	5.70	0.0001
		TEMP*PM	6	123.98	99.94	0.0001
		MC*TEMP*PM	24	7.87	6.34	0.0001
	35	BLK	3	0.61	0.36	0.7800
		MC	4	574.17	340.84	0.0001
		TEMP	3	1534.31	910.81	0.0001
		PM	2	56.27	33.40	0.0001
		MC*TEMP	12	17.14	10.18	0.0001
		MC*PM	8	5.8	3.42	0.0011
		TEMP*PM	6	130.31	77.36	0.0001
		MC*TEMP*PM	24	10.81	6.42	0.0001
	40	BLK	3	0.78	0.40	0.7528
		MC	4	595.77	306.84	0.0001
		TEMP	3	3427.29	1765.17	0.0001
		PM	2	30.47	15.69	0.0001
		MC*TEMP	12	22.57	11.62	0.0001
		MC*PM	8	5.97	3.07	0.0029
		TEMP*PM	6	149.75	77.13	0.0001
		MC*TEMP*PM	24	15.03	7.74	0.0001
	45	BLK	3	0.97	0.49	0.6876
		MC	4	590.93	301.34	0.0001
		TEMP	3	5915.11	3016.35	0.0001
		PM	2	30.20	15.40	0.0001
		MC*TEMP	12	35.55	18.13	0.0001
		MC*PM	8	5.53	2.82	0.0057
		TEMP*PM	6	146.38	74.64	0.0001
		MC*TEMP*PM	24	10.82	5.52	0.0001