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THESIS

INFLUENCE OF SEED KINDS AND SEED LOTS ON QUALITY  
AND STORABILITY OF OIL CROPS SEED UNDER LOCAL  
ENVIRONMENTAL CONDITION

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The influence of different seed kinds and seed lots of oil crops on seed quality and storage potential under local ambient condition were studied. Three kinds of oil crops: sesame (*Sesamum indicum* L.), peanut (*Arachis hypogaea* L.), and soybean [*Glycine max* (L.) Merrill] were used. The five seed lots of sesame were KU 18 (2006), KU 18 (2007), KU 18 (Contract Farmer, 2007), CPlus 2 (2006) and CPlus 2 (2007). KU 18 is black color and CPlus 2 is white color seed coat. For peanut, the four large seeded: Kaset 1, Kasetsart 50, Khon Kaen 4, Kalasin 2, and medium-seeded Tainan 9 including the five promising varieties of soybean: MJ 9518 2, MJ 9520 21, Morbi, KUSL 20004 and CM 60 were studied. Seed materials were stored for a period of 4 months from June to October 2008. Seed germination and vigor were determined at 0, 2 and 4 months after storage. Field emergence was conducted before and after 4 months storage.

Seed moisture content, seed germination, seed vigor as determined by first count germination, germination index, accelerated aging, electrical conductivity, field emergence percentage and field emergence index at initial before storage were higher than those of after storage. Seed quality and storage potential were different among seed kinds and seed lots. Seed or grain yield of sesame, peanut and soybean that planted from the initial before storage seeds gave higher yield than those that planted from after 4 months storage seeds.

Results also showed that seed quality of sesame as measured by germination, vigor and field emergence, KU 18 (2007) was the highest among all seed lots when stored up to 4 months. Black color seed coat and white color seed coat were different in seed quality and storage potential. The new sesame seed lots were better in seed quality and vigor than old seed lots. Sesame seeds that obtained from research station were better in viability and vigor than from farmer field production. According to germination, seed vigor and field emergence percentage, Kaset 1, Kasetsart 50, Khon Kaen 4 and Kalasin 2 peanut were higher quality and storability than Tainan 9. Tainan 9 was the lowest in seed quality and was totally damaged by groundnut borer (*Caryedon serratus* Olivier). Among the five seed lots of soybean, MJ 9518 2 was the best in seed quality and storability as measured by seed germination, seed vigor and field performance. Further research concerning the quality and storability of sesame, peanut and soybean cultivars should be carried out at different research farm and farmer field. It is also need to study concerning the quality and storability of different color of sesame seed. Seed storage duration in this study was short period, further experiment with longer storage duration should also be examined. Seed lots of sesame, peanut and soybean in this study were stored under ambient condition. Storage under the control condition should be considered for further study of new varieties.

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Student's signature

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Thesis Advisor's signature

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## LIST OF ABBREVIATIONS

%	=	Percentage
°C	=	Degree Celsius
°F	=	Degree Fahrenheit
μS	=	Micro Siemens
AA	=	Germination Percentages after Accelerated Aging
CF	=	Contract Farmer
cm	=	Centimeter
DAS	=	Days After Seeding
df	=	Degree of Freedom
EC	=	Electrical Conductivity
FE	=	Field Emergence
FEI	=	Field Emergence Index
GAP	=	Good Agricultural Practice
GI	=	Germination Index
g	=	Gram
ha	=	Hector
Kg	=	Kilogram
mm	=	Millimeter
RH	=	Relative Humidity
SG	=	Standard Germination
w. b.	=	Wet Basis

# **INFLUENCE OF SEED KINDS AND SEED LOTS ON QUALITY AND STORABILITY OF OIL CROPS SEED UNDER LOCAL ENVIRONMENTAL CONDITION**

## **INTRODUCTION**

Oilseeds are a very important component of tropical and semi-tropical agriculture (Weiss, 2000). In Myanmar, three crop groups namely cereals, oil seeds, and pulses dominate agriculture sector. The second important sector is oil seed group, not only peanut and sesame but soybean also plays a significant role. The national yield level of the oil seed crops was very low due to use of low agricultural inputs, including poor seed quality. Sesame is one of the export crops. In addition, most of Myanmar people consume peanut edible oil and peanut snacks. At the present, Myanmar government drives to produce edible oil from soybean. Therefore, it is important to produce quality oil crops seeds (Myanma Agriculture in Brief, 2007).

Good quality seed is essential for high agricultural productivity (Copeland, 1976). However, most of the growers in developing countries still using seeds from various sources which may not grant as high quality as seeds from certified seeds program especially oil crops. Moreover, in developing countries, farmers stored their own seeds under environmental or local condition. Seed program development and farmer's education as well as transforming technology are needed to improve oil crops production.

A uniform stand of healthy, vigorous plant was essential to get high yield and good quality needed for profitable oil crops seed production such as peanut, soybean and sesame. Good quality seeds came from good cultural practices and planted seed production program. Planting good quality seeds resulted in high yield and quality of crops (Delouche, 1973). However, the quality of oil crop seeds especially peanut (Duangpatra and Kuphotipan, 1986; Phyo *et al.*, 2004) and soybean (Delouche, 1974) were difficult to maintain due to the rapid deterioration of the seed. These oil crop

seeds were classified as poor storer especially under tropical climatic environment (Delouche *et al.*, 1973).

Seed storability under the same storage condition varied among different kinds of seed. Variation in storage potential of seed lots were depended on differences in their pre-storage history and storage environments (Delouche *et al.*, 1973). Quality and storage potential of seed lots from research farm or seed multiplication station were better than seed lots from farmer field production (Teingtham and Duangpatra, 2005). Moreover, seed quality and storability of oil crop seed were different among genotypic differences (Chuntirapongsa, 1992; Chanprasert and Tungsakul, 2001; Phyo *et al.*, 2004; Duangpatra and Boonkamjad, 2005). Seed quality and storage potential of oil crops were depended on their seed moisture content (Harrington, 1972), pre- harvest field conditions and post harvest processing or conditioning (Gregg, 1983), storage conditions (Ellis, 1991), seed sizes (Romkaew, 1996), condition of storage (Whitty *et al.*, 2006) and storage duration (Adebisi *et al.*, 2008).

Most of the previous researchers were well documented in each kind of oil crop on seed quality and storability. Study of seed quality and storability of oil crop seeds under local environmental condition were the objectives of this research. Since, Thailand and Myanmar are in the tropic. High temperature and high humidity around the year are the great problem of seed production, quality management and storage. Research results can be directly or indirectly application to oil crop production in Myanmar. In this study, seed quality and storage potential of different seed lots of sesame, peanut and soybean were determined at the same storage and duration. Results of this study will also contribute to improve seed storage management under ambient condition for the three oil crops: sesame, peanut and soybean. And also will lead to improve oil crops seed production and benefits to various seed stakeholders. Moreover, it will contribute in strengthening the oil crops seed program.

## **OBJECTIVES**

The objectives of this research were to determine the quality and storability of different seed kinds and seed lots of sesame, peanut and soybean.

## LITERATURE REVIEW

The principle purpose of seed storage was to preserve planting stocks from one season until the next. Seed vigor was an important factor that affects their storage life and the time of storage. The storage potential of an individual seed was affected by genetics, environment in storage room (temperature and RH), pre-harvest, seed dormancy, seed maturity, seed size, seed moisture content, mechanical damage, and seed vigor (Justice and Bass, 1979). Seed quality could not improve during storage. Even though, storage under the best conditions did not improve seed quality (Delouche, 1973 and Saenong, 1987). Storage potential of seed lot was affected by seed moisture content, temperature and relative humidity of the storage place, pest and disease infestations and pre-harvest and post-harvest management practices (Harrington, 1971; Gregg, 1983 and Acquaah, 2005).

Seed longevity was influenced markedly by the storage environment. Ambient environment in the tropical regions were mostly poorer for seed storage than those of temperate regions. Thus, the maintenance of viability during storage was a greater problem in tropical region (Ellis, 1991). Therefore, the storage condition of seed was a crucial factor to determine seed longevity and an acceptable level of germination and vigor maintaining (Lewis *et al.*, 1998). The seeds rapidly deteriorated at high temperature and high relative humidity during storage. Under tropical conditions, peanut and soybean seed viability and vigor rapidly reduced during storage at ambient temperatures (Yin-adsavaphan *et al.*, 1986; Duangpatra, 1988; Nkang and Umoh, 1996).

### **Effect of Seed Deterioration on Seed Quality**

Seed quality comprised of several important attributes such as genetic purity, physical purity, germination and vigor. Among these characteristics, other than genetic purity, seed germination (or viability) and seed vigor were the most important (Delouche, 1974). The use of high quality seeds would produce good crop stands and a higher grain yield. In addition, seed quality referred to the physical integrity of the

seed, the germination capability and ultimately, and the ability to produce a desirable stand of healthy plants in the field (Clark, 1975).

A seed lot consisted of a population of seed which was genetically and physically similar however, vary in degree of deterioration from a relatively non-deteriorated to completely dead condition (100 - 0%). Deterioration within a lot was different depending on an individual seed basis (Delouche and Baskin, 1973). Causes of seed deterioration were depletion of food reserves, starvation of meristematic cells, accumulation of toxic compounds, breakdown in mechanisms for triggering germination, enzyme degradation and inactivation, lipid autoxidation, formation and activation of functional structures and genetic degradation (Copeland, 1976). Seed deterioration was a natural process that involves cytological, physiological, biochemical and physical changes quality in each seed. Field deterioration was one of the most detrimental factors affecting soybean seed quality in the tropics (Franca Neto *et al.*, 1994).

Deterioration of seeds was observable in their lowered performance during germination such as delayed seedling emergence followed by a slower rate of seedling growth and development. Deteriorated seed also decreased resistance to environmental stresses during germination and early seedling growth (Isely, 1957). Seed deterioration led to reduce seed quality, performance and stand establishment. Short-termed deterioration in the field was likely to be a different physiological event than long-term deterioration in storage. Mechanical damage such as lesions influenced seed performance differently than uniform physiological damage occurring during seed storage (McDonald, 1999). The ultimate performance of seed deterioration was the complete loss of germinability and death of the seed (Copeland and McDonald, 2001).

### **Effect of Delayed Harvesting on Oil Crops Seed Quality**

Delay in harvest increased the process of soybean seed deterioration and a serious reduction in seed quality of soybean because of field weathering (Delouche,

1972; Sanguansat, 1996; Chanprasert *et al.*, 1996). Delayed harvest caused the decrease in yield of peanut cultivars: SK 38, Tainan 9, RCM 387 and NC 2, which was due to high quantity of over mature pods and subsequently loss of yield in the soil as well as germinated seeds on the mother plant (Homdork, 1984). Delay harvesting of sesame was significantly decreased seed quality (Khuentong, 2006).

### **Effect of Storage Conditions on Oil Seed Quality**

Sesame seed should be stored at moisture content not more than 6% at the temperature less than 18°C - 50% RH for long term storage (Bennett and Wood, 1995). Red sesame dormant-seeded gave high germination after dry heating at 70°C for 5 days and could be stored in thick plastic at room temperature for not more than 11 months (Suddhiyam and Kritjanarat, 2003). Unrefrigerated sesame seeds should be kept in an air tight container in a cool and dry place for up to three months, whereas refrigerated seeds up to six months and frozen seed up to one year (Filippone, 2006). The vigor of sesame seeds which were packaged in paper bags, plastic sacks and metallic cans and storage for six months under controlled and ambient conditions did not present significant differences between the two storage conditions. The highest vigor was obtained from the seeds in plastic sacks and metallic cans (Azevedo *et al.*, 2003). White sesame in vacuum package, storage of high vigor and low vigor seeds could be maintained for 20 months and 6 months, respectively (Suddhiyam *et al.*, 2007). Black-seed cultivar sesame, Nakhon Sawan showed a higher quality and storability than the white-seed cultivars Roi Et 1 and Maha Sarakham 60 (Chanprasert and Tungsakul, 2001).

Clark (1975) reported that peanut seed from uncontrolled environment emerged less rapidly than seed from cold storage, including a loss in vigor as well as a decrease in total emergence. Yin-adsavaphan *et al.* (1986) found that during 8 months storage, significant differences in germination percentage of groundnut were found among seed lots. The initial germination percentage ranged from 75-89% indicating varying quality of seeds from different farmers. Most of the seeds

maintained good viability for 6 months, but the germination percentage declined to below minimum standard (70%) after 8 months.

Stonsaovapak and Veeranishpong (1986) found that Tainan 9 peanut seeds with initial moisture content of 6.01-7.00%, kept in paper bags, and stored under ambient condition were the fastest reduction in germination. Groundnuts seeds could be stored for 8 months under an ambient condition with lower than 6% of seed moisture content and kept in sealed plastic bags. Duangpatra and Kittitanasuan (1990a) found that KUP 24D-084 and KUP 24D-421, the two promising lines of large-seeded peanuts were high in storability. The unshelled KUP 24D-084, KUP 24D-448 and KUP 24D-421 could maintain their germination and vigor at satisfactory level under condition for 10 months. These results showed that the storage of groundnut seeds depended on the genetic makeup of each groundnut line, initial seed germinability and vigor. Duangpatra and Kittitanasuan (1990b) also reported that higher germinability and higher vigor of the promising large-seeded peanut lines, KUP 24D-421 were maintained in the conditioned storage at 10-15°C- 60% RH up to 14 months.

Taweekul *et al.* (1994) found that the longer storage period of peanut seeds, the lower quality were obtained, especially the seeds that were shelled with rubber tire sheller. Taweekul *et al.* (2002) also found that drying peanut by the small dryer did not alter seed germination and vigor compared to sun and air drying methods. Seed germination and vigor of Khon Kaen-5 peanut as measured by accelerated ageing were higher than 80% both before and after storage under ambient condition for 5 months. Phyto *et al.* (2004) found that cold room condition was superior to ambient condition in peanut storage and that storage potential differed among peanut cultivars. Either pod or seed of Tainan 9 and Kasetsart 50 peanut could be stored under ambient condition for 6 months without losing seed quality.

TeKrony *et al.* (1980) found that soybean seed viability (germinability) was maintained at higher than 80% germination for 1 to 2 months after harvest maturity, whereas seed vigor began to decline within a few days after harvest. Nasreen *et al.*

(2000) investigated the effect of different seed moisture content (6.0, 7.7 and 9.8%), storage temperatures (-20, 5, 25, 37 and 50°C) and storage periods of 1 – 12 months on seed viability of soybean variety: NARC 2. He found that there was a decline in germination percentage after two months storage at every temperature levels in high (9.8%) and medium (7.7%) moisture content seed. In addition, the viability was zero at 37°C after two months storage in low, medium and high moisture content seeds.

### **Influence of Seed Moisture Content, Relative Humidity and Temperature on Seed Quality**

Seed quality especially viability and vigor during storage were affected by environmental factors such as temperature, moisture, and O<sub>2</sub>/CO<sub>2</sub> concentration (McDonald, 1976). Seed moisture and storage temperature were the two most important factors in seed longevity. Therefore, in two- rules of thumb: for every one percent decrease in seed moisture the life of the seed is doubled and for every 10° F decrease in storage temperature the life of the seed is doubled (Harrington, 1972). Further, the length of storage was important to determine the safe moisture contents (Owen, 1955). The seeds of low moisture and high initial viability were much more resistant to unfavorable storage humidity and temperature than those of high moisture and low initial viability (Barton, 1941).

Amthor (1989) stated that dry seeds consumed very little O<sub>2</sub>, when imbibition occurred, rates of O<sub>2</sub> uptake by seed increased. As the embryo started to grow, respiration rate increased. Ching (1972) reported that respiration involved oxidative breakdown of certain organic seed constituents to provide biological energy, which facilitated many of energy requiring anabolic activities accompanying germination and growth. The higher the rates of O<sub>2</sub> uptake, the faster the various metabolic activities were found. Ching (1973) pointed out that, moisture content and oxygen were the main causes for lipids autoxidation in soybean led to rapidly loss of seed deterioration and enzymatic activity, failure of protein synthesis and loss of membrane integrity, which had directed relationship with low seed germination and vigor.

Aponte (1973) found that sesame seeds were poor storer like soybeans and peanuts. Controlled atmospheric storage was advised to prolong the life of the seed. The conditions of a warehouse should not exceed 20°C - 55% RH for storage periods not longer than 10 months. The author also reported that at 30°C - 75% RH of environmental storage, germination percentage began to rapidly decline after 2 and 3 months storage. At the end of 6 months period both Vineyard and Glauca sesame cultivars were less than 40% germination. Adebisi (2004) also reported that sesame seed quality was depending upon the environment, genotype and their interaction. Adebisi *et al.* (2008) conducted the longevity of ten varieties of sesame seeds which were stored under ambient laboratory condition for 240 days (8 months). The results showed that favorable ambient locations support good potential for short-term seed quality maintenance.

Ramamoorthy (1989) stated that even in good storage, the signs of physiological deterioration in terms of slower germination and reduced seedling growth of carry-over seeds were apparent. Viability of sesame seeds declined with the storage length. Adebisi (1999) and Adebisi and Ajala (2000) found that seed deterioration rate and eventual seed storage life depended on the initial quality of seed before storage and thereafter declined. The sharp decline in seed viability after 4 months storage was due to adverse storage conditions of the humid tropics. Weiss (2000) reported that sesame seed could generally be stored for up to 2 years with little loss of viability provided it was dried below 8% moisture content and kept in airtight containers and should be maintained below 15°C for long term-storage. However, Oplinger *et al.* (1997) reported that in the United States of America, sesame seeds could be stored at room temperature for approximately 5 years without loss of viability.

Deterioration of large seeded Khon Khan 60-3 peanut seed increased as storage period increased (Jothityangkoon *et al.*, 2002). In addition, the initial seed quality also had strong influence on seed storability (Sarawat, 2001). Seed quality and storability of peanut were different among genotypic differences (Phyo *et al.*, 2004; Duangpatra and Boonkamjad, 2005). It was also found that peanut seed quality

from dry season was lower than those from rainy season planting because of the high relative humidity and high temperature after harvesting during the sun drying period (Duangpatra and Boonkamjad, 2005). In addition, Rao *et al.* (2002) found that low moisture content (below 4%) peanut seed hermetically stored at room temperature (23-25°C) could remain germination higher than 85% up to 8 years.

Soybean seed germination and vigor potential were low as compared to other grain crops and they were often reduced prior to the planting time (Byrd and Delouche, 1971; Justice and Bass, 1979). After soybean seeds were threshed and cleaned, seed moisture must be reduced to approximately 8 %. Then, the seeds must be kept in a moisture-proof container and stored at room temperature (Srisombun and Kaewmeechai, 2001). Storage at ambient temperature and 75% RH for 4 months period were able to reveal soybean genotypic differences for resistance to seed deterioration during storage (Chuntirapongsa, 1992). Varietal differences would be due to variation in genetic makeup. Differences in soybean seed deterioration during storage among genotype variations had also been reported (Agrwal *et al.*, 1974; Ellis *et al.*, 1982; Minor and Paschal, 1982 and Singh and Ram, 1996).

### **Role of Chemical Compositions in Oil Crops Seed**

The predominant unsaturated fatty acid composition was known to be the major cause of seed deterioration (Bewley and Black, 1985; Saenong, 1987). Most of fatty acids in peanut were oleic and linoleic acids which were unsaturated and both comprised about 80% of fatty acid composition (Amed and Yong, 1982). Soybean also contained fatty acids: oleic and linoleic acids and both comprised about 75% of fatty acid composition (Orthofer, 1978). Sesame seeds contained about 47% oleic and 39% linoleic acid. Sesame oil and foods fried in sesame oil had long shelf life because the oil contained an antioxidant called sesamol (Oplinger *et al.*, 1997). Sesame seed contained antioxidants which inhibited the development of rancidity in the oil (Namiki, 1995).

The qualities of oil crop seeds especially peanut and soybean seeds were very difficult to be maintained due to the rapid deterioration of the seed (Duangpatra and Kuphotipan, 1986 and Phyto *et al.*, 2004). Seed deterioration was studied in three different maturity groups (based on internal pericarp color) of peanut seeds. During seed maturation, lipid synthesis and accumulation increased rapidly and oleic acid and O/L ratio also increased. Immature seed deteriorated faster than mature seed. Deteriorated peanut seeds were low in both germinations and vigor, and in contrast, high electrical conductivity, high free fatty acid, and peroxide value from lipid peroxidation process (Promchote *et al.*, 2005). However total lipid content, fatty acid composition and O/L ratio did not change during peanut seed storage at ambient condition for 6 months (Promchote, 2000). Natural aging of soybean seeds was a marked decline in vigor and viability which was associated with a decrease in the proportion of the polyunsaturated fatty acids. Accelerated aging of soybean also declined in vigor and viability, however, without changing in polyunsaturated fatty acid (Priestley and Leopold, 2006).

Correlation between O<sub>2</sub> uptakes by germinating seeds and their germinability and seedling growth were positive and significant. Deteriorated seeds (e.g. mechanically injured seeds) probably exhibited higher respiration rates than sound seeds (Abdul and Anderson, 1972). Moreover, Ortloff (2002) also reported that peanut deterioration was affected by chemical reactions, particularly oxidation, between naturally occurring enzymes. When oxidation occurred, the fat in a peanut seed became rancid and produced off-flavors. Oxidation of peanut enzymes increased as the peanut storage temperature rose.

The damage that has been observed in seeds could be related to the DNA, RNA and proteins. Also the membranes from cells and cell organelles could be affected. This is why anti-oxidants were important in maintaining seed viability. Research with *Arabidopsis* seeds deficient in vitamin E production showed that this antioxidant was essential for seed longevity and for preventing lipid peroxidation during germination (Sattler *et al.*, 2004).

### **Effect of Seed Vigor on Seed Quality**

Seed vigor comprised those properties which determined the potential of rapid uniform emergence and development of normal seedlings under a wide range of field conditions. Seed vigor was determined by seedling growth, speed of germination, measurement of seed leakages, and different types of stress tests (AOSA, 1983). Vigorous seed or new lots possessed a greater storage potential than low vigor or older seed lots. As storage periods increased, seed deterioration increased. The symptoms of seed deterioration were shown by reducing of germination rate, weak of seedling and radical stunt (Justice and Bass, 1979). Vigor was defined as that condition of active good health and natural robustness in seeds which, upon planting permitted germination to proceed rapidly under a wide range of environmental conditions. The potential of rapid and vigorous germination increased when a seed mature. Fully mature seeds had completed physical and physiological development needed for maximum expression of vigor (Copeland, 1976).

Seed germination was defined as the emergence from the seed embryo of those essential structures which indicated to develop into a normal plant under favorable conditions in soil (ISTA, 2004). Seed germination and seed vigor were measured to provide an indication of the future performance of a seed lot. In most cases, performance related to the ability of seeds to germinate and produce a seedling that would emerge from the soil and develop into a healthy vigorous plant. Useful measure of seed quality should relate to field emergence and standard germination accurately predicted field emergence only when seedbed conditions were nearly ideal for germination and emergence. Measures of seed vigor provided better estimates of field emergence in less than ideal seedbed conditions (Egli and TeKrony, 1995).

A seed had its highest vigor at physiological maturity thereafter declining of seed quality during storage was expressed firstly as a decrease in growth rate or vigor and subsequently as a loss of actual germinability (Harrington, 1972; Justice and Bass, 1979). A high initial germination percentage of the seed prior to storage could not be used as the indicator for determined storability of the seed. The seeds were

considered to be in storage when the seeds reached physiological maturity on the mother plant until germination (Douglas, 1975). Moreover, storage temperature and seed moisture played the important role in maintaining soybean and peanut seed quality. It could be predicted by accelerated aging test and used to predict the germination of seed lots during storage as well as field emergence (Delouche and Baskin, 1973; Baskin and Vieira, 1980; Duangpatra and Kittitanasuan, 1990b and Parde *et al.*, 2002). Accelerated aging test was one of the most powerful methods in determination of seed vigor and storage potential of seed lots and closely associated with field emergence (Delouche and Baskin, 1973; TeKrony and Egli, 1977; Egli *et al.*, 1978 and Liklatachev *et al.*, 1984).

Normal period of germination for sesame seed exceeded 4 to 5 days. The cause of delayed germination was due to the structure of the seed-coat. At favorable environment, the seed could germinate (Richharia and Dhodapkar, 1939). High vigor groundnut seeds germinated faster and gave higher field emergence than low vigor seeds (Duangpatra *et al.*, 1990). Immature peanut seeds not only deteriorated faster but also lower in germination and vigor potential than mature seeds (Duangpatra and Promchote, 2000; Spears, 2000; Promchote *et al.*, 2005). Soybean seed vigor as measured by response to accelerated aging, declined to very low levels but there was not any change in standard germination (Ferguson *et al.* 1990b). Soybean seed with an AA  $\geq$  80% or SG  $\geq$  95% ensured adequate performance in many field environments (Egli and TeKrony, 1995).

Accelerated aging test provided an accurate estimation of field emergence of soybean seedlings. However, as seedbed environmental condition became less favorable, the ability of the AA test to estimate field performance significantly decreased (Torres *et al.*, 2004). There was no relationship between soybean seed vigor and seedling emergence and stand establishment, regardless of cultivar or planting rate. Seed vigor also had no effect on yield regardless of cultivar and planting rate. In the absence of stand differentials, there appears to be no yield advantage associated with the utilization of high vigor planting seed (Egli and TeKrony, 1979).

Soybean seed germination and vigor potential were low as compared to other grain crops and were often reduced prior to the planting time (Byrd and Delouche, 1971; Justice and Bass, 1979 and Nkang and Umoh, 1996). In addition, seed vigor as measured by accelerated aging response was very high for seeds harvested at harvest maturity but decreased rapidly as weathering period and storage times increased (Turnipseed, 1993). Accelerated aging inhibited seed germination and seedling growth. Enhanced lipid peroxidation and increased peroxide accumulation were observed in the axis and cotyledons of aged seed. Accelerated aging also inhibited the activity of superoxide dismutase, peroxidase, ascorbate peroxidase, and lipoxygenase. Seed axes appeared to be more susceptible to aging than cotyledons (Sung and Jeng, 2006). Both natural and accelerated aging enhanced lipid peroxidation as germination was depressed (Sung, 2008).

EC valued measured in seed soaking solutions varied with leaching and was directly related to the cellular membrane integrity. Seeds with lower physiological potential liberated a greater amount of electrolytes as a consequence of lower cellular membrane selectivity. In addition, field emergence value depended on electrolyte leakage from seed lots (Bewley and Black, 1994; Loeffler *et al.*, 1988 and Vieira *et al.*, 2004). EC indirectly evaluated the concentration of electrolytes released by soybean seeds during imbibitions and the conductivity of seed leachates was the most commonly use to measure soybean seed permeability (Dias *et al.*, 1996).

EC test could be estimated precisely soybean seed performance in the field under favorable establishment conditions. The EC of a seed lot was the measure of membrane function, and this test could be utilized as a predictor of the normal seedling production ability of a seed lot (Siddique and Goodwin, 1985). The degree of deterioration was associated with the concentration of seed exudates that would be found in the steep solution. These exudates were a reflection of the amount of membrane degradation that has occurred (Copeland and McDonald, 2001). Leaching of sugars from barley did not correlate well with vigor, however, sugars utilization and mechanical injury appeared to affect leakage more than age of seed (Abdul-Baki and Anderson, 1970). The amount of electrolytes in the soaked water increased as the

period of time and the temperature of storage increased. On the other hand the amount of leakage decreased along the time for those seeds storage of 10°C or transferred from the temperature of 20 to that of 10°C. The temperature that soybean seeds remained during storage affected the amount of electrolytes in the soaked water (Vieira *et al.*, 2008).

EC was negatively correlated with seed viability and vigor (McKersie and Senaratna, 1983). Soybean seed lots that presented EC test values between 60 and 70  $\mu\text{S cm}^{-1}\text{g}^{-1}$  were considered as high vigor seed lots, between 70 and 80  $\mu\text{S cm}^{-1}\text{g}^{-1}$  were intermediary vigor seed lots (Vieira *et al.*, 1999). On the other hand, seeds with EC values higher than 150  $\mu\text{S cm}^{-1}\text{g}^{-1}$  were classified as low vigor seed lots and considered inadequate for sowing in the United States of America (AOSA, 1983). EC of groundnut seeds showed a strong negative correlation ( $r = - 0.81^{**}$ ) with germination percentage (Yin-adsavaphan *et al.*, 1986).

The high germination percentage and vigor determined by accelerated aging test presented also high field seedling emergence although their respective high EC test values had placed them as low seed vigor lots. This fact might be related to seed moisture content of the seed lots (Tao, 1978). Low moisture content seed was high in structural disorganization of cellular membrane and high in the seed leachates during the initial period of seed soaking. Consequently, high value of EC of the seed soaking solute did not necessarily mean low seed vigor (Bewley and Black, 1994). This phenomenon might be seed soaking injury or variation in the seed tegument lignin content provided different seed soaking velocities, depending on the seed lot. The effect of the initial seed moisture content interacted with other factors affecting EC (Alvarez *et al.*, 1997 and Panobianco *et al.*, 1999).

Panobianco *et al.* (1999) investigated that there was a significant relationship ( $R^2 = 0.84^{**}$ ) between EC and seed coat lignin content. The higher the amount of lignin in the seed coat, the lower the levels of seed exudates to the soaking solution and consequently the lower the EC. It was concluded that seed soaking EC was influenced by the seed coat lignin content, which was a characteristic that varied

among soybean genotypes. Therefore, the higher the value of EC of the seed soaking solute did not necessarily mean lower seed vigor. Marwanto *et al.* (2003) found that seed coat lignin content was significantly and negatively correlated with membrane deterioration associated with a decline in soybean seed quality after storage, however, not well related to the decline in seed viability after storage. Mohamed-Yasseen *et al.* (2008) reported that hard seed coat protected the seed not only from mechanical stress but also from microorganism invasion and from temperature and humidity fluctuations during storage. During germination, the seed coat protected the seed from hydration stress and electrolyte leakage.

Vieira *et al.* (2004) found that vigorous soybean seeds had greater probability of superior performance under a wider range of environmental conditions. This did not mean vigorous seeds will always present the best field performance. Under marginal environmental conditions high vigor seed lot did not guarantee high seed emergence and adequate plant population in the field. However, EC values indicated soybean seed vigor and identified soybean seed lots field emergence potential.

### **Shelled and In-Shell Peanut Seed Quality**

Delouche (1968) reported that storage potential of in-shelled peanuts were higher than those of shelled out peanut seeds but in-shelled peanut seeds were bulky and required more space for storage. Duangpatra (1984) investigated the unshelled Tainan 9 and found that peanut seed could maintain satisfactory germination and vigor under ambient condition for only 4 months and after 10 months of storage gave no field emergence. Slay *et al.* (1985) also reported that storage peanut lose seed viability more quickly in the kernel form (shelled or seed) than in in-shell (pod) form. Controlling deterioration of shelled peanut became more difficult because the seeds were much more sensitive to conditions and environments that caused loss of quality. Duangpatra *et al.* (1985) found that storage quality of unshelled groundnut seed at ambient and controlled conditions varied with groundnut type, variety, and seed lot. The deterioration of unshelled SK 38 groundnut seed was more severe than that occur in Tainan 9, particularly under ambient condition.

Duangpatra and Kuphotipan (1986) reported that the germination of shelled peanut of SK 38 decreased at 2 months after storage under ambient condition. Duangpatra (1988) also found that under ambient condition, in-shell peanuts of KUP 24D-448, KUP 24D-615 and Tainan 9 could maintain high viability and vigor up to 10 months, while shelled seeds could maintain only four months. The effect of high relative humidity on peanut germination had been investigated by Navarro *et al.* (1989). They reported that at 71-76% RH and 15-20°C, in-shelled peanut of cultivar Hanoch preserved a germination level above 90% for 83 days, whereas at 79-83% RH and above, there was a gradual reduction in germination in proportion to storage temperature and humidity. Ketring (1971) found that peanut seeds were reduced in total germination, vigor and ethylene production at high relative humidity (80%), at which the low quality seeds were more susceptible to damage.

In addition, Phyo *et al.* (2004) found that high quality shelled peanuts could maintain high seed quality as in-shelled peanuts did. Differences in stability of seed quality confirmed that cold room condition was superior to ambient condition, and that storage potential was different among peanut cultivars. Either pod or seed of Tainan 9 and Kasetsart 50 peanut could be stored under ambient condition for 6 months without losing their initial quality. However, practically, peanut seeds were stored in pod but more bulky and required some more space in storage than the shell out peanuts. Whitty *et al.* (2006) also reported that peanut seed quality was easier to maintain in unshelled peanut and did not dry peanut seed too rapidly or too dry, either in the field or store warehouse. Moreover, peanut seeds were very fragile, therefore, skin slippage and splitting of the kernels would be increased when they were shelled.

Peanuts rapidly lost seed viability and vigor during storage under ambient condition (Duangpatra and Kuphotipan, 1986; Duangpatra and Promchote, 2000). Quality of soybean seed produced under favorable environment was usually good. However, in tropical and some sub-tropical countries, the environmental conditions were unfavorable to produce high seed quality. The environment was a major contribution for the rapid deterioration of the seed (Andrews, 1982). Therefore, if seed kinds and seed lots were kept well in good store, those seeds life could be long.

### **The Effect of Storage Pest on Seed Quality of Groundnut**

Groundnut stored borer seriously damaged on stored groundnuts. Dick (1987) reported that *Caryedon serratus* Olivier was the major pest of stored groundnuts in tropical Asia and Africa. They hatched their eggs on common tree legumes such as tamarind as well as on harvest groundnut. It was the only one species that could penetrate intact mature pods to infest kernels. Infestation of harvested groundnut could occur while the crop was drying in the field or when it was stored near infested stocks or crop residues. Adult females attached their eggs to the outside of pods or kernels, when the first instar larva hatched it burrow directly through the pod wall to the kernel. Each larva fed solely within a single kernel. A single larva could make a large excavation in the cotyledons, but no sign of damage was visible externally at this stage. When mature, larvae partially or completely emerged from the pod, leaving a characteristic round hole approximately 3 mm in diameter. Larvae migrated to the bottom of a sack or heap before pupating in distinctive ovoid cocoons.

### **Effect of Temperature on Field Emergence of Oil Crop Seed**

Temperature around 30°C encouraged rapid germination and initial growth of sesame, but up to 40°C tolerated some specific cultivars (Weiss, 2000). Genotypic variations of sesame in germination response to temperature were reported by Peter (2004). The optimum temperature of sesame seedling emergence ranged from 27 to 33°C. A temperature of 25 to 27°C encouraged rapid germination and seedling emergence. Temperature below 20°C delayed seedling emergence and below 10°C inhibited both sesame germination and field emergence. Moreover, temperatures around 25 and 30°C appeared to be the optimum and below 20°C retarded seedling emergence of peanut. Low temperatures initially retarded, and then prevented plant growth. Henning *et al.* (1982) reported that climatic conditions such as temperature and rainfall influenced seedling emergence of peanut. Peanuts should be planted in warm and moist soil. However, planting in cool and wet soil often resulted in slow seed germination and seedling emergence. Weiss (2000) also reported effect of temperature on soybean field emergence that optimum temperature of field emergence

was 25-33°C, below 15°C and above 37°C reduced seedling emergence. The optimum soil temperature for germination and early seedling growth was 25 to 30°C. Differences among genotypes in the relative effect of temperature on germination of soybean were found by Wallace (1988). Bragg and Cobb soybean germinated temperatures ranged from 25 to 40°C. Soybean seedling emergence decreased with increasing temperature above 37°C. No emergence was found at 40°C. Emergence of the other twelve soybean cultivars at 38°C ranged from 25 to 95%.

## MATERIALS AND METHODS

### Materials

Three kinds of oil crops: sesame (*Sesamum indicum* L.), peanut (*Arachis hypogaea* L.), and soybean [*Glycine max* (L.) Merrill.] were used in this study. Five different seed lots of each seed kind were investigated for quality and storage potential. Four seed lots of sesame: KU 18 (2006), KU 18 (2007), CPlus 2 (2006) and CPlus 2 (2007) were obtained from the seed production field of National Corn and Sorghum Research Center in 2006 and 2007 seed multiplication plots, Pakchong District, Nakhon Ratchasima Province. Another seed lot of sesame KU 18 (Contract Farmer, 2007) was obtained from the contract farmer in Nakhon Sawan Province. KU 18 is black color seed coat and CPlus 2 is white color seed coat. For peanut, three seed lots of peanut: Kaset 1, Kasetsart 50 and Kalasin 2 were from the seed multiplication plot of National Corn and Sorghum Research Center, Pakchong District, Nakhon Ratchasima Province while Khon Kaen 4 and Tainan 9 were obtained from contract farmers in Khon Kaen Province. For the five seed lots of soybean: MJ 9518 2, MJ 9520 21, Morbi, KUSL 20004 and CM-60 were provided by the Field Crop Research Institute, Department of Agriculture, Ministry of Agriculture and Co-operative, Thailand.

### Methods

Each seed lot of sesame was kept in the paper bag. Dried pods of each peanut seed lot were put in the jute bag. For soybean, each seed lot was put in the paper bag and covered with seal plastic. These fifteen seed lots were stored under local ambient condition for a period of four months from June to September 2008 at Seed Technology Laboratory, Department of Agronomy, Faculty of Agriculture, Kasetsart University, Bangkok, Thailand. Seed moisture content, germination and vigor were determined before storage and at 2 and 4 months after storage. Field emergence tests were also conducted before storage and at 4 months after storage. Split plot design with four replications was used. Duration of storage period was treated as main plot

factor, and the combination of three seed kinds and five different seed lots of each seed kind was treated as sub-plot factor. Determination of seed quality of each lot was conducted using the following procedures:

#### 1. Moisture content test

Seed moisture content was determined by hot air-oven method. Five grams of sesame, fifteen seeds of peanut and twenty five seeds of soybean with four replications were measured for the fresh weight, then put in moisture can and dried in hot air-oven at 105°C for 24 hour. After drying the samples were put in the desiccators for 30 minutes, and the dry weight was recorded. Seed moisture content was calculated, and reported in percentage by fresh weight basis using the following formula as those mentioned by ISTA (2004).

$$\text{Moisture content (\%w. b.)} = \frac{\text{Fresh weight of seed} - \text{Dry weight of seed}}{\text{Fresh weight of seed}} \times 100$$

#### 2. Germination test

Twenty five seeds of each seed lot with four replications of sesame were germinated on top of three layers of blotting paper in the petridish. The petridishes were sterilized with 90% alcohol. Appropriate quantity of water was added at the beginning of the test. All petridishes with lid cover were kept at 25°C. Addition water was added in every germination media to keep the saturation of germination media at optimum level. First count germination was done at 3 days after seeding (DAS) and final count was done at 6 DAS. Seedling evaluation was followed those that mentioned in ISTA (2004).

Four replications of fifty peanut seeds of each seed lot were treated with carboxin (5-6-dihydro-2 methyl-1, 4-oxathi-ine-3-carbosanilide) 75% WP and seeded in the 26 x 17 x 10 cm plastic germination box containing about 40 mm height from

the bottom of compressed sand, and covered with about 10 mm height of uncompressed sand. The sand was sterilized at 100.3°C for 24 hours before used. Sufficient water was applied throughout the germination test to meet the moisture requirements for germination. The germination boxes were placed on the germination shelf in germination room at 25°C throughout the germination testing period. Evaluation was done as described by ISTA (2004). First count germination was done at 5 DAS and final count was done at 10 DAS.

For soybean, four replications of fifty seeds of each seed lot were germinated on the top of the two layers of moist germination paper and covered with an additional layer of germination paper. The germinating papers containing soybean seeds were rolled and wrapped in plastic bags, placed in an upright position in plastic boxes and kept at 25°C room temperature throughout the testing periods. First count germination was done at 5 DAS and final count was done at 8 DAS. Germination and seedling evaluation followed those described in ISTA (2004).

### 3. Seed Vigor Test

Seed vigor was determined by the following tests:

#### 3.1 Germination index

Data collection for germination index was done together with germination test. The number of normal seedlings was counted daily from the day that the first seed germinated until the final germination test. Germination index was calculated by:

$$\text{Germination index} = \frac{N_i}{D_i}$$

Where  $N_i$  = Number of normal seedlings counted at  $i^{\text{th}}$  date

$D_i$  = Number of days required to the  $i^{\text{th}}$  germination

### 3.2 Accelerated Aging Test

Accelerated aging bottles and mesh trays were sterilized with 90% alcohol. Four replications of 2 g of each sesame seed lot were put in the sterilized mesh trays. The mesh trays were placed in the sterilized aging bottles, which contained 100 ml of deionized water at the bottom. The mesh tray in the bottle was held above the water level. The aging bottles were covered and seal locked with the bottle lid and kept in the accelerated aging chamber at 42°C and 100% relative humidity for 96 hours. After 96 hours, the seeds were taken out from the accelerated aging chamber and aged seeds were tested for germination. Germination evaluation was done as those conducted in the germination test.

Four replications of 50 peanut seeds from each seed lot were put in the sterilized mesh trays and aged at 42°C and 100% relative humidity for 96 hours using accelerated aging bottles and mesh trays as those used in sesame. After 96 hours, the seeds were taken out from the accelerated aging chamber and kept under ambient condition for three days. Aged seeds were tested for germination. Germination evaluation was done as those conducted in the germination test.

Soybean seeds were treated with Vitavax [5, 6 – dihydro – 2 – methyl – 1, 4 – oxathiin – 3 – carboxamide (56)] at the rate of 2 g / kg of soybean seed before aging. Four replications of 50 seeds of each soybean seed lot were aged at 41°C and 100% relative humidity for 72 hours (3 days) using accelerated aging bottles and mesh trays as those used in sesame and peanuts. The aging procedures were conducted as those in sesame and peanut. Aged soybean seeds were tested for germinability. Germination determination was done as those conducted in the germination test.

### 3.3 Electrical Conductivity Test

Four replicates of 25 seeds of sesame from each seed lot were weighed and placed in each beaker. 35 ml of deionized water was added to each

beaker which contained seeds. The beakers were incubated at 30°C for 24 hours. After 24 hours, the seeds were removed from the soaking solute (water) and electrical conductivity of leachates was determined using the Electrical Conductivity Meter Cyber Scan PC 510. The dip cell was rinsed in deionized water and then dried by blotting paper before and after each sample was tested.

Four replicates of 25 seeds from each lot of peanut and soybean were weighed and placed in each beaker. 75 ml of deionized water was added to each beaker which contained seeds. The beakers were incubated at 25°C for 24 hours. The electrical conductivity procedure was conducted as those mentioned previously in sesame. The EC value of each seed lot was expressed in  $\mu\text{S cm}^1 \text{g}^{-1}$  (AOSA, 1983).

### 3.4 Field Emergence Test

Sesame seeds were sown in row planting while peanut and soybean seeds were planted two seeds per hill in well-prepared seed bed with 50 x 20 cm spacing at National Corn and Sorghum Research Center, Pakchong District, Nakhon Ratchasima Province. Field emergence was counted at 7, 14 and 21 days after seeding (DAS). Field emergence at 21 DAS was noted as total field emergence for initial (before) storage and extended to 28 days after planting of those 4 months storage. Seedlings those emerged from the soil surface without having deformed, damaged or missing terminal bud and primary leaves, but having normal shape and normal size of primary leaves were counted as normal seedling.

### 3.5 Field Emergence Index

Field emergence index was conducting together in the field emergence test (3.4). The number of normal seedlings emergence was counted at 7, 14 and 21 DAS, and the emergence index was calculated by:

$$\text{Field Emergence Index} = \sum \frac{\text{Seedlings at } i^{\text{th}} \text{ days}}{i^{\text{th}} \text{ days}}$$

Where  $i^{\text{th}}$  = day 7, 14 and 21

\*Due to the cold season of the field emergence test after 4 months storage, the field emergence index was extended up to 28 DAS.

#### 4. Yield Collection

Yield data were collected from the harvested area of 6 square-meters from the field emergence testing plot at field maturity or harvesting maturity. Cultural practices were followed the GAP (Good Agricultural Practice) for sesame, peanut and soybean which recommended by Department of Agriculture, Ministry of Agriculture and Co-operative. Sesame which planted from the seed lots of those initial (before) storage, KU 18 (2007) and CPlus 2 (2006) were harvested at 90 DAS and KU 18 (2006), KU 18 (CF, 2007) and CPlus 2 (2007) were harvested at 98 DAS. For sesame that planted from the 4 months storage seed lots were harvested on the same day at 129 DAS. The whole sesame plants were hand cut and sun dried for 7 days and threshed by hand. The threshing seeds were sun drying to decrease the seed (grain) moisture to safe moisture level. Sesame seed yield was adjusted to 6% moisture content.

For peanut that planted from 0 month storage, Tainan 9 was harvested at 90 DAS, Khon Kaen 4 and Kalasin 2 were harvested at 98 DAS and Kaset 1 and Kasetsart 50 were harvested at 120 DAS. Whereas after 4 months storage, Khon Kaen 4 and Kalasin 2 were harvested at 135 DAS and Kaset 1 and Kasetsart 50 were harvested at 150 DAS. Peanut plants were hand harvested and depoded in the field. Freshly harvested pods were put in the gunny bag and sun dried to decrease the moisture content to 9% or lower. Peanut pods yield were recorded at 7% moisture content. For 4 months storage, no harvested peanut of Tainan 9 due to the groundnut borer seed damage during storage.

Soybean that planted from the 0 month storage: KUSL 20004 was harvested at 90 DAS and MJ 9518 2, MJ 9520 21, Morbi and CM 60 were harvested

at 103 DAS. For 4 months storage, CM 60 was harvested at 101 DAS. MJ 9518 2, Morbi and KUSL 20004 were harvested at 124 DAS. Hand harvested soybean plants were put in the gunny bags and sun dried. After drying, soybeans were threshed by hand and the undesirable materials were removed. Cleaned soybean seed yield was recorded at 14% moisture content.

## 5. Statistical Analysis

The data were analyzed by using the analysis of variance (ANOVA) procedure of the IRRI Statistic described by Gomez and Gomez (1984). The comparison of means was calculated by Fisher's LSD.

### **Places**

Seeds were stored under ambient condition at the Seed Technology Laboratory, Department of Agronomy, Kasetsart University. Field study was carried out at the National Corn and Sorghum Research Center, Pakchong District, Nakhon Ratchasima Province. Seed quality determination was conducted at the Seed Technology Laboratory, Department of Agronomy, Faculty of Agriculture, Kasetsart University, Bangkok, Thailand.

### **Duration**

The study periods started from October 2007 to May 2009. Sesame, peanut and soybean storage periods were from June to October, 2008.

## RESULTS AND DISCUSSION

### Results

#### 1. Seed moisture content

Analysis of variance of seed moisture content showed that storage periods were highly significant different (Appendix Table 1). Seed moisture content of the 15 seed lots significantly decreased after 2 and 4 months storage (Table 1). But, at two months storage, average seed moisture content was lower than at 4 months storage. At initial (0 month) and after 2 months storage, seed moisture content of soybean were higher than sesame and peanut but sesame and peanut were not different. However, after 4 months storage, seed moisture content of sesame, peanut and soybean were significantly different. Seed moisture content of soybean was the highest and peanut was the lowest. But, in sesame and peanut, moisture content at 2 and 4 months after storage were not different. In case of soybean, moisture content decreased at 2 months and slightly increased at 4 months (Table 1).

ANOVA of seed moisture also showed that treatment combination (seed kind and seed lot) was highly significant (Appendix Table 1). At initial before storage, the three seed lots of soybean: MJ 9520 21, Morbi and KUSL 20004 showed the highest moisture content, but MJ 9520 21 and KUSL 20004 were not higher than MJ 9518 2. The three lots of sesame: KU 18 (2006), KU 18 (2007) and KU 18 (CF, 2007), and CM 60 soybean were lower in seed moisture than the four soybean seed lots previously mentioned, but the three seed lots of sesame: KU 18 (2006), KU 18 (2007) and KU 18 (CF, 2007) were not higher than CPlus 2 (2007) sesame, and the two lots of peanut: Kasetsart 50 and Tainan 9, as well as CPlus 2 (2006) and CPlus 2 (2007) sesame, and the other four lots of peanut: Kaset 1, Khon Kaen 4, Tainan 9 and Kalasin 2 were the lowest in seed moisture content.

After 2 months storage, moisture content of the five seed lots of soybean decreased but showed the highest among the 15 seed lots. The two lots of sesame:

CPlus 2 (2006) and CPlus 2 (2007) and the four lots of peanut: Kaset 1, Kasetsart 50, Khon Kaen 4 and Kalasin 2 were the lowest in seed moisture content but not lower than the two lots of sesame: KU 18 (2007) and KU 18 (CF, 2007) and the two lots of peanut: Tainan 9 and Kalasin 2.

When storage extended to 4 months, moisture content of the 5 lots of soybean increased. Moisture contents of MJ 9520 21, Morbi and KUSL 20004 were the highest among the 15 seed lots but not different from MJ 9518 2 and CM 60. The 5 lots of sesame and Tainan 9 peanut seed moisture content were lower than the previous mentioned seed lots and the lowest in seed moisture at 4 months storage were the four seed lots of peanut: Kaset 1, Kasetsart 50, Khon Kaen 4 and Kalasin 2. Seed moisture indicated that high moisture content before storage resulted in high moisture content after storage.

Average mean of the 15 seed lots over the storage study periods showed in the last column of Table 1 also revealed that the three seed lots of soybean: MJ 9520 21, Morbi and KUSL 20004 were the highest in seed moisture but MJ 9520 21 and KUSL 20004 were not different from MJ 9518 2 and CM 60. Lower seed moisture was followed by the three lots of sesame: KU 18 (2006), KU 18 (2007) and KU 18 (CF, 2007) and Tainan 9 peanut, in which KU 18 (2006) sesame and Tainan 9 peanut seed moisture content were not different from CPlus 2 (2007) sesame. Lowest seed moisture was found in the three lots of peanut: Kaset 1, Khon Kaen 4 and Kalasin 2 which were not lower than Kasetsart 50 and CPlus 2 (2006) sesame.

Initial seed moisture content of the four sesame seed lots: KU 18 (2006), KU 18 (2007), KU 18 (CF, 2007) and CPlus 2 (2007) were not different and were higher than CPlus 2 (2006). At 2 and 4 months storage, seed moisture content of sesame seeds decreased. At 2 months storage, seed moisture content of KU 18 (2006), KU 18 (2007) and KU 18 (CF, 2007) were the highest but KU 18 (2007) and KU 18 (CF, 2007) were not higher than CPlus 2 (2006) and CPlus 2 (2007). At 4 months storage, seed moisture contents of the 5 sesame seed lots were not different. Moisture content

of CPlus 2 (2006) was the lowest as shown in the average mean in the last column of Table 1.

In case of peanut, before storage, seed moisture contents of Kasetsart 50 and Tainan 9 were higher than Kaset 1, Khon Kaen 4 and Kalasin 2 but Kaset 1, Khon Kaen 4 and Kalasin 2 were not lower than Tainan 9. At 2 and 4 months storage, seed moisture content decreased. After 2 months storage, seed moisture content of Tainan 9 was higher than Kasetsart 50 and Khon Kaen 4, however, moisture content of these 2 seed lots were not different. Moreover, seed moisture content of Kaset 1, Tainan 9 and Kalasin 2 were not different. At 4 months storage, seed moisture content of Tainan 9 was higher than those of the other 4 peanut seed lots, but no differences in seed moisture content were found in Kaset 1, Kasetsart 50, Khon Kaen 4 and Kalasin 2. Among the 5 seed lots of peanut, moisture content of Tainan 9 was the highest. This might be the thin pericarp of peanut pod that could absorb the atmosphere moisture faster than the other 4 lots. However, seed moisture content of the 5 peanut seed lots decreased with increasing time because of the low RH of the storage place (Figure 1).

For soybean, initial seed moisture content of Morbi was higher than MJ 95182 and CM 60 but not higher than MJ 9520 21 and KUSL 20004. Seed moisture content of CM 60 was the lowest. At 2 months storage, seed moisture content of the 5 soybeans decreased and no differences were found among seed lots. After 4 months storage, seed moisture contents of the 5 soybean seed lots were higher than at 2 months storage. Seed moisture content of Morbi was higher than MJ 9518 2 and CM 60 but not higher than MJ 9520 21 and KUSL 20004. Seed moisture content of MJ 9518 2, MJ 9520 21, KUSL 20004 and CM 60 were also not differences. The changes in seed moisture content of the overall mean of soybean were the same as those at 4 months storage. It was important to note that seed moisture content of the 5 soybean seed lots at 2 months storage were lower than 0 month and after 4 months storage (Table 1). It was also very interested to note that the moisture content of the five soybean seed lots were higher than those recommend for storage and to be used

for seeds as previously mentioned by many researchers which would result in low seed germination after storage.

## **2. Seed Germination**

Results from the analysis of variance showed that the interaction between storage durations and treatment combination of seed kinds and seed lots significantly influenced on seed germination (Appendix Table 2). Germination percentage of the 15 seed lots significantly decreased after 2 and 4 months storage (Table 2). Before storage, germination percentage of soybean was higher than that of peanut but not higher than sesame, while the germination of sesame and peanut were not different. No differences of germination among seed kinds were found when storage period reached at 2 and 4 months.

Among the fifteen seed lots, the initial germination of the two lots of sesame: KU 18 (2007) and KU 18 (CF, 2007), the two lots of peanut: Kaset 1 and Kasetsart 50 and the five seed lots of soybean were the highest in germination as shown in Table 2, followed by the two lots of sesame: KU 18 (2006) and CPlus 2 (2007) and Khon Kaen 4 peanut, respectively. However, germination of the four lots of sesame: KU 18 (2006), KU 18 (2007), KU 18 (CF, 2007) and CPlus 2 (2007) as well as the three lots of peanut: Kaset 1, Kasetsart 50 and Khon Kaen 4 and also the two lots of soybean: MJ 9520 21 and KUSL 20004 were not different. CPlus 2 (2006) sesame and the two lots of peanut: Tainan 9 and Kalasin 2 were the lowest. These initial germination percentages revealed the different germinability of different seed lots. Similar results were also found after 2 and 4 months storage but different in some extent.

At 2 months storage, the two lots of sesame: KU 18 (2006) and KU 18 (2007) and the two lots of soybean: Morbi and CM 60 were the highest germination followed by the three lots of sesame: KU 18 (CF, 2007), CPlus 2 (2006), CPlus 2 (2007), the two lots of peanut: Kaset 1 and Khon Kaen 4 and KUSL 20004 soybean, but germination of the four lots of sesame: KU 18 (2006), KU 18 (CF, 2007), CPlus 2 (2006) and CPlus 2 (2007), the two lots of peanut: Kaset 1 and Khon Kaen 4 and

KUSL 20004 soybean were not different. The next lower germination at 2 months were the two lots of peanut: Kasetsart 50 and Tainan 9 and MJ 9520 21 soybean but the two lots of sesame: KU 18 (CF, 2007) and CPlus 2 (2006) and Kaset 1 peanut were not higher in germination than Kasetsart 50 and Tainan 9 peanut as well as MJ 9520 21 soybean.

After 4 months storage, KU 18 (2007) sesame, the two lots of peanut: Kaset 1 and Khon Kaen 4 and the two lots of soybean: MJ 9518 2 and CM 60 were the highest germination whereas Tainan 9 peanut and the two lots of soybean: MJ 9520 21 and KUSL 20004 were the lowest. The germination percentages of four lots of sesame: KU 18 (2006), KU 18 (CF, 2007), CPlus 2 (2006) and CPlus 2 (2007), and the two lots of peanut: Kasetsart 50 and Kalasin 2, and Morbi soybean were not higher than Tainan 9 peanut, MJ 9520 21 and KUSL 20004 soybean. These results indicated that initial seed germination before storage influenced the germination of seed lot after storage. High germination seed lots before storage were high in germination after 2 and 4 months storage. Mean germination showed in the last column in Table 2 also revealed and confirmed similar results of germination of the 15 seed lots.

Germination mean of over all of the fifteen seed lots revealed that after storage, seed germination decreased. This reflected seed deterioration during storage. KU 18 (2007) sesame and CM 60 soybean seed were the highest in germination but CM 60 soybean was not higher than KU 18 (2006) sesame, Kaset 1 and Khon Kaen 4 peanut and Morbi soybean. While Morbi soybean was not higher than KU 18 (2006), KU 18 (CF, 2007) and CPlus 2 (2007) sesame, Kaset 1, Kasetsart 50 and Khon Kaen 4 peanut and MJ 9518 2 soybean. KU 18 (CF, 2007) sesame was not higher than CPlus 2 (2007) sesame, Kasetsart 50 peanut and KUSL 20004 soybean. The two lots of peanut: Tainan 9, Kalasin 2 and MJ 9520 21 soybean were the lowest. These revealed that germination after storage was depending upon initial seed quality and different among seed kind and seed lot.

In case of sesame, initial germination of KU 18 (2006), KU 18 (2007), KU 18 (CF, 2007) and CPlus 2 (2007) were the highest and were higher than CPlus 2 (2006).

At 2 months storage, germination percentage of KU 18 (2006) and KU 18 (2007) were the highest but KU 18 (2006) was not higher than the other 3 sesame seed lots. At 4 months storage, highest germination percentage was found in KU 18 (2007) which was higher than the other 4 sesame seed lots. The second high was KU 18 (2006) and CPlus 2 (2007) but these two seed lots were not higher than KU 18 (CF, 2007) and CPlus 2 (2006). For mean germination percentage of sesame, KU 18 (2007) was the highest followed by KU 18 (2006). But KU 18 (2006) was not higher than KU 18 (CF, 2007) and CPlus 2 (2007).

Before storage, peanut also showed the similar results in germination as sesame. Germination of Kaset 1, Kasetsart 50 and Khon Kaen 4 were higher than Tainan 9 and Kalasin 2. After 2 months storage, germination percentage of Khon Kaen 4 was higher than those of other 3 seed lots but not higher than Kaset 1. Among the 5 peanut seed lots, Kalasin 2 had the lowest germination percentage. Germination percentage of Tainan 9 and Kasetsart 50 were higher than Kalasin 2, but were not lower than germination percentage of Kaset 1. In contrast, the lowest germination of Tainan 9 was found at 4 months storage while the germination percentages of the other 4 seed lots were not different. For mean germination, Kaset 1, Kasetsart 50 and Khon Kaen 4 showed higher germination percent than Tainan 9 and Kalasin 2 which were the lowest in germination.

It was also found in soybeans that before storage, germination percentage of the five seed lots were not different. At 2 months storage, seed germination of Morbi, KUSL 20004 and CM 60 were higher than the other 2 seed lots, while MJ 9518 2 showed the lowest germination. After 4 months storage, germination percentage of MJ 9518 2 was the highest as well as CM 60, but germination of CM 60 was not different from Morbi. Germination percentage of MJ 9520 21 and KUSL 20004 were the lowest. Considering the mean germination of the five seed lots of soybean, CM 60 and Morbi showed the highest germination but Morbi was not higher than MJ 9518 2 whereas MJ 9520 21 was the lowest germination (Table 2).

### 3. First count germination

The Analysis of variance showed that storage periods and treatment combinations were highly significant on first count germination (Appendix Table 3). First count germination of the 15 seed lots significantly decreased after 2 and 4 months storage (Table 3). At initial, sesame and soybean were higher in first count germination than peanut. At 2 months storage, first count germination of sesame was higher than peanut but not higher than soybean, while first count germination of peanut and soybean were not different. However, the three oil crops seed were not different in first count germination after 4 months storage. For sesame, first count germination at 2 months was not lower than before storage but after 4 months storage was lower than at initial before storage and at 2 months storage. In peanut, first count germination was not different throughout the storage periods. In case of soybean, no difference in first count germination was found at 2 and 4 months storage, however first count germinations were lower than before storage.

Analysis of variance in Appendix Table 3 also indicated highly significant different of treatment combination. In Table 3, at 0 month or initial storage, the two seed lots of sesame: KU 18 (2007) and KU 18 (CF, 2007) and all five seed lots of soybean were the highest in first count germination. However KU 18 (CF, 2007) sesame and the two seed lots of soybean: MJ 9520 21 and KUSL 20004 were not higher than the other two seed lots of sesame: KU 18 (2006) and CPlus 2 (2007). CPlus 2 (2006) sesame and the three seed lots of peanut: Kaset 1, Kasetsart 50 and Khon Kaen 4 were the next lower in first count germination than the previous mentioned seed lots, followed by Kalasin 2 peanut. Tainan 9 peanut was the lowest.

After 2 months storage, KU 18 (2007) sesame was the highest in first count germination followed by the other four lots of sesame and the three lots of soybean: Morbi, KUSL 20004 and CM 60. The three lots of sesame: KU 18 (CF, 2007), CPlus 2 (2006) and CPlus 2 (2007) and the two lots of soybean: Morbi and KUSL 20004 were not higher in first count germination than Kaset 1 peanut. The lowest in first count germination were the two lots of peanut: Kasetsart 50 and Kalasin 2, although

these two seed lots were not lower than Khon Kaen 4 peanut and MJ 9518 2 soybean but were lower than Tainan 9 peanut and MJ 9520 21 soybean.

After storage extended to 4 months, KU 18 (2007) sesame, MJ 9518 2 and CM 60 soybean were the highest in first count germination. But KU 18 (2007) sesame and CM 60 soybean were not higher than KU 18 (CF, 2007), CPlus 2 (2006) and CPlus 2 (2007) sesame, Khon Kaen 4 and Kalasin 2 peanut and Morbi soybean. Among the 15 seed lots, KU 18 (2006) sesame, and the three lots of peanut: Kaset 1, Kasetsart 50 and Tainan 9 as well as the two lots of soybean: MJ 9520 21 and KUSL 20004 were the lowest in first count germination but not lower than the two lots of sesame: KU 18 (CF, 2007) and CPlus 2 (2006), and the two lots of peanut: Khon Kaen 4 and Kalasin 2 as well as Morbi soybean.

The average mean of the 15 seed lots for first count germination in the last column of Table 3 also showed out similar trend of this seed characteristic. The highest first count germination was KU 18 (2007) sesame and CM 60 soybean followed by the two lots of sesame: KU 18 (CF, 2007) and CPlus 2 (2007) and the two lots of soybean: MJ 9518 2 and Morbi. The first count germination of KU 18 (CF, 2007) sesame and Morbi soybean were not higher than the two lots of sesame: KU 18 (2006) and CPlus 2 (2006) and MJ 9520 21 soybean. Lowest first count germination was found in the three lots of peanut: Kasetsart 50, Tainan 9 and Kalasin 2 which were higher than CPlus 2 (2006) sesame, the two lots of peanut: Kaset 1 and Khon Kaen 4 and MJ 9520 21 soybean.

In sesame, first count germination at initial in Table 3 indicated that KU 18 (2007) and KU 18 (CF, 2007) were the highest but KU 18 (CF, 2007) was not higher than KU 18 (2006) and CPlus 2 (2007). CPlus 2 (2006) had the lowest in first count germination. At 2 months storage, first count germination of KU 18 (2007) was the highest and higher than the other four seed lots. However, first count germination percentage decreased after storage for 4 months. KU 18 (2007) was the highest but not higher than KU 18 (CF, 2007), CPlus 2 (2006) and CPlus 2 (2007). KU 18 (2006) had the lowest first count germination but not lower than KU 18 (CF, 2007) and

CPlus 2 (2006). For the average mean of sesame, similar trend was also found that KU 18 (2007) was the highest in first count germination followed by KU 18 (CF, 2007), CPlus 2 (2006) and CPlus 2 (2007). First count germination of KU 18 (CF, 2007) was not higher than KU 18 (2006) and CPlus 2 (2006).

In peanut, before storage, first count germination of Kaset 1, Kasetsart 50 and Khon Kaen 4 were not different and were higher than Kalasin 2 and Tainan 9. After 2 months storage, Kaset 1 was the highest followed by Tainan 9 and Khon Kaen 4, but Khon Kaen 4 was not higher than Kasetsart 50 and Kalasin 2. At 4 months storage, no difference in first count germination was found. For overall mean, first count germination of Kaset 1 and Khon Kaen 4 were higher than Kalasin 2, Kasetsart 50 and Tainan 9.

First count germination of soybean at 0 month (before storage) was not different. At 2 month storage, first count germination of CM 60 was the highest but not higher than Morbi and KUSL 20004. First count germination of MJ 9518 2 was the lowest but not lower than MJ 9520 21. As storage extended to 4 months, first count germination of MJ 9518 2 and CM 60 were the highest and but CM 60 was not higher than Morbi. MJ 9520 21 was the lowest in first count germination but not lower than Morbi and KUSL 20004. According to the overall mean, first count germination of CM 60 was the highest followed by MJ 9518 2 and Morbi. But Morbi was not higher than MJ 9520 21 and KUSL 20004.

#### **4. Germination index**

Germination index (GI) was influenced by storage durations and treatment combinations (Appendix Table 4). It was found that, GI of the 15 different seed lots decreased after 2 and 4 months storage and were lower than at initial before storage. However, GI at 2 and 4 months storage were not different (Table 4).

In sesame, GI before storage and at 2 months storage was not different. However, after 4 months storage GI was lower than 0 and 2 months storage. For

peanut, GI at initial and after 2 and 4 months storage were not different. In case of soybean, before storage, GI was higher than after 2 and 4 months storage. GI at 2 and 4 months storage were not different. Comparison of seed kinds, before storage, GI of sesame and soybean were not different but higher than peanut. After 2 and 4 months storage, GI of sesame was higher than peanut and soybean but GI of soybean and peanut were not different (Table 4).

Among the 15 seed lots, at 0 month, GI of the three lots of sesame: KU 18 (2007), KU 18 (CF, 2007) and CPlus 2 (2007) showed the highest GI followed by KU 18 (2006) sesame and the five seed lots of soybean but the two lots of sesame: KU 18 (CF, 2007) and CPlus 2 (2007) were not higher than KU 18 (2006) and the five seed lots of soybean. GI of three lots of peanut: Kasetsart 50, Tainan 9 and Kalasin 2 were the lowest, but Kasetsart 50 peanut was not lower than CPlus 2 (2006) sesame and the other two lots of peanut: Kaset 1 and Khon Kaen 4. For 2 months storage, KU 18 (2007) sesame was still the highest in GI followed by the other three lots: KU 18 (2006), CPlus 2 (2006) and CPlus 2 (2007), but GI of KU 18 (2006) and CPlus 2 (2006) were not higher than KU 18 (CF, 2007). The next rank in GI were Morbi, KUSL 20004 and CM 60 soybean but Morbi and KUSL 20004 soybean were not higher than the three lots of peanut: Kaset 1, Khon Kaen 4, Tainan 9 and MJ 9520 21 soybean. The lowest GI at 2 months were Kasetsart 50 and Kalasin 2 peanut and MJ 9518 2 soybean but were not lower than Tainan 9 peanut and MJ 9520 21 soybean. At 4 months of storage, GI of the two lots of sesame: KU 18 (2007) and CPlus 2 (2007) were the highest but CPlus 2 (2007) sesame was not higher than the other three sesame seed lots and Khon Kaen 4 peanut and MJ 9518 2 and CM 60 soybean. The three lots of sesame: KU 18 (2006), KU 18 (CF, 2007), CPlus 2 (2006), the four lots of peanut except Tainan 9 and the three lots of soybean: MJ 9518 2, Morbi and CM 60 were also not different in GI, but were higher than Tainan 9 peanut and the two lots of soybean: MJ 9520 21 and KUSL 20004. The two lots of peanut: Kasetsart 50 and Tainan 9 and the two lots of soybean: MJ 9520 21 and KUSL 20004 were the lowest in GI.

Similar trend of GI was also found in average mean of storage periods. KU 18 (2007) sesame was the highest in GI followed by KU 18 (CF, 2007) and CPlus 2 (2007) sesame. But KU 18 (CF, 2007) was not higher than KU 18 (2006) sesame. These two sesame seed lots were higher in GI than CPlus 2 (2006) and the three lots of soybean: MJ 9518 2, Morbi and CM 60. The fourth high rank in GI were Kaset 1 and Khon Kaen 4 peanut and MJ 9520 21 and KUSL 20004 soybean, but MJ 9520 21 soybean was not higher than Kasetsart 50 and Kalasin 2 peanut. The lowest GI was Tainan 9 peanut which was not lower than Kalasin 2 peanut. These results revealed that oil crop seed lots that high in GI before storage were also high GI after storage.

In case of GI of each seed kind, at initial, GI of KU 18 (2007), KU 18 (CF, 2007) and CPlus 2 (2007) sesame were the highest. However, KU 18 (CF, 2007) and CPlus 2 (2007) were not higher than KU 18 (2006) and CPlus 2 (2006) was the lowest. After 2 months storage, GI of KU 18 (2007) was the highest and KU 18 (CF, 2007) was the lowest but not lower than KU 18 (2006) and CPlus 2 (2006). GI of KU 18 (2006), CPlus 2 (2006) and CPlus 2 (2007) were not differences. Similar results also found at 4 months storage. GI of KU 18 (2007) and CPlus 2 (2007) were the highest but CPlus 2 (2007) was not higher than KU 18 (2006), KU 18 (CF, 2007) and CPlus 2 (2006). It was also found in the mean GI of the 5 sesame seed lots that KU 18 (2007) was the highest in GI followed by CPlus 2 (2007) and KU 18 (CF, 2007) in which KU 18 (CF, 2007) was not different from KU 18 (2006) and CPlus 2 (2006) was the lowest.

In case of peanut, before storage, GI of Kaset 1 and Khon Kaen 4 were higher than Tainan 9 and Kalasin 2, but were not higher than Kasetsart 50. However, Kasetsart 50 was not higher than Tainan 9 and Kalasin 2. After 2 months storage, GI of Kaset 1, Khon Kaen 4 and Tainan 9 were higher than Kasetsart 50 and Kalasin 2 but Tainan 9 was not higher than Kasetsart 50 and Kalasin 2. Different results were found at 4 months storage. GI of Kasetsart 50, not different but Kaset 1, Khon Kaen 4 and Kalasin 2 were higher than Tainan 9 while Kasetsart 50 was not higher than

Tainan 9. For the mean GI of peanut, Kaset 1 and Khon Kaen 4 were the highest and Tainan 9 was the lowest but not lower than Kalasin 2 and Kasetsart 50.

For soybean, before storage, GI of the five seed lots was not different. At 2 months storage, GI of CM 60 was the highest but was not higher than Morbi and KUSL 20004. The lowest GI was found in MJ 9518 2 but not lower than MJ 9520 21. At the end of 4 months storage, GI of MJ 9518 2 was the highest but not higher than CM 60, while GI of CM 60 and Morbi were not different. GI of MJ 9520 21 and KUSL 20004 were the lowest. For mean GI of soybean, MJ 9518 2, Morbi and CM 60 were the highest and MJ 9520 21 and KUSL 20004 were the lowest (Table 4).

## **5. Germination after accelerated aging**

Analysis of variance showed that germination percentage after accelerated aging (AA) was significantly influenced by storage duration and seed kinds and seed lots treatments combination (Appendix Table 5). AA of the 15 different seed lots significantly decreased after 2 and 4 months storage, respectively (Table 5). Before storage, germination percentage after AA of sesame, peanut and soybean were not different but after 2 and 4 months storage, AA of sesame and peanut were higher than soybean. For sesame and peanut, AA was not different throughout the storage periods. However, in soybean, AA was dramatically decreased at 2 and 4 months storage.

Among the 15 seed lots, at initial (before storage) AA of the two lots of sesame: KU 18 (2007) and KU 18 (CF, 2007), the two lots of peanut: Kasetsart 50 and Kalasin 2 were the highest. However, AA of KU 18 (CF, 2007) sesame and the two lots of peanut: Kasetsart 50 and Kalasin 2 were not higher than CPlus 2 (2007) sesame, Kaset 1 and Khon Kaen 4 peanut and the two lots of soybean: MJ 9518 2 and CM 60. AA of MJ 9520 21 and KUSL 20004 soybean were not lower than CPlus 2 (2007) sesame, Kaset 1 peanut and the two lots of soybean: MJ 9518 2 and CM 60. The lowest in AA were Tainan 9 peanut and Morbi soybean, but not lower than CPlus 2 (2006) sesame, and MJ 9520 21 and KUSL 20004 soybean.

AA at 2 and 4 months storage were different in some extents from initial. The 5 lots of soybean at 4 months storage were zero (0), while KU 18 (2007) sesame stored at 2 and 4 months showed the highest AA. KU 18 (2006) sesame also showed the highest AA at 2 months storage. After 2 months storage, KU 18 (CF, 2007) and CPlus 2 (2007) sesame and the five lots of peanut were lower in AA than KU 18 (2006) and KU 18 (2007) sesame. AA of KU 18 (CF, 2007) sesame and the two lots of peanut: Kasetsart 50 and Khon Kaen 4 were not higher than the other three seed lots of peanut: Kaset 1, Tainan 9 and Kalasin 2, but were higher than CPlus 2 (2006) sesame which has the lowest in AA. However, after 4 months storage, as mentioned previously that KU 18 (2007) sesame was the highest in AA followed by the three lots of sesame: KU 18 (2006), KU 18 (CF, 2007) and CPlus 2 (2007) as well as the three lots of peanut: Kasetsart 50, Khon Kaen 4 and Kalasin 2. AA of KU 18 (CF, 2007) and CPlus 2 (2007) sesame and Kasetsart 50 and Khon Kaen 4 peanut were not higher than CPlus 2 (2006) sesame and Kaset 1 peanut. However, CPlus 2 (2006) sesame and Kaset 1 peanut were higher than Tainan 9 peanut which was the lowest in AA after 4 months storage.

The average mean of AA of the 15 seed lots in the last column in Table 5 were similar to those of 2 and 4 months storage. AA of KU 18 (2007) sesame was the highest followed by KU 18 (CF, 2007) sesame and Kasetsart 50 and Kalasin 2 peanut but Kasetsart 50 peanut was not higher than KU 18 (2006) and CPlus 2 (2007) sesame and Khon Kaen 4 peanut. Lower AA than the previous mentioned seed lots were Kaset 1 peanut followed by CPlus 2 (2006) sesame, Tainan 9 peanut, the two lots of soybean: MJ 9518 2 and CM 60 soybean, respectively. The three lots of soybean: MJ 9520 21, Morbi and KUSL 20004 were the lowest in AA.

In case of sesame, before storage, AA of KU 18 (2007) and KU 18 (CF, 2007) were the highest but KU 18 (CF, 2007) was not higher than CPlus 2 (2007). It was obviously found that at 2 months storage, AA of KU 18 (2006) and KU 18 (2007) were the highest followed by KU 18 (CF, 2007) and CPlus 2 (2007). AA of CPlus 2 (2006) was the lowest among the 5 lots. After 4 months storage, AA of KU 18 (2007) was the highest followed by KU 18 (2006), KU 18 (CF, 2007) and CPlus 2

(2007) in which these 3 seed lots were not differences. The lowest AA was CPlus 2 (2006) but not lower from KU 18 (CF, 2007). The mean AA of sesame showed that KU 18 (2007) was the highest followed by KU 18 (CF, 2007), KU 18 (2006) and CPlus 2 (2007), respectively, in which the last 2 lots were not different and CPlus 2 (2006) was the lowest.

For peanut, before storage AA of Kasetsart 50 and Kalasin 2 were the highest but were not higher than Khon Kaen 4 and Kaset 1. Among the 5 seed lots of peanut, AA of Tainan 9 was the lowest. Different trend was found at 2 months storage. AA of the 5 seed lots were not different. But, after 4 months storage, AA of Kalasin 2 was the highest but not higher than Khon Kaen 4 and Kasetsart 50. AA of Khon Kaen 4 and Kasetsart 50 were not higher than Kaset 1. Tainan 9 was the lowest in AA among the 5 peanut seed lots. Mean germination of AA showed that Kalasin 2 and Kasetsart 50 were the highest but Kasetsart 50 was not higher than Khon Kaen 4. It was also showed in the last column of Table 5 that mean AA of Tainan 9 was the lowest.

In soybean, at initial (before storage) AA of MJ 9518 2 and CM 60 were higher than Morbi but not higher than MJ 9520 21 and KUSL 20004. However, AA of MJ 9520 21, KUSL 20004 and Morbi were not different. It was important to note that at 2 and 4 months storage, AA of the 5 soybean seed lots were zero. Mean AA of MJ 9518 2 and CM 60 were higher than those of MJ 9520 21, KUSL 20004 and Morbi (Table 5).

## **6. Electrical conductivity (EC)**

Statistical analysis showed that EC was influenced by storage durations and treatment combination of seed kinds and seed lots (Appendix Table 6). EC of the 15 seed lots at 2 months storage was higher than 0 month and after 4 months storage (Table 6). At 0 and at 2 months storage, EC of sesame was higher than soybean and EC of peanut was the lowest. At 4 months storage, EC of sesame and soybean were not significantly different but higher than EC of peanut. In sesame, EC of seed

storage at 2 months was higher than at initial and at 4 months storage. In case of peanut and soybean, EC values were not different throughout the storage periods.

At 0 month, the five seed lots of peanut were the lowest in EC and CPlus 2 (2007) sesame was the highest, followed by KU 18 (2007), CPlus 2 (2006) sesame and MJ 9518 2 soybean but KU 18 (2007) and CPlus 2 (2006) sesame were not higher than KU18 (2006), KU 18 (CF, 2007) sesame and KUSL 20004 soybean. At 2 months, CPlus 2 (2006) sesame showed the highest EC followed by KU 18 (2007) and CPlus 2 (2007) sesame, and MJ 9518 2 soybean but MJ 9518 2 soybean was not higher than KUSL 20004 soybean. EC of KU18 (2006), KU 18 (CF, 2007) sesame and MJ 9520 21 soybean were lower than the previous mentioned seed lots. EC of Morbi and CM 60 soybean at 2 months were higher than those of the lowest 5 peanut seed lots. However, at 4 months storage, the 4 peanut seed lots except Tainan 9 were the lowest in EC but EC values of Kasetsart 50 and Tainan 9 were not differences. KUSL 20004 soybean was the highest in EC followed by CPlus 2 (2006) and CPlus 2 (2007) sesame. CPlus 2 (2006) sesame was not higher in EC than KU18 (2006), KU 18 (2007) and KU 18 (CF, 2007) sesame and MJ 9520 21 and Morbi soybean. EC values of MJ 9518 2 and CM 60 soybean were lower than the previous mentioned seed lots but higher in EC than the five peanut seed lots, while the four peanut seed lots Kaset 1, Kasetsart 50, Khon Kaen 4 and Kalasin 2 were the lowest but not lower than Tainan 9.

For sesame, before storage EC of CPlus 2 (2007) was the highest among the 5 seed lots. At 2 months storage, EC of CPlus 2 (2006) was the highest followed by KU 18 (2007) and CPlus 2 (2007) whereas EC of KU 18 (2006) and KU 18 (CF, 2007) were the lowest among the 5 seed lots. After 4 months storage, EC of CPlus 2 (2006) was higher than KU 18 (2007), KU 18 (CF, 2007) and KU 18 (2006) but not higher than CPlus 2 (2007). For average mean EC of sesame, CPlus 2 (2006) was the highest followed by CPlus 2 (2007) and KU 18 (2007) whereas EC values of KU 18 (2006) and KU 18 (CF, 2007) were the lowest.

In peanut, before storage and at 2 months storage, EC of the 5 peanut seed lots were not different. At 4 months storage, EC of Tainan 9 and Kasetsart 50 were the highest but EC value of Kasetsart 50 was not higher than the other three peanut seed lots: Kaset 1, Khon Kaen 4 and Kalasin 2. In mean EC of peanut, Tainan 9 and Kasetsart 50 were the highest but EC of Kasetsart 50 was not higher than Kaset 1 and Kalasin 2. EC of Khon Kaen 4 was the lowest but it was not lower than Kalasin 2.

In soybean, before storage, EC values of MJ 9518 2 was the highest and EC of Morbi was the lowest but was not lower than CM 60. EC of KUSL 20004 was the second high and was higher than MJ 9520 21 and CM 60. EC of MJ 9520 21 and CM 60 were not different. After 2 months storage, EC of MJ 9518 2 and KUSL 20004 seed lots were the highest followed by MJ 9520 21. EC of Morbi and CM 60 were lower than those of the previous mentioned 3 lots. After 4 months storage, EC of KUSL 20004 was the highest followed by MJ 9520 21 and Morbi. EC of CM 60 and MJ 9518 2 were not different and were the lowest among the 5 soybean lots. In mean EC of soybean, EC of KUSL 20004 was the highest followed by MJ 9518 2, MJ 9520 21, Morbi and CM 60, respectively. EC of CM 60 was the lowest (Table 6).

## **7. Field emergence percentage at 7 days after seeding (DAS)**

Analysis of variance showed that storage durations, seed kinds and seed lots treatments combination significantly influenced FE at 7 DAS (Appendix Table 7). FE at 7 DAS of the 15 seed lots decreased after 4 months storage (Table 7). Before storage, FE at 7 DAS of soybean was the highest and sesame and peanut were not different. After 4 months storage, FE at 7 DAS of sesame, peanut and soybean were not different but were lower than before storage.

At 0 month, the five seed lots of soybean and Kalasin 2 peanut showed the highest FE at 7 DAS but the three lots of soybean: MJ 9518 2, MJ 9520 21 and Morbi and Kalasin 2 peanut were not higher than FE at 7 DAS of the 4 seed lots of sesame except KU 18 (CF, 2007) and Kaset 1 and Khon Kaen 4 peanut. KU 18 (CF,

2007) sesame and Kasetsart 50 and Tainan 9 peanut were the lowest but not different from those of KU 18 (2006), CPlus 2 (2006) and CPlus 2 (2007) sesame and Kaset 1 and Khon Kaen 4 peanut. After 4 months storage, KU 18 (2007) sesame and MJ 9518 2 soybean were the highest FE at 7 DAS, followed by CPlus 2 (2006) and CPlus 2 (2007) sesame and CM 60 soybean. No FE at 7 DAS was found in five seed lots of peanut as well as MJ 9520 21, Morbi and KUSL 20004 soybean. Considering the mean of FE, the five seed lots of soybean, KU 18 (2007) sesame and Kalasin 2 peanut were the highest in FE at 7 DAS. But, FE at 7 DAS of KU 18 (2007) sesame, Kalasin 2 peanut and the three seed lots of soybean: MJ 9518 2, MJ 9520 21 and Morbi were not higher than KU 18 (2006), CPlus 2 (2006) and CPlus 2 (2007) sesame. The three seed lots of sesame: KU 18 (2006), CPlus 2 (2006) and CPlus 2 (2007) were also not higher in FE at 7 DAS than KU 18 (CF, 2007) sesame and the four seed lots of peanuts except Kalasin 2. Thus, the last 5 mentioned seed lots were the lowest in FE at 7 DAS.

For sesame, before storage, FE at 7 DAS of KU 18 (2007) was higher than KU 18 (CF, 2007) but not higher than CPlus 2 (2006), CPlus 2 (2007) and KU 18 (2006). It was also found that CPlus 2 (2006), CPlus 2 (2007), KU 18 (2006) and KU 18 (CF, 2007) were not different in FE at 7 DAS. After 4 months storage, FE at 7 DAS of KU 18 (2007) was the highest, followed by FE at 7 DAS of CPlus 2 (2007) and CPlus 2 (2006) but CPlus 2 (2006) was not higher than KU 18 (2006) and KU 18 (CF, 2007). In mean FE at 7 DAS of sesame, KU 18 (2006), KU 18 (2007), CPlus 2 (2006) and CPlus 2 (2007) were the highest and FE of KU 18 (CF, 2007) was the lowest but not lower than KU 18 (2006), CPlus 2 (2006) and CPlus 2 (2007).

For peanut, before storage, FE at 7 DAS of Kalasin 2 was the highest but not higher than Kaset 1 and Khon Kaen 4. Kalasin 2 was higher than Kasetsart 50 and Tainan 9. However, FE at 7 DAS of Khon Kaen 4, Kaset 1, Kasetsart 50 and Tainan 9 were not different. After 4 months storage, FE of the 5 peanut seed lots were not found at 7 DAS. In mean FE at 7 DAS, Kalasin 2 was the highest followed by Khon Kaen 4, Kaset 1, Kasetsart 50 and Tainan 9 in which the last four lots were not different.

In soybean, before storage, FE at 7 DAS of the 5 soybean lots were not different. After 4 months storage, FE at 7 DAS of MJ 9518 2 was the highest followed by CM 60 while the other 3 seed lots were not germinated. No difference in FE at 7 DAS was found in the overall mean of soybean 5 seed lots (Table 7).

#### **8. Field emergence percentage at 14 days after seeding (14 DAS)**

Analysis of variance showed that storage durations, seed kinds and seed lots-treatments combination affected on FE at 14 DAS (Appendix Table 8). FE at 14 DAS of the 15 seed lots decreased after 4 months storage (Table 8). Before storage, FE at 14 DAS of soybean and peanut were not different. However, FE at 14 DAS of sesame was lower than those of the peanut and soybean. After 4 months storage, FE at 14 DAS of sesame, peanut and soybean were not different (Table 8). For sesame and soybean, after 4 months storage, FE at 14 DAS was lower than before storage. In peanut, before and after 4 months storage, FE at 14 DAS was not different.

At initial, before storage, the three lots of peanut: Kaset 1, Kasetsart 50 and Kalasin 2, the four lots of soybean: MJ 9520 21, Morbi, KUSL 20004 and CM 60 were the highest in FE at 14 DAS followed by the two lots of peanut: Khon Kaen 4 and Tainan 9 and MJ 9518 2 soybean. KU 18 (2007) and CPlus 2 (2006) sesame were lower in FE at 14 DAS than the previous mentioned seed lots. However, FE at 14 DAS of CPlus 2 (2006) sesame was not higher than KU 18 (2006) and CPlus 2 (2007) sesame. KU 18 (CF, 2007) sesame was the lowest in FE at 14 DAS but not lower than KU 18 (2006). After 4 months storage, the three lots of peanut: Kaset 1, Khon Kaen 4 and Kalasin 2 and MJ 9518 2 soybean were the highest in FE at 14 DAS followed by Kasetsart 50 peanut which were not different from that of Khon Kaen 4 peanut. Moreover, FE at 14 DAS of KU 18 (2007) sesame and CM 60 soybean were lower than Kasetsart 50 peanut. FE at 14 DAS of the two lots of sesame: KU 18 (2006) and KU 18 (CF, 2007) as well as Tainan 9 peanut which was zero. The three lots of soybean: MJ 9520 21, Morbi and KUSL 20004 were the lowest.

Mean FE at 14 DAS of the 15 seed lots also showed that Kalasin 2 peanut was the highest but not higher than Kaset 1 peanut and Kaset 1 peanut was also not higher than Khon Kaen 4 and MJ 9518 2 soybean, which were also not higher than CM 60 soybean. FE at 14 DAS of KU 18 (2007) sesame, and the three seed lots of soybean: MJ 9520 21, Morbi and KUSL 20004 were lower than the previous mentioned seed lots and were higher than KU 18 (2006), CPlus 2 (2006) and CPlus 2 (2007) sesame and Tainan 9 peanut. The last 4 mentioned seed lots were not higher than KU 18 (2007), the lowest FE at 14 DAS.

It was also found that before storage, FE at 14 DAS of the 5 sesame seed lots, KU 18 (2007) and CPlus 2 (2006) were the highest but CPlus 2 (2006) was not higher than KU 18 (2006) and CPlus 2 (2007). FE at 14 DAS of KU 18 (CF, 2007) was the lowest but not lower than KU 18 (2006). After 4 months storage, FE at 14 DAS of KU 18 (2007) was the highest and the other 4 sesame lots were not different. In terms of mean FE at 14 DAS of KU 18 (2007) sesame was the highest and no differences were found among the other 4 sesame seed lots.

For peanut, before storage, FE at 14 DAS of Kaset 1, Kasetsart 50 and Kalasin 2 were not different. These 3 peanut seed lots were higher than Khon Kaen 4 and Tainan 9. But Khon Kaen 4 and Tainan 9 were not different. After 4 months storage, FE at 14 DAS of Kaset 1, Khon Kaen 4 and Kalasin 2 were the highest but Khon Kaen 4 was not higher than Kasetsart 50. FE at 14 DAS of Kaset 1 and Khon Kaen 4 were not different. FE at 14 DAS of Tainan 9 was the lowest. In mean FE at 14 DAS, Kaset 1 and Kalasin 2 were the highest followed by Kasetsart 50 and Khon Kaen 4 and Tainan 9 was the lowest. FE percentages at 14 DAS of Kaset 1, Kasetsart 50 and Khon Kaen 4 were not different.

In case of soybean, before storage, FE at 14 DAS of MJ 9520 21, Morbi, KUSL 20004 and CM 60 were not different and were higher than MJ 9518 2 which was the lowest among the 5 soybean lots. At 4 months storage, FE at 14 DAS of MJ 9518 2 was the highest among the 5 soybean seed lots followed by CM 60. FE at 14

DAS of MJ 9520 21, KUSL 20004 and Morbi were the lowest. In mean FE at 14 DAS, MJ 9518 2 and CM 60 were higher than the other 3 seed lots (Table 8).

### **9. Field emergence percentage at 21 days after seeding (DAS)**

The analysis of variance (Appendix Table 9) showed that storage durations and treatments combination were significant in FE at 21 DAS. FE at 21 DAS of the 15 different seed lots decreased after 4 months storage (Table 9). Before storage, FE at 21 DAS of peanut and soybean were not different but higher than sesame. After 4 months storage, FE at 21 DAS of sesame, peanut and soybean were not different. For sesame and peanut, both before and after 4 months storage, FE at 21 DAS were not different but in case of soybean, after 4 months storage, FE at 21 DAS was lower than at 0 month storage.

At 0 month, the three seed lots of peanut: Kaset 1, Kasetsart 50 and Kalasin 2 and the two lots of soybean: Morbi and CM 60 were the highest in FE at 21 DAS. Kaset 1 and Kalasin 2 peanut and Morbi and CM 60 soybean were not higher than the two seed lots of peanut: Khon Kaen 4 and Tainan 9 and the two seed lots of soybean: MJ 9520 21 and KUSL 20004. FE at 21 DAS of Khon Kaen 4 and Tainan 9 peanut were also not higher than MJ 9518 2 soybean. KU 18 (2007) sesame was lower in FE at 21 DAS than the previous mentioned seed lots but higher than the other seed lots of sesame. KU 18 (CF, 2007) and KU 18 (2006) were the lowest, but KU 18 (2006) was not lower than CPlus 2 (2006) and CPlus 2 (2007) in FE at 21 DAS.

For the FE at 21 DAS of the 4 months storage seeds, the three lots of peanut: Kaset 1, Khon Kaen 4 and Kalasin 2 and MJ 9518 2 soybean were the highest but the three lots of peanut were not higher than Kasetsart 50. KU 18 (2007) sesame and CM 60 soybean were lower in FE at 21 DAS than the previous mentioned seed lots but higher than the four lots of sesame: KU 18 (2006), KU 18 (CF, 2007), CPlus 2 (2006) and CPlus 2 (2007), the two seed lots of soybean: MJ 9520 21 and Morbi.

MJ 9520 21 and Morbi soybean were not higher than KUSL 20004 soybean and Tainan 9 peanut. These last four seed lots were the lowest in FE at 21 DAS.

Mean FE at 21 DAS revealed that the three lots of peanut: Kaset 1, Kasetsart 50 and Kalasin 2 were the highest but Kasetsart 50 was not higher than MJ 9518 2 soybean and Khon Kaen 4 peanut. But, FE at 21 DAS of Khon Kaen 4 peanut was not higher than CM 60 soybean. KU 18 (2007) sesame, MJ 9520 21 and Morbi soybean were lower in FE at 21 DAS than the previous mentioned seed lots, but FE at 21 DAS of KU 18 (2007) sesame, MJ 9520 21 were not higher than KUSL 20004 soybean. FE at 21 DAS of KUSL 20004 soybean was not higher than CPlus 2 (2006) sesame and Tainan 9 peanut. These two mentioned seed lots: CPlus 2 (2006) sesame and Tainan 9 peanut were also not higher in FE at 21 DAS than KU 18 (2006), KU 18 (CF, 2007) and CPlus 2 (2007) sesame which were the lowest in FE at 21 DAS.

For sesame, before storage, FE at 21 DAS of KU 18 (2007) was the highest and KU 18 (2006) and KU 18 (CF, 2007) were the lowest, but CPlus 2 (2006) and CPlus 2 (2007) were not higher than KU 18 (2006). After 4 months storage, FE at 21 DAS of KU 18 (2007) was higher than the other 4 seed lots. For mean FE at 21 DAS of sesame, KU 18 (2007) was the highest but not higher than CPlus 2 (2006). Moreover, FE at 21 DAS of CPlus 2 (2006) was not higher than the other three sesame seed lots: KU 18 (2006), KU 18 (CF, 2007) and CPlus 2 (2007).

For peanut, before storage, FE at 21 DAS of Kasetsart 50 was higher than Khon Kaen 4 and Tainan 9. However, Kaset 1, Khon Kaen 4, Tainan 9 and Kalasin 2 were not different in FE at 21 DAS. After 4 months storage, FE at 21 DAS of Kaset 1, Kasetsart 50, Khon Kaen 4 and Kalasin 2 were higher than Tainan 9 which was zero FE. In mean FE at 21 DAS of peanut, Kaset 1, Kasetsart 50 and Kalasin 2 were the highest, but FE at 21 DAS of Kasetsart 50 was not higher than Khon Kaen 4 and Tainan 9 was the lowest.

In soybean, before storage, FE at 21 DAS of MJ 9518 2 was the lowest among the 5 soybean seed lots and there was no difference among the other 4 seed lots. After 4 months storage, FE at 21 DAS of MJ 9518 2 was the highest followed by CM 60 and the other 3 seed lots were the lowest in FE. Mean FE at 21 DAS showed that MJ 9518 2 was the highest followed by CM 60. KUSL 20004 was the lowest but not lower than MJ 9520 21 whereas MJ 9520 21 and Morbi were not different but lower than CM 60.

#### **10. Field emergence percentage at 28 days after seeding (DAS)**

Analysis of variance showed that seed kinds and seed lots treatments combination affected FE at 28 DAS of sesame, peanut, and soybean seed lots after 4 months storage (Appendix Table 10). Statistical analysis showed that FE at 28 DAS of sesame, peanut and soybean were not different (Table 10).

Among the 15 seed lots, FE at 28 DAS of the 4 lots of peanut except Tainan 9 and MJ 9518 2 soybean were the highest followed by KU 18 (2007) sesame and CM 60 soybean. FE at 28 DAS of the 4 lots of sesame except KU 18 (2007) were the third high but KU 18 (2006) and KU 18 (CF, 2007) were not higher than MJ 9518 2, MJ 9520 21 and KUSL 20004 soybeans. FE at 28 DAS of Tainan 9 peanut was the lowest due to the zero germination, but not lower than MJ 9520 21, Morbi and KUSL 20004 soybean.

After 4 months storage, FE at 28 DAS of KU 18 (2007) sesame was higher than the other 4 sesame seed lots. FE at 28 DAS of KU 18 (2006), KU 18 (CF, 2007), CPlus 2 (2006) and CPlus 2 (2007) were not different. For peanut, FE at 28 DAS of Kaset 1, Kasetsart 50, Khon Kaen 4 and Kalasin 2 were not different and were higher than Tainan 9 which did not emerge from the soil surface at 28 DAS. In case of soybean, FE at 28 DAS of MJ 9518 2 was the highest followed by CM 60 and the other 3 seed lots, respectively (Table 10).

## 11. Field emergence index at 21 days after seeding (DAS)

Storage durations and seed kinds and seed lots treatments combination significantly affected FEI at 21 DAS (Appendix Table 11). FEI at 21 DAS of the 15 different seed lots decreased after 4 months storage (Table 11). At 0 month, FEI at 21 DAS of sesame was higher than those of peanut and soybean but peanut and soybean were not different. Same results were also found at 4 months storage.

At 0 month, KU 18 (2007) sesame was the highest in FEI at 21 DAS followed by CPlus 2 (2006) and CPlus 2 (2007), KU 18 (2006) and KU 18 (CF, 2007) sesame and the 5 seed lots of peanut and soybean, respectively. Similar results were also found at 4 months after storage. The highest FEI at 21 DAS was KU 18 (2007) sesame followed by the three lots of sesame: KU 18 (CF, 2007), CPlus 2 (2006) and CPlus 2 (2007), and KU 18 (2006) sesame, respectively. Peanut and soybean were lower than those previous mentioned sesame seed lots in FEI at 21 DAS. However, FEI at 21 DAS of the four lots of peanut: Kaset 1, Kasetsart 50, Khon Kaen 4 and Kalasin 2 as well as FEI at 21 DAS of MJ 9518 2 and CM 60 soybeans were higher than Tainan 9 peanut and the other three lots of soybean, but FEI at 21 DAS of CM 60 soybean was not higher than Tainan 9 peanut and the three lots of soybean: MJ 9520 21, Morbi and KUSL 20004 soybean.

Mean at FEI at 21 DAS also showed the similar trend. FEI at 21 DAS of KU 18 (2007) sesame was the highest followed by CPlus 2 (2006) and CPlus 2 (2007), KU 18 (2006) and KU 18 (CF, 2007) sesame, respectively. Peanut and soybean were lower in FEI at 21 DAS than sesame in which Tainan 9 peanut was the lowest, but not lower than Khon Kaen 4 peanut and the three lots of soybean: MJ 9520 21, Morbi and KUSL 20004. Before and after 4 months storage, FEI at 21 DAS of sesame was the highest (Table 11). FEI at 21 DAS of sesame and peanut were not different. However, in case of soybean, after 4 months storage, FEI at 21 DAS decreased with increasing time.

For sesame, before storage, FEI at 21DAS of KU 18 (2007) was the highest and KU 18 (2006) and KU 18 (CF, 2007) were the lowest. FEI at 21DAS of CPlus 2 (2006) and CPlus 2 (2007) were not different but higher than KU 18 (2006) and KU 18 (CF, 2007). After 4 months storage, KU 18 (2007) was still the highest followed by KU 18 (CF, 2007), CPlus 2 (2006) and CPlus 2 (2007) and KU 18 (2006) was the lowest. In mean FEI at 21DAS of sesame showed that KU 18 (2007) was the highest and KU 18 (2006) and KU 18 (CF, 2007) were the lowest and CPlus 2 (2007) and CPlus 2 (2006) were higher than KU 18 (CF, 2007).

In peanut, before storage, FEI at 21 DAS of the 5 peanut seed lots were not different. However, after 4 months storage, FEI at 21 DAS of Kaset 1, Kalasin 2, Khon Kaen 4 and Kasetsart 50 were not different. However, FEI at 21 DAS of Tainan 9 was zero. In mean FEI at 21 DAS of the 5 peanut lots: Kaset 1, Kasetsart 50 and Kalasin 2 were higher than Tainan 9 but FEI at 21 DAS of Khon Kaen 4 was not higher than Tainan 9.

For soybean, before storage, FEI at 21 DAS of the 5 soybean seed lots were not different. After 4 months storage, FEI at 21 DAS of MJ 9518 2 was higher than MJ 9520 21, Morbi and KUSL 20004 but not higher than CM 60. CM 60 was not higher than MJ 9520 21, Morbi and KUSL 20004. In case of mean FEI at 21 DAS, the 5 soybean lots were not different (Table 11).

## **12. Field emergence index at 28 days after seeding (DAS)**

ANOVA indicated that treatments combination significantly influenced FEI at 28 DAS of 15 seed lots of sesame, peanut and soybean after 4 months storage (Appendix Table 12). FEI at 28 DAS of sesame was the highest and peanut and soybean were not different (Table 10).

In Table 10, FEI at 28 DAS of KU 18 (2007) sesame was the highest followed by the three seed lots of sesame: KU 18 (CF, 2007), CPlus 2 (2006) and CPlus 2 (2007). These 3 previous mentioned seed lots were higher than KU 18 (2006) and

also higher than Kaset 1, Kasetsart 50, Khon Kaen 4 and Tainan 9 peanut and MJ 9518 2 and CM 60 soybean. FEI at 28 DAS of MJ 9520 21, Morbi and KUSL 20004 soybean were the lowest but not lower than CM 60 soybean.

In case of sesame, after 4 months storage, FEI at 28 DAS of the 5 sesame seed lots, KU 18 (2007) was the highest and higher than KU 18 (CF, 2007), CPlus 2 (2006) and CPlus 2 (2007). FEI at 28 DAS of KU 18 (2006) was the lowest. KU 18 (CF, 2007), CPlus 2 (2006) and CPlus 2 (2007) were not different. For peanut, after 4 months storage, FEI at 28 DAS of Kaset 1, Kasetsart 50, Khon Kaen 4 and Kalasin 2 were not different and higher than Tainan 9. In soybean, after 4 months storage, FEI at 28 DAS of the 5 soybean seed lots were different. FEI at 28 DAS of MJ 9518 2 and CM 60 were the highest, but CM 60 was not higher than MJ 9520 21, Morbi and KUSL 20004 (Table 10).

### **13. Effect of storage on yield of oil crops seed**

Analysis of Variance of the three oil crop yield planted from seed lots of initial before storage and 4 months storage period and seed kinds and seed lots (treatment combination) were highly significant (Appendix Table 13). Yield of the oil crop planted from different 15 seed lots after 4 months storage were lower than those planted from 0 month storage seed lots (Table 12). Yields of sesame, peanut and soybean decreased when planted from 4 months storage seed lots (Table 12). Before storage, yield of peanut and soybean were not different but sesame was lower than those of peanut and soybean. After 4 months storage, yield of peanut was the highest and sesame and soybean were not different.

Grain (seed) yields of sesame, peanut and soybean planted from initial storage seed lots showed out that the four lots of soybean except Morbi gave the highest yield as well as Kalasin 2 peanut but yields of MJ 9520 21, KUSL 20004 and CM 60 soybean and Kalasin 2 peanut were not higher than Morbi soybean and the three lots of peanut: Kasetsart 50, Khon Kaen 4 and Tainan 9. Seed or grain yield of sesame planted from the three seed lots of sesame: KU 18 (CF, 2007), CPlus 2 (2006) and

CPlus 2 (2007) were the lowest but not lower than those planted from KU 18 (2006) and KU 18 (2007).

Grain yields of these three oil crops that planted from 4 months storages seed lots were different from initial before storage seed lots. Khon Kaen 4 peanut had the highest yield followed by Kalasin 2 and Kaset 1. Kaset 1 was not higher than Kasetsart 50 peanut and MJ 9518 2 soybean. CM 60 soybean was the forth high yield. Yields planted from the 3 seed lots of sesame: KU 18 (2006), KU 18 (2007) and KU 18 (CF, 2007) were not higher than CPlus 2 (2006) and CPlus 2 (2007) sesame and MJ 9520 21, Morbi and KUSL 20004 soybean, while Tainan 9 had no grain yield because of zero germination.

Mean yields of sesame, peanut and soybean planted from 0 and 4 months storage seeds showed that yield of Khon Kaen 4 peanut was the highest followed by MJ 9518 2 soybean. The third group of high yield was Kaset 1 and Kasetsart 50 peanut, and the 3 lots of soybean: MJ 9520 21, KUSL 20004 and CM 60. Yields of Kaset 1 peanut and MJ 9520 21 and KUSL 20004 soybeans were not higher than Tainan 9 peanut and Morbi soybean. The four sesame seed lots except KU 18 (2006) gave the lowest seed yield, even though seed and grain yield planted from KU 18 (2007) and KU 18 (CF, 2007) sesame were not lower than KU 18 (2006) and Tainan 9 peanut.

Before storage, sesame yields planted from the 5 seed lots were not different. After 4 months storage, yields planted from the 5 sesame lots were also not different. However, the average mean yield of KU 18 (2006) was higher than those planted from CPlus 2 (2006) and CPlus 2 (2007) but not higher than those that planted from KU 18 (2007) and KU 18 (CF, 2007).

In peanut, before storage, peanut yield from Kalasin 2 was the highest but not higher than Kasetsart 50, Khon Kaen 4 and Tainan 9. But Khon Kaen 4 was higher than Kaset 1, while Kaset 1, Kasetsart 50 and Tainan 9 were not different in seed yields. After 4 months storage, yield planted from Khon Kaen 4 was the highest

followed by Kalasin 2 and Kaset 1 but yield of Kaset 1 was not higher than Kasetsart 50. However, Tainan 9 did not give any seed yield. In mean yields of peanut, Khon Kaen 4 was the highest and Tainan 9 was the lowest but not lower than Kaset 1.

In soybean, before storage, MJ 9518 2 seed yield was the highest but not higher than yields planted from MJ 9520 21, KUSL 20004 and CM 60 and these three mentioned lots grain yield were not higher than Morbi. After 4 months storage, among the 5 different lots of soybean, MJ 9518 2 gave the highest yield followed by CM 60. Yield of MJ 9520 21, Morbi and KUSL 20004 were the lowest. In mean yields of soybean, yield of the MJ 9518 2 was the highest followed by soybean planted from MJ 9520 21, KUSL 20004 and CM 60 and yield planted from Morbi was the lowest but not lower than MJ 9520 21 and KUSL 20004 (Table 12).

#### **14. Influence of different seed kinds and seed lots on germination and seed vigor of oil crops**

Differences of seed kinds and seed lots of sesame, peanut and soybean were compared within seed kind and different seed kinds (Table 13). The statistical analysis showed that SG, GI, AA of the 5 sesame seed lots: KU 18 (2006), KU 18 (2007), CPlus 2 (2006), CPlus 2 (2007) and KU 18 (CF, 2007) were not different, however, EC, FE and FEI at 21 DAS of KU 18 (2006), KU 18 (2007), CPlus 2 (2006), CPlus 2 (2007) were highly significant different than KU 18 (CF, 2007).

Moreover, it was also found that GI and EC of the 5 peanut seed lots were not significantly different. However, SG and FEI at 21 DAS were significantly different at  $P < 0.05$  and AA and FE at 21 DAS were highly significant difference at  $P < 0.01$ . SG, seed vigor as measured by AA, EC, GI, FE and FEI at 21 DAS of KU 18 (CF, 2007) sesame and Tainan 9 and Khon Kaen 4 peanut seed lots were highly significant differences.

Statistical analysis also showed that SG, GI, EC, FE and FEI at 21 DAS of KU 18 (2006), KU 18 (2007), CPlus 2 (2006), CPlus 2 (2007) sesame and Kaset 1,

Kasetsart 50 and Kalasin 2 peanut were highly significant difference whereas AA was not significantly different.

Seed vigor which determined by AA, EC, GI, FE and FEI at 21 DAS of sesame and soybean were highly significant different at  $P < 0.01$ , although SG was not different.

The results of statistical analysis showed that, SG and seed vigor as measured by AA, EC, GI, FE and FEI at 21 DAS were highly significant difference at  $P < 0.01$  while comparing among different seed lots of Kaset 1, Kasetsart 50, Kalasin 2 of peanut and MJ 9518 2, MJ 9520 21, Morbi, KUSL 20004, CM 60 of soybean (Table 13).

#### **15. Effect of ambient storage duration and treatment combination (seed kind and seed lots) on seed germination, seed vigor and grain (seed) yield**

Summary results in Table 14 revealed that seed moisture contents of the 15 seed lots changed during storage. Changes in seed moisture content were different among seed kind, initial seed lots and types of container or packages. Seed moisture contents after storage were lower than before storage. For germination, initial germination of 15 different seed lots were higher than after 2 and 4 months storage and germination percentages were not difference among these 15 seed lots after 2 and 4 months storage. Result of seed vigor as determined by first count germination indicated that at initial, first count germinations of 15 different seed lots were higher than after 2 and 4 months storage, as well first count germination after 2 months storage was higher than after 4 months storages. Delayed germinations were found during the period of 4 months storage. It was one of the early noticeable symptoms of seed deterioration.

Seed vigor that measured by GI which means germination rate changed during storage periods for 4 months. Initial GI of 15 different seed lots of sesame, peanut and soybean were higher than after 2 and 4 months storage. However, after 2 and 4

months storage, GI of 15 different seed lots were not different. Seed vigor of the three seed kinds decreased after 2 and 4 months storage.

Seed vigor as determined by AA decreased with increasing storage periods. Initial AA of 15 different seed lots was higher than after 2 months storage and at 2 months storage was also higher than at 4 months storage. AA of 15 different seed lots indicated the decreasing of seed vigor. In case of EC, the other vigor determination revealed that at 0 month and after 4 months storage, EC of 15 different seed lots were not different. However, after 2 months storage, EC value was higher than initial and 4 months storage. The higher of EC at 2 months storage was possibly caused by the low moisture content of the seed lots.

FE and FEI of 15 different seed lots of sesame, peanut and soybean decreased after 4 months storage. Decreasing in FE and FEI were due to the decreasing in seed quality during storage. In case of yield, seed (grain) yield of those three seed kinds oil crops planted from 15 different seed lots of 4 months storage seeds were lower than that planted from initial, before storage. These phenomena revealed that storage duration and seed quality of the 15 seed lots of sesame, peanut and soybean influenced crop yields.

**Table 1** Moisture contents of five seed lots of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.

Seed kinds and seed lots (B)		Storage durations (A)			Mean
		0 month	2 months	4 months	
Sesame					
1	KU 18 (2006)	6.10 cd	5.45 b	5.09 c	5.55 de
2	KU 18 (2007)	6.30 cd	5.33 bc	5.29 c	5.64 d
3	KU 18 (CF, 2007)	6.37 cd	5.30 bc	5.29 c	5.65 d
4	CPlus 2 (2006)	5.57 e	4.75 cd	5.06 c	5.13 f
5	CPlus 2 (2007)	5.92 de	5.05 cd	5.22 c	5.40 e
Mean		A 6.05 B	B 5.18 B	B 5.19 B	
Peanut					
1	Kaset 1	5.44 e	4.92 cd	4.50 d	4.95 fg
2	Kasetsart 50	6.13 d	4.64 d	4.66 d	5.14 f
3	Khon Kaen 4	5.54 e	4.68 d	4.47 d	4.90 g
4	Tainan 9	5.97 de	5.37 bc	4.99 c	5.44 de
5	Kalasin 2	5.20 e	4.78 cd	4.57 d	4.85 g
Mean		A 5.66 B	B 4.88 B	B 4.64 C	
Soybean					
1	MJ 9518 2	10.56 b	7.49 a	9.04 b	9.03 b
2	MJ 9520 21	10.66 ab	7.87 a	9.17 ab	9.23 ab
3	Morbi	11.05 a	7.97 a	9.41 a	9.48 a
4	KUSL 20004	10.63 ab	7.64 a	9.29 ab	9.19 ab
5	CM 60	9.95 c	7.78 a	8.87 b	8.87 b
Mean		A 10.57 A	C 7.75 A	B 9.16 A	
<b>Grand Mean</b>		<b>D 7.43</b>	<b>F 5.93</b>	<b>E 6.33</b>	
LSD 5%		0.48	0.34	0.33	0.22
C.V. (%)		4.50	4.10	3.70	4.22

Means within each column of 15 different lots followed by the same small letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each row preceded by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each column followed by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

(A)= Storage durations

(B)= Seed kinds and seed lots

**Table 2** Germination (%) of five seed lot of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.

Seed kinds and seed lots (B)		Storage durations (A)			Mean
		0 month	2 months	4 months	
<b>Sesame</b>					
1	KU 18 (2006)	73.00 b	80.00 ab	70.00 bc	74.33 bc
2	KU 18 (2007)	89.00 ab	93.00 a	93.00 a	91.67 a
3	KU 18 (CF, 2007)	84.00 ab	64.00 bc	62.00 c	70.00 cd
4	CPlus 2 (2006)	47.00 c	68.00 bc	59.00 c	58.00 de
5	CPlus 2 (2007)	74.00 b	76.00 b	70.00 bc	73.33 c
Mean		A 73.44 AB	A 76.20 A	A 70.80 A	
<b>Peanut</b>					
1	Kaset 1	87.00 ab	67.50 bc	87.50 ab	80.67 bc
2	Kasetsart 50	84.50 ab	46.00 c	75.00 bc	68.50 cd
3	Khon Kaen 4	75.59 b	70.00 b	85.50 ab	77.00 bc
4	Tainan 9	39.50 c	56.00 c	30.50 d	42.00 f
5	Kalasin 2	36.50 c	28.00 d	78.00 b	47.50 ef
Mean		A 64.60 B	A 53.50 A	A 71.30 A	
<b>Soybean</b>					
1	MJ 9518 2	96.50 a	28.00 d	93.50 a	72.67 c
2	MJ 9520 21	86.00 ab	52.00 c	24.50 d	54.17 e
3	Morbi	93.00 a	86.00 ab	65.00 bc	81.33 bc
4	KUSL 20004	88.50 ab	74.00 b	27.00 d	63.17 d
5	CM 60	95.00 a	83.00 ab	84.50 ab	87.50 ab
Mean		AB91.80 A	B 64.60 A	B 58.90 A	
<b>Grand Mean</b>		<b>D 76.60</b>	<b>E 64.77</b>	<b>E 67.00</b>	
LSD 5%		14.74	13.49	13.00	7.82
C.V. (%)		13.50	14.60	13.60	13.94

Means within each column of 15 different lots followed by the same small letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each row preceded by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each column followed by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

(A)= Storage durations

(B)= Seed kinds and seed lots

**Table 3** First count germination (%) of five seed lots of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.

Seed kinds and seed lots (B)		Storage durations (A)			Mean
		0 month	2 months	4 months	
<b>Sesame</b>					
1	KU 18 (2006)	69.00 b	76.00 b	17.00 c	54.00 c
2	KU 18 (2007)	89.00 a	92.00 a	60.00 ab	80.33 a
3	KU 18 (CF, 2007)	84.00 ab	62.00 bc	38.00 bc	61.33 bc
4	CPlus 2 (2006)	39.00 c	61.00 bc	39.00 bc	46.33 cd
5	CPlus 2 (2007)	74.00 b	68.00 bc	57.00 b	66.33 b
Mean		A 71.00 A	A 71.80 A	B 42.20 A	
<b>Peanut</b>					
1	Kaset 1	40.00 c	54.00 c	28.00 c	40.67 d
2	Kasetsart 50	40.00 c	21.00 e	13.00 c	24.67 e
3	Khon Kaen 4	41.00 c	36.50 de	50.50 bc	42.67 d
4	Tainan 9	6.50 e	37.00 d	8.00 c	17.17 e
5	Kalasin 2	21.50 d	18.50 e	42.00 bc	27.33 e
Mean		A 29.80 B	A 33.40 B	A 28.30 A	
<b>Soybean</b>					
1	MJ 9518 2	96.50 a	24.00 de	85.00 a	68.50 b
2	MJ 9520 21	86.00 ab	38.00 d	12.50 c	45.50 cd
3	Morbi	93.00 a	61.00 bc	41.50 bc	65.17 bc
4	KUSL 20004	84.50 ab	62.50 bc	18.50 c	55.17 c
5	CM 60	95.00 a	75.00 b	72.50 ab	80.83 a
Mean		A 91.80 A	B 52.10 AB	B 46.00 A	
<b>Grand Mean</b>		<b>D 63.93</b>	<b>E 52.43</b>	<b>F 38.83</b>	
LSD 5%		14.77	15.90	26.22	11.11
C.V. (%)		16.20	21.30	47.30	26.59

Means within each column of 15 different lots followed by the same small letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each row preceded by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each column followed by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

(A)= Storage durations

(B)= Seed kinds and seed lots

**Table 4** Germination index of five seed lots of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.

Seed kinds and seed lots (B)		Storage durations (A)				Mean
		0 month	2 months	4 months		
Sesame						
1	KU 18 (2006)	33.25 b	26.23 bc	18.75 bc		26.08 c
2	KU 18 (2007)	43.50 a	36.40 a	31.00 a		36.97 a
3	KU 18 (CF, 2007)	42.00 ab	24.03 c	19.25 bc		28.43 bc
4	CPlus 2 (2006)	20.75 c	26.98 bc	19.50 bc		22.41 d
5	CPlus 2 (2007)	36.75 ab	29.28 b	27.50 ab		31.18 b
	Mean	A 35.25 A	A 28.58 A	B 23.20 A		
Peanut						
1	Kaset 1	16.75 c	13.77 e	14.75 c		15.09 e
2	Kasetsart 50	15.50 cd	7.89 f	11.75 cd		11.71 f
3	Khon Kaen 4	18.50 c	13.45 e	15.75 bc		15.90 e
4	Tainan 9	6.50 d	10.77 ef	4.75 d		7.34 g
5	Kalasin 2	8.75 d	6.21 f	14.50 c		9.82 fg
	Mean	A 13.20 B	A 10.42 B	A 12.30 B		
Soybean						
1	MJ 9518 2	31.50 b	6.87 f	21.75 b		20.04 d
2	MJ 9520 21	28.25 b	10.18 ef	4.75 d		14.39 ef
3	Morbi	30.75 b	16.87 de	13.75 c		20.46 d
4	KUSL 20004	27.50 bc	16.92 de	5.25 d		16.56 e
5	CM 60	30.25 b	18.04 d	18.75 bc		22.35 d
	Mean	A 29.65 A	B 13.78 B	B 12.85 B		
	<b>Grand Mean</b>	<b>D 26.03</b>	<b>E 17.59</b>	<b>E 16.12</b>		
	LSD 5%	6.92	3.77	6.69		3.39
	C.V. (%)	18.60	15.10	29.10		21.90

Means within each column of 15 different lots followed by the same small letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each row preceded by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each column followed by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

(A)= Storage durations

(B)= Seed kinds and seed lots

**Table 5** Germination (%) after accelerated aging of five seed lots of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.

Seed kinds and seed lots (B)		Storage durations (A)			Mean
		0 month	2 months	4 months	
<b>Sesame</b>					
1	KU 18 (2006)	56.00 c	87.00 a	82.00 b	75.00 c
2	KU 18 (2007)	97.00 a	95.00 a	97.00 a	96.33 a
3	KU 18 (CF, 2007)	87.00 ab	73.00 bc	76.00 bc	78.67 b
4	CPlus 2 (2006)	44.00 cd	49.00 d	67.00 c	53.33 e
5	CPlus 2 (2007)	72.00 bc	77.00 b	78.00 bc	73.67 c
	Mean	A 71.20 A	A 76.20 A	A 80.00 A	
<b>Peanut</b>					
1	Kaset 1	75.00 bc	67.50 c	69.00 c	70.50 d
2	Kasetsart 50	83.50 ab	73.50 bc	75.50 bc	77.50 bc
3	Khon Kaen 4	76.50 b	69.50 bc	76.00 bc	74.00 c
4	Tainan 9	21.50 d	61.00 c	23.50 d	35.33 f
5	Kalasin 2	89.50 ab	67.50 c	84.00 b	80.33 b
	Mean	A 69.20 A	A 67.80 A	A 65.60 A	
<b>Soybean</b>					
1	MJ 9518 2	73.50 bc	0.00 e	0.50 e	24.67 g
2	MJ 9520 21	41.50 cd	0.00 e	0.00 e	13.83 h
3	Morbi	35.00 d	0.00 e	0.00 e	11.67 h
4	KUSL 20004	37.00 cd	0.00 e	0.00 e	12.33 h
5	CM 60	64.00 bc	0.00 e	6.00 e	23.33 g
	Mean	A 50.20 A	B 0.00 B	B 1.30 B	
	<b>Grand Mean</b>	<b>D 63.54</b>	<b>E 48.00</b>	<b>F 1.30</b>	
	LSD 5%	19.20	8.89	9.38	7.55
	C.V. (%)	21.20	13.00	13.40	17.50

Means within each column of 15 different lots followed by the same small letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each row preceded by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each column followed by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

(A)= Storage durations

(B)= Seed kinds and seed lots

**Table 6** Electrical conductivity ( $\mu\text{S cm}^{-1}\text{g}^{-1}$ ) of five seed lots of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.

Seed kinds and seed lots (B)		Storage durations (A)			Mean
		0 month	2 months	4 months	
<b>Sesame</b>					
1	KU 18 (2006)	421.00 c	477.23 d	376.74 c	424.99 f
2	KU 18 (2007)	471.50 bc	605.21 b	408.78 c	495.16 d
3	KU 18 (CF, 2007)	435.50 c	463.05 d	396.55 c	431.70 f
4	CPlus 2 (2006)	483.25 bc	701.19 a	472.55 b	552.33 a
5	CPlus 2 (2007)	579.75 a	619.79 b	421.39 bc	540.31 b
Mean		B 478.20 A	A 573.29 A	B 415.20 A	
<b>Peanut</b>					
1	Kaset 1	50.10 f	51.59 f	40.29 f	47.33 k
2	Kasetsart 50	43.83 f	64.73 f	57.25 ef	55.27 jk
3	Khon Kaen 4	24.98 f	41.86 f	35.41 f	34.08 l
4	Tainan 9	49.28 f	37.73 f	102.18 e	63.06 j
5	Kalasin 2	23.43 f	70.68 f	38.24 f	44.12 kl
Mean		A 38.32 C	A 53.32 C	A 54.67 B	
<b>Soybean</b>					
1	MJ 9518 2	492.15 b	561.84 bc	302.61 d	452.20 e
2	MJ 9520 21	350.63 d	457.18 d	416.51 c	408.11 g
3	Morbi	296.33 e	381.59 e	377.33 c	351.75 h
4	KUSL 20004	416.23 c	544.01 c	579.92 a	513.39 c
5	CM 60	313.63 de	354.98 e	308.37 d	325.66 i
Mean		A 373.79 B	A 459.92 B	A 396.95 A	
<b>Grand Mean</b>		<b>E 296.77</b>	<b>D 362.18</b>	<b>E 288.94</b>	
LSD		52.43	59.36	54.74	30.96
C.V. (%)		12.40	11.50	13.30	18.30

Means within each column of 15 different lots followed by the same small letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each row preceded by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each column followed by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

(A)= Storage durations

(B)= Seed kinds and seed lots

**Table 7** Field emergence percentage at 7 DAS of five seed lots of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.

Seed kinds and seed lots (B)		Storage durations (A)		Mean
		0 month	4 months	
<b>Sesame</b>				
1	KU 18 (2006)	15.75 bc	1.30 c	8.52 bc
2	KU 18 (2007)	24.50 b	9.36 a	16.93 ab
3	KU 18 (CF, 2007)	13.00 c	1.01 c	7.01 c
4	CPlus 2 (2006)	21.75 bc	3.52 bc	12.64 bc
5	CPlus 2 (2007)	16.25 bc	4.78 b	10.52 bc
	Mean	A 18.25 B	B 3.99 A	
<b>Peanut</b>				
1	Kaset 1	15.67 bc	0.00 c	7.84 c
2	Kasetsart 50	12.59 c	0.00 c	6.30 c
3	Khon Kaen 4	15.85 bc	0.00 c	7.93 c
4	Tainan 9	7.79 c	0.00 c	3.89 c
5	Kalasin 2	32.52 ab	0.00 c	16.26 ab
	Mean	A 15.79 B	B 0.00 A	
<b>Soybean</b>				
1	MJ 9518 2	27.63 ab	8.06 a	17.84 ab
2	MJ 9520 21	31.61 ab	0.00 c	15.81 ab
3	Morbi	26.99 ab	0.00 c	13.50 ab
4	KUSL 20004	36.68 a	0.00 c	18.34 a
5	CM 60	35.05 a	1.90 bc	18.48 a
	Mean	A 31.59 A	B 1.99 A	
	<b>Grand Mean</b>	<b>C 22.24</b>	<b>D 1.99</b>	
	LSD 5%	10.44	2.92	5.34
	C.V. (%)	32.90	100.20	44.40

Means within each column of 15 different lots followed by the same small letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each row preceded by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each column followed by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

(A)= Storage durations

(B)= Seed kinds and seed lots

**Table 8** Field emergence percentage at 14 DAS of five seed lots of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.

Seed kinds and seed lots (B)		Storage durations (A)		Mean
		0 month	4 months	
<b>Sesame</b>				
1	KU 18 (2006)	22.25 de	15.91 de	19.08 ef
2	KU 18 (2007)	37.75 c	37.74 c	37.75 d
3	KU 18 (CF, 2007)	16.25 e	19.32 de	17.78 f
4	CPlus 2 (2006)	29.00 cd	22.66 d	25.83 ef
5	CPlus 2 (2007)	27.00 d	23.69 d	25.34 ef
Mean		A 26.45 B	B 23.86 A	
<b>Peanut</b>				
1	Kaset 1	66.84 a	72.83 a	69.83 ab
2	Kasetsart 50	71.37 a	58.15 b	67.76 b
3	Khon Kaen 4	53.62 b	62.50 ab	58.06 bc
4	Tainan 9	51.99 b	0.00 e	25.99 ef
5	Kalasin 2	74.36 a	71.02 a	72.69 a
Mean		A 63.64 A	A 52.90 A	
<b>Soybean</b>				
1	MJ 9518 2	53.62 b	71.74 a	62.68 bc
2	MJ 9520 21	67.75 a	0.36 e	34.06 d
3	Morbi	71.46 a	9.15 e	40.30 d
4	KUSL 20004	66.57 a	0.18 e	33.38 d
5	CM 60	71.56 a	39.13 c	55.34 c
Mean		A 66.19 A	B 24.11 A	
<b>Grand Mean</b>		<b>C 52.09</b>	<b>D 33.62</b>	
LSD 5%		10.33	10.58	7.35
C.V. (%)		13.90	22.00	17.26

Means within each column of 15 different lots followed by the same small letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each row preceded by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each column followed by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

(A)= Storage durations

(B)= Seed kinds and seed lots

**Table 9** Field emergence percentage at 21 DAS of five seed lot of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.

Seed kinds and seed lots (B)		Storage durations (A)				
		0 month		4 months		Mean
<b>Sesame</b>						
1	KU 18 (2006)		24.25 ef		18.56 f	21.41 f
2	KU 18 (2007)		41.25 d		40.68 c	40.96 de
3	KU 18 (CF, 2007)		17.25 f		20.65 def	18.95 f
4	CPlus 2 (2006)		30.25 e		24.82 def	27.54 ef
5	CPlus 2 (2007)		27.50 e		24.84 def	26.17 f
	Mean	A	28.10 B	A	25.91 A	
<b>Peanut</b>						
1	Kaset 1		73.46 ab		77.72 ab	75.59 a
2	Kasetsart 50		81.52 a		66.03 b	73.78 ab
3	Khon Kaen 4		63.13 bc		70.75 ab	66.94 bc
4	Tainan 9		61.32 bc		0.00 g	30.66 ef
5	Kalasin 2		78.44 ab		73.19 ab	75.81 a
	Mean	A	71.57 A	A	57.54 A	
<b>Soybean</b>						
1	MJ 9518 2		54.89 c		79.62 a	67.26 b
2	MJ 9520 21		71.01 b		1.58 fg	36.29 de
3	Morbi		73.91 ab		12.50 fg	43.20 d
4	KUSL 20004		69.65 b		0.54 g	35.10 e
5	CM 60		75.99 ab		42.57 c	59.28 c
	Mean	A	69.09 A	B	27.36 A	
	<b>Grand Mean</b>	<b>C</b>	<b>56.25</b>	<b>D</b>	<b>36.94</b>	
	LSD 5%		10.35		11.74	7.88
	C.V. (%)		12.90		22.10	17.03

Means within each column of 15 different lots followed by the same small letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each row preceded by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each column followed by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

(A)= Storage durations

(B)= Seed kinds and seed lots

**Table 10** Field emergence percentage and FEI at 28 DAS of five seed lots of sesame, peanut and soybean stored under ambient condition after 4 months.

Seed kinds and seed lots (B)		Storage at 4 months (A)	
		FE (%)	FEI
Sesame			
1	KU 18 (2006)	18.88 cd	29.01 c
2	KU 18 (2007)	40.94 b	92.69 a
3	KU 18 (CF, 2007)	20.88 cd	38.60 b
4	CPlus 2 (2006)	24.87 c	40.76 b
5	CPlus 2 (2007)	24.82 c	44.81 b
Mean		26.08 A	49.17 A
Peanut			
1	Kaset 1	78.99 a	15.13 d
2	Kasetsart 50	67.48 a	12.65 d
3	Khon Kaen 4	72.56 a	13.59 d
4	Tainan 9	0.00 e	0.00 e
5	Kalasin 2	74.37 a	14.40 d
Mean		58.68 A	11.15 B
Soybean			
1	MJ 9518 2	79.62 a	16.77 d
2	MJ 9520 21	1.58 de	0.27 e
3	Morbi	12.50 de	2.24 e
4	KUSL 20004	0.54 de	0.08 e
5	CM 60	42.57 b	9.49 de
Mean		27.36 A	5.77 B
<b>Grand Mean</b>		<b>37.37</b>	<b>22.03</b>
LSD		12.15	9.31
C.V. (%)		22.80	29.60

Means within each column of 15 different lots followed by the same small letter or letters are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each column followed by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

(A)= Storage durations

(B)= Seed kinds and seed lots

**Table 11** Field emergence index at 21 DAS of five seed lots of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.

Seed kinds and seed lots (B)		Storage durations (A)		Mean
		0 month	4 months	
<b>Sesame</b>				
1	KU 18 (2006)	59.77 c	28.92 c	44.34 c
2	KU 18 (2007)	116.90 a	92.44 a	104.67 a
3	KU 18 (CF, 2007)	55.22 c	38.39 b	46.81 c
4	CPlus 2 (2006)	76.80 b	41.20 b	58.70 b
5	CPlus 2 (2007)	73.87 b	44.62 b	59.25 b
Mean		A 76.51 A	A 49.11 A	
<b>Peanut</b>				
1	Kaset 1	17.14 d	15.00 d	16.07 d
2	Kasetsart 50	17.88 d	12.50 d	15.19 d
3	Khon Kaen 4	14.90 d	13.41 d	14.15 de
4	Tainan 9	13.24 d	0.00 e	6.62 e
5	Kalasin 2	21.61 d	14.28 d	17.95 d
Mean		A 16.95 B	A 11.04 B	
<b>Soybean</b>				
1	MJ 9518 2	16.19 d	16.77 d	16.48 d
2	MJ 9520 21	19.95 d	0.27 e	10.11 de
3	Morbi	19.73 d	2.24 e	10.99 de
4	KUSL 20004	20.75 d	0.08 e	10.41 de
5	CM 60	23.60 d	9.49 de	16.55 d
Mean		A 20.04 B	B 5.77 B	
<b>Grand Mean</b>		<b>C 36.52</b>	<b>D 21.97</b>	
LSD 5%		14.33	9.33	8.05
C.V. (%)		25.90	29.80	26.90

Means within each column of 15 different lots followed by the same small letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each row preceded by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each column followed by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

(A)= Storage durations

(B)= Seed kinds and seed lots

**Table 12** Yield (Kg/ha) of sesame, peanut and soybean planted from different five seed lots of sesame, peanut and soybean before and after 4 months storage under ambient condition.

Seed kinds and seed lots (B)		Storage durations (A)		Mean
		0 month	4 months	
<b>Sesame</b>				
1	KU 18 (2006)	1164.79 cd	483.34 de	824.07 e
2	KU 18 (2007)	1140.75 cd	420.84 de	780.79 ef
3	KU 18 (CF, 2007)	1007.50 d	370.84 de	689.18 ef
4	CPlus 2 (2006)	664.17 d	162.50 e	413.33 f
5	CPlus 2 (2007)	627.92 d	179.17 e	403.54 f
Mean		A 921.03	B 323.34	B
<b>Peanut</b>				
1	Kaset 1	1769.17 c	1483.35 bc	1626.26 cd
2	Kasetsart 50	2087.92 bc	1308.10 c	1698.01 c
3	Khon Kaen 4	2466.67 b	3150.04 a	2808.36 a
4	Tainan 9	2437.17 bc	0.00 e	1217.08 de
5	Kalasin 2	2978.75 ab	1766.69 b	2372.72 b
Mean		A 2349.49	A 1541.64	B
<b>Soybean</b>				
1	MJ 9518 2	3461.25 a	1220.85 c	2341.05 b
2	MJ 9520 21	2923.75 ab	55.00 e	1489.38 cd
3	Morbi	2368.33 bc	112.50 e	1240.42 d
4	KUSL 20004	3016.67 ab	29.17 e	1522.92 cd
5	CM 60	2971.67 ab	737.51 d	1854.59 c
Mean		A 2948.33	A 431.01	B
<b>Grand Mean</b>		<b>C 2072.23</b>	<b>D 765.33</b>	
LSD 5%		671.47	436.86	394.68
C.V. (%)		22.70	40.00	27.98

Means within each column of 15 different lots followed by the same small letter (or) letters are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each row preceded by the different capital letter are significantly different at  $P < 0.01$  as determined by Fisher's LSD.

Means within each column followed by the same capital letter are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.

(A)= Storage durations

(B)= Seed kinds and seed lots

**Table 13** Balanced ANOVA for Variate (Mean Square)

Treatment combinations	SG	GI	AA	EC	FE 21 DAS	FEI 21 DAS
Se1 Se2 Se4 Se5 vs Se3	180.27	5.13	123.27	49072.2**	642.00**	2711.7**
Pe1 Pe2 Pe5 vs Pe3 Pe4	528.04*	4.97	6622.04**	1.59	6619.83**	347.28*
Se3 vs Pe3 Pe4	882.00**	2259.49**	4608.00**	1174310**	4751.32**	7073.73**
Se1Se2 Se4 Se5 vs Pe1 Pe2 Pe5	1585.02**	5909.93**	21.73	4245600**	29134.9**	35654.4**
Se1Se2 Se4 Se5 vs Sy1 Sy2 Sy3 Sy4 Sy5	175.67	2883.67**	89449.1**	230530**	6593.9**	52771.6**
Pe1 Pe2 Pe5 vs Sy1 Sy2 Sy3 Sy4 Sy5	868.00**	965.50**	78175.1**	2937370**	10799.8**	183.21

Se1 = KU 18 (2006)

Se2 = KU 18 (2007)

Se3 = KU 18 (CF,2007)

Se4 = CPlus 2 (2006)

Se5 = CPlus 2 (2007)

Pe1 = Kaset 1

Pe2 = Kasetsart 50

Pe3 = Khon Kaen 4

Pe4 = Tainan 9

Pe5 = Kalasin 2

Sy1 = MJ 9518 2

Sy2 = MJ 9520 21

Sy3 = Morbi

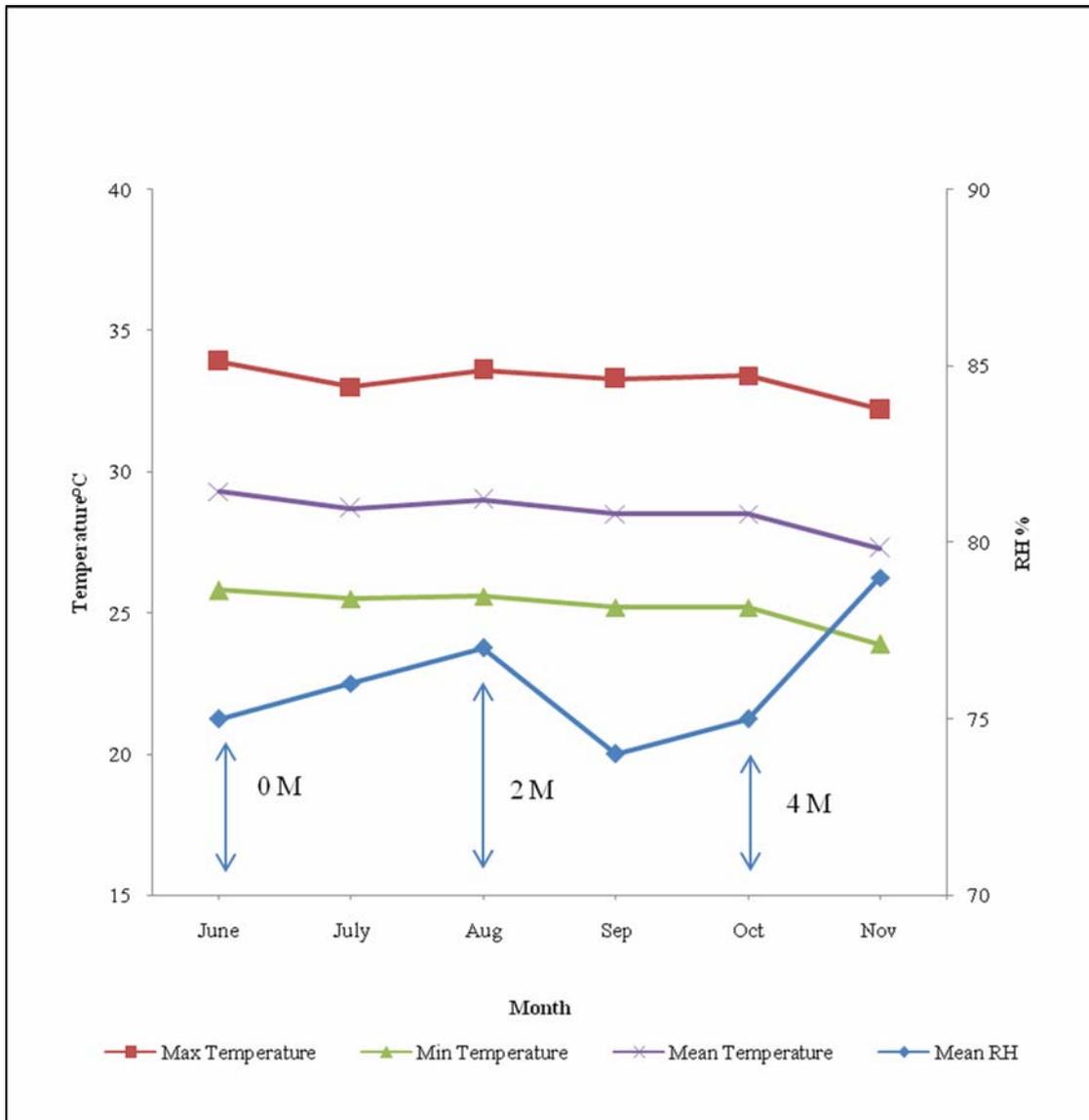
Sy 4 = KUSL 20004

Sy5 = CM 60

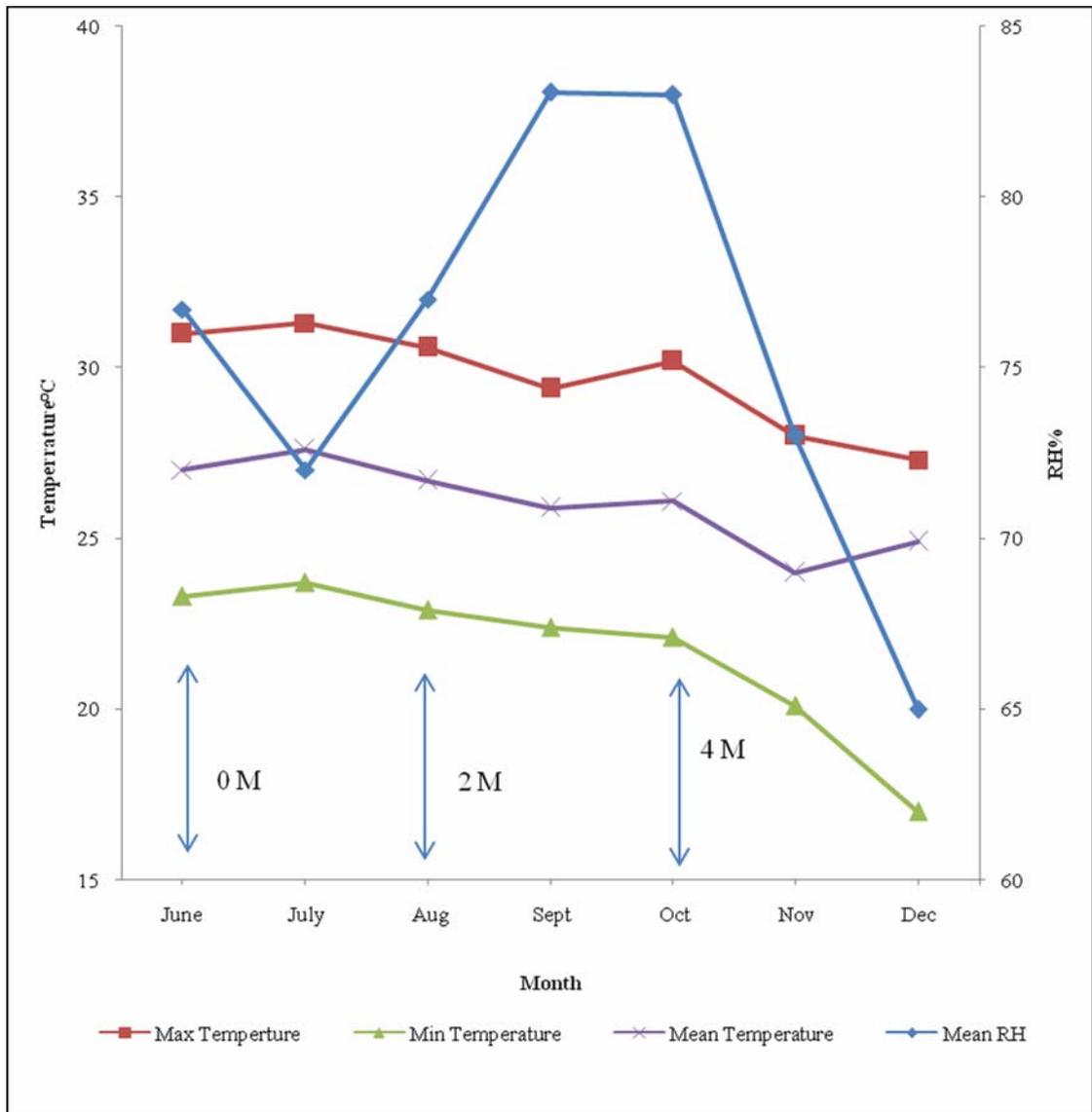
**Table 14** Effect of storage durations on seed germination, seed vigor and yield of sesame, peanut and soybean

Seed character	Storage durations		
	0 month	2 months	4 months
Seed moisture	D	F	E
Seed germination	D	E	E
Seed vigor			
First count germination	D	E	F
Germination index	D	E	E
Accelerated aging	D	E	F
Electrical conductivity	E	D	E
Field emergence at 7 DAS	C	—	D
14 DAS	C	—	D
21 DAS	C	—	D
28 DAS	—	—	—
Field emergence index at 21 DAS	C	—	D
28 DAS	—	—	—
Seed / grain yield	C	—	D

The same capital letters are not significantly different at  $P < 0.01$  as determined by Fisher's LSD.



**Figure 1** Means of relative humidity (%), maximum temperature, minimum temperature, and mean temperature (°C) during June through November 2008 at Bangkok Metropolis Station.



**Figure 2** Means of relative humidity(%), maximum temperature, minimum temperature, and mean temperature (°C) during June through December 2008 at Suwan Farm.

## Discussion

In this study, sesame, peanut and soybean were stored under ambient condition in which the relative humidity as shown in Figure 1 was lower than 85% throughout the storage periods. Peanut was stored in-shelled form. Initial seed moisture contents of soybean were higher than sesame and peanut which were ranged from 9.95 to 11.05%, 5.57 to 6.37% and 5.20 to 6.13%, respectively. Seed moisture contents of sesame and peanut were safe for short term storage but soybean was too high (Sanders *et al.*, 1982; Copeland and McDonald, 2001 and Weiss, 2000). Therefore, initial seed moisture content of sesame and peanut (Table 1) were low enough for safe storage for a period of 4 months. Copeland and McDonald (2001) reported that storage of most seeds between 5 and 6% seed moisture content appeared to be ideal for maximum longevity.

At 2 and 4 months storage, moisture content of sesame (5.18 and 5.19%) and peanut (4.88 and 4.64%) were decreased with increasing time (Table 1). Moisture content of peanut was lower than sesame probably because the hull of in-shell peanut prevented hygroscopic moisture adsorption from the environment. In case of soybean, after 4 months storage, moisture content (9.16%) was higher than after 2 months storage (7.75%). This would probably due to seed container and low temperature in storage after 2 months up to 4 months (Figure 1) cause the increase seed moisture content of soybean seed lots. Moreover, sesame, peanut and soybean seed lots were stored under ambient condition. Sesame seed was small and peanut were stored in unshelled (pod) form, therefore, seed moisture of these two kinds of seed after 2 and 4 months storage were not different. In seeds, the main chemical component that imbibes water is protein. McDonald and Copeland (1997) stated that the equilibrium moisture content associated with a specific relative humidity was different for each crop due to seeds differs in chemical content, size, surface-to-volume ratios, and seed coat thickness. High protein seeds attract more water than those high in starch or lipids. Protein contents of the sesame, peanut and soybean were 19-25, 25- 30, and 40- 45%, respectively (Weiss, 2000). Thus, soybean seed were high in moisture content after 4 months storage.

Germination (Table 2), vigor as determined by first count germination (Table 3), GI (Table 4) and AA (Table 5) of KU 18 (2007) and KU 18 (CF, 2007) sesame, were not different before storage, however, after 2 and 4 months storage, KU 18 (2007) sesame was significantly higher than KU 18 (CF, 2007). In this study, KU 18 (2007) was obtained from research farm station and KU 18 (CF, 2007) was obtained from the contract farmer. These results were confirmed by Teingtham and Duangpatra (2005) that the quality and storability of peanut seed produced by local farmer in rainfed area was lower than those that produced in the experiment station under irrigated condition. However, it is necessary to carry out further researches concerning the quality and storability of sesame cultivars from research farm stations and farmers' field.

Moreover, before storage, germination of KU 18 (2007) and KU 18 (CF, 2007) sesame were higher than KU 18 (2006). But, at 2 months storage, germination and seed vigor as measured by AA of KU 18 (2007) and KU 18 (2006) were not different. It might also due to the production techniques of the research farms station which resulted in better seed quality of KU 18 (2006). However, after 2 and 4 months storage, germination (Table 2), first count germination (Table 3) and GI (Table 4) of KU 18 (2007) was higher than KU 18 (2006). After 4 months storage, seed vigor as measured by AA (Table 5) and FEI (Table 11) of KU 18 (2007) was higher than KU 18 (2006). Before storage, germination, seed vigor as measured by AA, GI and first count germination of CPlus 2 (2007) was higher than CPlus 2 (2006), and seed vigor as measured by AA of CPlus 2 (2007) was greater than CPlus 2 (2006) at 2 months storage and higher than at 4 months storage. Since different sesame seed lots were both new and carry over lots. These findings were supported by Juistice and Bass (1979) who found that new seed lots were good in seed vigor and storage potential than old seed lots. Moreover, Ibrahim *et al.* (1993) also pointed out that freshly harvested high vigor seed lot of sorghum was higher germination after accelerated aging than carryover lower vigor seed lots.

After 2 and 4 months storage, germination (Table 2), first count germination (Table 3), GI (Table 4) of CPlus 2 (2007) and CPlus 2 (2006) decreased with

increasing storage time but no differences were found between these two seed lots. Since ambient environment in the tropical regions were mostly poorer for seed storage than those of temperate regions (Ellis, 1991). After 4 months storage, AA of CPlus 2 (2006) (Table 5) was higher than after 2 months storage. This result was different from Sung (2008) who reported that both natural and accelerated aging enhanced lipid peroxidation, as germination was depressed. Aging also inhibited the activity of superoxide dismutase, catalase, ascorbate peroxidase and peroxidase. However, cause of delayed germination was the structure of the seed-coat and environment (Richharia and Dhodapkar, 1939).

It was found that in means of germination, seed vigor as indicated by first count germination (Table 3), GI (Table 4), AA (Table 5), EC (Table 6), FE at 7, 14 and 21 DAS (Table 7, 8 and 9) and FEI at 21 and 28 DAS (Table 10 and 11) showed that black-seeded KU 18 (2007) was significantly higher than white-seeded CPlus 2 (2007). These results confirmed Chanprasert and Tungsakul (2001) who reported that black-seed cultivar sesame, Nakhon Sawan was higher in seed quality and storability than the white-seed cultivar sesame Roi Et 1 and Maha Sarakham 60.

In this study, the five seed lots of sesame were kept in the paper bags and stored under ambient condition from June to September 2008. After 2 months storage, EC values of the five sesame lots were higher than before and after 4 months storage (Table 6) which means that seed vigor at initial of those 5 sesame seed lots were higher than after 2 and 4 months storage. The storage duration was fallen in the monsoon season. Sesame seed cell membranes deteriorated quickly. Therefore, more lechates came out from the seed resulted in higher EC values. However, at 4 months storage, relative humidity of environment was higher than at 2 months. Same result was found out by Bewley and Black (1994) that the lower the seed moisture content, the higher the structural disorganization of cellular membrane, and the higher the loss of lechates during the initial period of seed soaking and, consequently, the higher the value of EC of the seed soaking solute does not necessarily mean lower seed vigor. The effect of the initial seed moisture content may interact with other factors affecting EC. However, Loeffler *et al.* (1988) and Vieira *et al.* (1999) stated that seeds with

lower physiological potential liberate a greater amount of electrolytes as a consequence of lower cellular membrane selectivity. Therefore, many researchers found that decreased physiological potential and seed germination were directly related to increase quantity of leachate solutes resulting from a loss of membrane integrity (Phyo *et al.*, 2004 and Teingtham and Duangpatra, 2005).

Moreover, it was found that, before and after 4 months storage, EC, of KU 18 (2007) were higher than KU 18 (CF, 2007) and KU 18 (2006) (Table 6). However, FE at 21 and 28 DAS (Table 9 and 10), of KU 18 (2007) was higher than KU 18 (2006) and KU 18 (CF, 2007). According to the results, EC and FE percentage and FEI of KU 18 (2007) were positively correlated. However, McKersie and Senaratna (1983) reported that EC was negatively correlated with seed viability and vigor. Likewise, these results confirmed by Panobianco *et al.* (1999) statements that there was a significant relationship ( $R^2 = 0.84^{**}$ ) between electrical conductivity and seed coat lignin content. The higher the amount of lignin in the seed coat, the lower the levels of seed exudates to the soaking solution and consequently the lower electrical conductivity. It was concluded that seed soaking EC was influenced by the seed coat lignin content, which was a characteristic of variation among genotypes. Therefore, the higher the value of EC of the seed soaking solute does not necessarily mean lower seed vigor.

At initial (0 month), EC of CPlus 2 (2006) and CPlus 2 (2007) were higher than those of the other 3 sesame lots (Table 6), however, initial seed moisture contents of CPlus 2 (2006) and CPlus 2 (2007) were lower than those of the other 3 sesame lots (Table 1). Bewley and Black (1994) pointed out that, low initial seed moisture content may result in high EC values, which does not necessarily mean low vigor seeds. This phenomenon might be seed soaking injury or variation in the seed tegument lignin content (Alvarez *et al.*, 1997 and Panobianco *et al.*, 1999) which might provide different seed soaking velocities, depending on the seed lot.

Before storage, vigor of CPlus 2 (2007) as indicated by EC was higher (considered as low vigor) than CPlus 2 (2006), however FE at 21 DAS of CPlus 2

(2007) and CPlus 2 (2006) were not different (Table 9). It was also found that after 4 months storage, EC of CPlus 2 (2007) and CPlus 2 (2006) were not different and also FE at 21 and 28 DAS were not different in the field establishment (Table 9 and 10). Siddique and Goodwin (1985) investigated that electrical conductivity test could be estimated precisely seed performance in the field under favorable establishment conditions. The electrical conductivity of a seed lot was the measure of membrane function, and this test could be utilized as a predictor of the normal seedling production ability of a seed lot.

FE at 7, 14 and 21 DAS of KU 18 (2007) seed lot was higher than those of the other 4 sesame lots at initial and after 4 months storage (Table 7, 8 and 9). The higher FE of KU 18 (2007) was related to high in seed vigor as determined by GI (Table 4) and AA (Table 5). This result was similar to Tao (1978) findings in which the high percentage germination and vigor as determined by accelerated aging test presented high field seedling emergence although their respective high electrical conductivity test values had placed them as low seed vigor lots. This fact might be because of seed moisture content of the seed lots.

After 4 months storage, FE at 7 DAS (Table 7) of the 5 sesame seed lots were sharply lower than before storage, the 5 peanut lots were not germinated at 7 DAS, and for soybean, only MJ 9518 2 and CM 60 germinated at 7 DAS but MJ 9520 21, Morbi and KUSL 20004 did not emerged. It would probably due to the effect of the weather condition at that sowing time. For field emergence experiment of the 15 seed lots after 4 months storage, the seeds were planted in November. At that time, maximum mean temperature was 28°C, minimum mean temperature was 20.1°C and mean relative humidity was 72.77%. These field conditions were unfavorable for seed germinations. Weiss (2000) reported that a temperature around 30°C encouraged rapid germination, initial growth and flower formation of sesame, temperatures between 25 and 30°C were the optimum and below 20°C retarded development of peanut and then optimum field emergence temperature of soybean was 25 - 33°C and below 15°C and above 37°C reduced emergence.

The 5 peanut lots were stored in pod (in-shelled peanut) form under ambient condition. At initial and after 4 months storage, germination percentages of Khon Kaen 4, Kaset 1 and Kasetsart 50 increased (Table 2), however these 3 peanut lots at 2 months storage were slightly decreased in germination. It probably due to the storage season as mentioned in sesame. In the tropic regions, rapid reduction of seed quality or shelled peanut seed were found because of high relative humidity during monsoon season, while the hull of in-shell peanut prevented the loss of seed quality. The effect of high relative humidity on peanut germination had been investigated by Navarro *et al.* (1989). They reported that at a RH of 71-76% and 15-20°C, in-shelled Hanoch peanut preserved a germination level above 90% for 83 days, whereas at RH of 79-83% and above, there was a gradual reduction in germination in proportion to storage temperature and humidity. Ketring (1971) also supported the effect of high relative humidity on peanut seeds that total germination, vigor, and ethylene production were reduced at high relative humidity (80%) and the low quality seeds were more susceptible to damage.

Germination percentage (Table 2) and seed vigor of Tainan 9 were lower than those of other 4 peanut lots at initial, after 2 months and 4 months storage as measured by GI and AA (Table 4 and 5). This result closely supported by Duangpatra (1984) that unshelled Tainan 9 peanut seed could maintain satisfactory germination and vigor for only 4 months under ambient condition and after 10 months storage, no field emergence was found. In contrast, in another experiment, Duangpatra (1988) found that in-shell peanuts of the large-seeded peanut KUP 24D-448, KUP 24D-615 and the medium seeded cultivar Tainan 9 could maintain high viability and vigor up to 10 months, while shelled seeds could maintain only four months under ambient condition. Moreover, Sarawat (2001) proposed that the initial seed quality also had strong influenced on seed storability. Therefore, it could be explained that Tainan 9 peanut seed lot in this experiment was low in initial seed quality.

It was also found that at initial and after 2 months storage, germination percentage of Kalasin 2 was lower than those of other 4 peanut seed lots (Table 2). However, AA of Kalasin 2 at initial stage and after 2 months storage (Table 5) were

higher than without aging (Table 2). It might be due to the dormancy of Kalasin 2. High relative humidity and temperature during accelerated aging possibly overcame dormancy of peanut or long exposure to high relative humidity and high temperature during aging favored the germination of Kalasin 2 peanut. This result disagreed with Perez and Arguello (1995) who reported that accelerated aging decreased peanut germination and Sung and Jeng (2006) who found that accelerated aging inhibited seed germination and seedling growth.

In table 4, germination index which means faster germination rate of the large-seeded peanut: Kaset 1, Kasetsart 50 and Khon Kaen 4 were higher than that of medium seed Tainan 9. In case of Kalasin 2, although, it was large seeded peanut but it was slow germination rate.

Kaset 1, Kasetsart 50 and Khon Kaen 4 were rapid in germination rate at initial and Kaset 1 and Khon Kaen 4 showed continual faster germination rate when the storage period reached to 2 and 4 months (Table 4). This result was different from Copeland and McDonald (2001) who reported that long storage seeds were deterioration, weak and weak respiration resulted in the loss of germination and vigor. Similarly, Harrington (1972) reported that seed quality was gradually decreased with increasing storage time and finally loss of actual germinability. Tainan 9 peanut was low GI at initial storage probably was deteriorated seed at initial time.

Before storage, first count germination (Table 3) of Kaset 1, Kasetsart 50 and Khon Kaen 4 were not different but at 2 months storage, Kaset 1 was higher than Khon Kaen 4 and Kasetsart 50. At 4 months storage, Kaset 1 decreased in first count germination. These results were confirmed by research results of Copeland and McDonald (2001) experiment that deterioration of seed was observable in their lowered performance during germination and the first noticeable symptoms were delayed seedling emergence followed by a slower rate of seedling growth, development and decreased germination.

It was found that at initial, 2 and 4 months storage, germination (Table 2) and vigor of Tainan 9 as measured by first count germination (Table 3), GI (Table 4) , AA (Table 5) and EC (Table 6) (high value) were low. Likewise, at 4 months storage, FE and FEI at 21 and 28 (Table 9, 10 and 11) DAS of Tainan 9 was very low as well as EC (Table 6) value was the highest which mean that lowest in seed vigor. These findings agreed with McKersie and Senaratna (1983) report which indicated that electrical conductivity was negatively correlated with seed viability and vigor. Bewley and Black (1994) also pointed out that field emergence value depended on electrolyte leakage from seed lots. Lower physiological potential seeds liberated greater amount of electrolytes as a consequence of lower cellular membrane selectivity. Besides, Copeland and McDonald (2001) also noted that the degree of deterioration was associated with the concentration of seed exudates which were a reflection of the amount of membrane degradation.

During storage, Tainan 9 peanut was damaged by stored groundnut insect. This seed lot was obtained from one local farmer in Khon Kaen province. As Tainan 9 was severely attacked by the stored groundnut insect, therefore after 4 months storage, seed germination and seed vigor were the lowest among the peanut lots. Dick (1987) reported about this damage of stored groundnut insect that *Caryedon serratus* Olivier was the major pest of stored groundnuts in tropical Asia and Africa. They hatched their eggs in legumes plants such as tamarind as well as in harvested groundnut. It was the only one species that could penetrate intact pods to infest kernels. Infestation of harvested groundnut could occur while the crop was drying in the field or when it was stored near infested stocks or crop residues. Adult females laid their eggs outside the pods or kernels. The first instar larva hatched and burrowed directly through the pod wall to the kernel. Each larva fed solely within a single kernel. A single larva could make a large excavation in the cotyledons, but no sign of damage was visible externally at this stage. Mature, larvae may partially or completely emerge from the pod, leaving a characteristic of round hole approximately 3 mm in diameter. Larvae migrated to the bottom of a sack or heap before pupating in distinctive ovoid cocoons.

Seed vigor of Kaset 1, Kasetsart 50, Khon Kaen 4 and Kalasin 2 peanut as measured by AA (Table 5), EC (Table 6), FE (Table 9) and FEI at 21 DAS (Table 11) were not different whereas FE at 21 DAS of Kasetsart 50 was higher than Khon Kaen 4 (Table 9). Same finding was also reported by Romkaew (1996) that after 6 months of storage at room temperature (ambient condition), seed quality of Kasetsart 50 and Kaset 1 as determined by accelerated aging and electrical conductivity test revealed that high vigor peanut seeds were higher in storability than the medium and low vigor seed and accelerated aging test was related to the field performance and storability of seed.

At 4 months storage, FE at 21 and 28 DAS of Kaset 1 (Table 9 and 10) was higher than germination percentage (Table 2). This was probably due to the number of abnormal seedlings that made a larger contribution to the failure of germination in the laboratory. The abnormal seedlings caused by root system such as defective or distorted roots was unable to identify under field condition, and normal and abnormal seedlings in the field condition were differentiated only by shoot system. However, in many legumes such as peanut and soybean, some abnormal seedlings developed under field conditions and field emergences were higher than the germination in laboratory (Ketring *et al.*, 1982).

Delouche (1974) and McDonald and Copeland (1997) noted that seed quality was the sum of many seed characters and differing components among these were genetic quality, physical purity, germination, vigor and seed health that lead to excellent performance in the field. Phyo *et al.* (2004) and Duangpatra and Boonkamjad (2005) worked in many peanut and pointed out that seed quality and storability of peanut were different among genotypic differences and history of seed lots. Kaset 1, Khon Kaen 4 and Kalasin 2 seemed to be high in seed quality and storability. However, since the storage period was too short and storage form of peanuts was not the main purpose of this study, therefore, carrying out further researches concerning the storage form of different peanut seed lots or variety under ambient and controlled condition must be considered.

Results in soybean showed that before storage, initial germination of MJ 9518 2, CM 60, Morbi, KUSL 20004 and MJ 9520 21 were higher than 80% (Table 2). Similarly, seed vigor of the 5 soybean lots as determined by first count germination (Table 3) and GI (Table 4) were not different at initial. However, at 2 months storage, germination, first count germination and GI decreased as those that reported by Delouche (1973), Copeland (1976), Roberts (1986) and Dornbos (1988) that the standard germination test was the most widely accepted procedure for estimating seed viability, but it was an inadequate predictor for estimating seed viability.

These 5 soybean lots were stored under ambient condition for 4 months. This condition was not good for maintaining seed storability because Gregg (1982) recommended that in tropical countries, ambient conditions were inadequate for safe soybean seed storage for the required periods and conditioned storage was required to store even bagged seed for the necessary time. Besides, he also pointed out that soybean seeds of high initial quality could be safely stored under tropical conditions for nine months at moisture contents of 9.0 to 9.5 percent (50 to 60% RH) and temperatures of 20 to 25°C. In this study initial seed moisture content of the 5 soybean lots were 9.95-11.05% and at that storage time relative humidity was over 75% which resulted in rapid seed deterioration. However, it was found that after 4 months storage, germination percentages of MJ 9518 2 and CM 60 were higher than those of the other 3 soybean lots (Table 2). Therefore, varietal differences might be due to variation in genetic makeup. Genotype variations in soybean have also been reported for response to seed deterioration due to storage (Agrwal *et al.*, 1974; Ellis *et al.*, 1982; Minor and Paschal, 1982 and Singh and Ram, 1996). However, storage at ambient and 75% RH for 4 months period was able to reveal soybean genotypic differences for resistance to seed deterioration during storage (Chuntirapongsa, 1992).

After 4 months storage, MJ 9518 2 and CM 60 maintained higher seed germination as indicated by germination percentages than those of the other 3 soybean lots and which might be classified as a good “storer”, while germination percentages of MJ 9520 21, Morbi and KUSL 20004 decreased to 65- 25%, which might be classed as poor “storer”. This finding was confirmed by Chuntirapongsa (1992),

Ferguson *et al.* (1990a) and Marwanto *et al.* (2003) that different genotypes of soybeans were different in germination of the seeds.

Seed vigor as measured by AA (Table 5) pointed out that MJ 9518 2, CM 60, MJ 9520 21, KUSL 20004 and Morbi soybean were very low at initial time and seed vigor decreased down to 0% after 2 and 4 months storage. This result agreed with Perez and Arguello (1995) that accelerated aging decreased seed germination. Sung and Jeng (2006) also found that accelerated aging inhibited seed germination and seedling growth. Similarly, Zhang *et al.* (1995) reported that a major cause of the rapid seed deterioration of seeds at 75% RH at room temperature seems to be the rapid development of mitochondrial respiration. Abdul-Baki and Anderson (1972) found that reduction of vigor was associated with declines in respiration and synthesis of proteins and carbohydrates, and with increased permeability of membranes of the embryonic axes. Moreover, they also investigated and found that different seed lots within the same cultivar, and low germinability or seedling growth should be imposed by reduced vigor and not by dormancy.

In this research, at initial, after 2 and 4 months storage, EC values of the 5 soybean seed lots were ranged from 296-492, 355-562, and 302-579  $\mu\text{S cm}^{-1}\text{g}^{-1}$ , respectively (Table 6). These findings were something different from Vieira *et al.* (1999) that soybean seed lots that present EC values between 60 and 70  $\mu\text{S cm}^{-1}\text{g}^{-1}$  were considered high vigor seed lots and values between 70 and 80  $\mu\text{S cm}^{-1}\text{g}^{-1}$  were presented by intermediary vigor seed lots. AOSA (1983) also showed that, in USA, seeds with EC values higher than 150  $\mu\text{S cm}^{-1}\text{g}^{-1}$  were classified as low vigor seed lots and considered not to be used for sowing. According to the results, the 5 soybean seed lots might be considered as low vigor seed lots. Further investigations are needed to measure correlation of electrical conductivity values and seed vigor of different new soybean cultivars.

Before storage, FE (Table 9) of the 5 soybean seed lots was lower than germination percentages (Table 2). TeKrony *et al.* (1974) and Egli and TeKrony (1995) found that standard germination has been shown to be an excellent predictor

and accurately predicted field emergence only when seedbed conditions were nearly ideal for germination and emergence. Measures of seed vigor provided better estimates of field emergence in less than ideal seedbed conditions. Soybean seed with an AA  $\geq$  80% or SG  $\geq$  95% ensured adequate performance in many field environments. In contrast, in this study, AA of the 5 soybean seed lots were lower than 80% (Table 5). Gregg (1983) described that seed deterioration was a natural process and caused by pre-harvest field condition, maturity at harvest, mechanical injury, high temperature, high moisture, fungi, insects, pests, seed treatment, fumigation and natural storage life. According to the standard germination (Table 2), first count germination (Table 3), EC (Table 6) and FE (Table 9 and 10) results, CM 60 and MJ 9518 2 could be good in seed quality and storability.

Results showed that FE of MJ 9518 2 was higher than those of the other 4 soybean seed lots after 4 months storage (Table 10). However, TeKrony and Egli (1977) and Johnson and Wax (1978) reported that high vigor soybean seed exhibited higher field emergence under adverse soil conditions than does low vigor seed even though both had acceptable standard germination. In this study MJ 9518 2 was the highest storability as measured by germination (Table 2) and FE (Table 10).

According to the yield results, yield of the 15 seed lots decreased with increasing storage periods (Table 12). These results proved that sesame, peanut and soybean planted from high germination and vigor gave higher seed or grain yield than those that planted from low germination and lower seed vigor. However, no different was found among grain or seed yield planted from different seed lots of sesame both at initial before storage and after 4 months storage seeds, even though seed germination and seed vigor of this 5 sesame seed lots were different. These results revealed that seed quality of sesame was not affected sesame yields. Yield of the sesame was also significantly lower than peanut and soybean. This is the nature of seed kinds.

In case of peanuts, pod yield of Kaset 1 planted from initial seed before storages was lower than those planted from the other 4 seed lots. Peanuts that planted

from after 4 months storage were different in pod yield. Khon Kaen 4 gave the highest followed by Kalasin 2, Kaset 1, Kasetsart 50 and zero yield of Tainan 9 due to the zero field emergence. These results reflected that in peanut, yield different was upon variety and planted seed quality which determined by seed germination and vigor.

For soybean seed yield, at initial before storage, seed yield that planted from Morbi was lower than the others that planted from the other 4 seed lots, but at 4 months storage, MJ 9518 2 gave the highest yield followed by MJ 9520 21, Morbi and KUSL 20004 while CM 60 gave the lowest seed or grain yield. It might be due to the genotypic differences and quality among seed lots that planted from low quality seeds were weak in plant growth, late flowering and resulted in low yield as reported by Andrews (1973).

AA, FE at 21 DAS and FEI of different seed sources of peanut were different, although GI and EC values were not different while comparing between the three research farm seed lots: Kaset 1, Kasetsart 50, Kalasin 2 and Khon Kaen 4 and Tainan 9 the two peanut seed lots from farmer field (Table 13). These results agreed with that quality and storability of peanut seeds produced in research farm were higher than those produced in farmer field as those reported by Teingtham and Duangpatra (2005).

The results of statistical analysis showed that GI, AA, EC, FE and FEI at 21 DAS (Table 13) of the 4 sesame seed lots: KU 18 (2006), KU 18 (2007), CPlus 2 (2006) and CPlus 2 (2007) were highly significant than MJ 9518 2, MJ 9520 21, Morbi, KUSL 20004, CM 60 soybean. Seed lots were produced from different research stations. However, germination of both seed kinds was not different. Under tropical conditions it has been established that soybean seed viability and vigor rapidly reduced during storage at ambient temperatures (Nkang and Umoh, 1996). However, AOSA (1983) described that, in the United States of America, seeds with EC values higher than  $150 \mu\text{S cm}^{-1} \text{g}^{-1}$  were classified as low vigor seed lots and considered not to be used for sowing.

SG, GI, AA, EC, FE and FEI at 21 DAS (Table 13) of peanut were significantly higher than soybean might due to soybean seeds (*Glycine max*) have highly protein and lipid content (Bewley and Black, 1978). Moreover, the 5 peanuts were stored in pod form. These results were supported Whitty *et al.* (2006) that peanut seed quality was easier to maintain quality in unshelled peanut either in the field or store warehouse. Soybean seed germination and vigor potential was short as compared to other grain crops and rapidly deteriorated by high temperature and high relative humidity during storage (Byrd and Delouche, 1971; Justice and Bass, 1979 and Nkang and Umoh, 1996).

In this study, seed quality and vigor decreased with increasing storage times under ambient environmental condition. Low vigor seed lots performed poor field emergence and stand establishment. If the seeds were stored for some longer time, seed becomes more and more deteriorated, respiration becomes progressively weaker and weaker, and ultimately leads to the loss of germination and vigor. Moreover, the ultimate performance of seed deterioration was the complete loss of germinability and death of the seed (Copeland and McDonald, 2001). High vigor groundnut seeds germinated faster and gave higher field emergence than low vigor seed, in addition, planting with high vigor seeds resulted in higher pod and seed yields than planting from those of low vigor seeds (Duangpatra and Kittitanasuan, 1990b).

## CONCLUSION AND RECOMMENDATION

Influence of seed kinds and seed lots on seed quality and storability of oil crop seed were conducted in the 15 seed lots of sesame, peanut and soybean under local ambient storage condition for a period of 4 months. Research results found that:

1) Seed moisture content, seed germination, seed vigor as determined by first count germination, germination index, accelerated aging, electrical conductivity, field emergence percentage and field emergence index at initial before storage were higher than those of after storage.

2) Seed quality and storage potential were different among seed kind and seed lot.

3) Seed or grain yield of the three oil crops: sesame, peanut and soybean that planted from the initial before storage seed gave higher yield than those that planted from after 4 months storage seeds.

4) Seed quality of sesame as measured by germination, vigor and field emergence, KU 18 (2007) was the highest among all seed lots when stored up to 4 months period. Black color seed coat and white color seed coat were different in seed quality and storage potential. The new sesame seed lots were better in seed quality and vigor than old seed lots. Sesame seeds that obtained from research station were better in viability and vigor than from farmer field production.

5) According to seed germination, seed vigor and field emergence percentage, Kaset 1, Kasetsart 50, Khon Kaen 4 and Kalasin 2 peanut were higher quality and storability than Tainan 9.

6) Among the five seed lots of soybean, MJ 9518 2 was the best in seed quality and storability as measured by seed germination, seed vigor and field performance.

7) Further research concerning the quality and storability of sesame, peanut and soybean cultivars should be carried out at different research farm and farmer field. It is also need to study concerning the quality and storability of different colors of sesame seed. Seed storage duration in this study was short period, further experiment with longer storage duration should also be examined.

8) Seed lots of sesame, peanut and soybean in this study were stored under ambient condition. Storage under the control condition should be considered for further study of new varieties.

## LITERATURE CITED

- Abdul-Baki, A.A. and J.D. Anderson. 1970. Viability and leaching of sugars from germinating barley. **Crop Sci.** 10: 31-34.
- \_\_\_\_\_ and \_\_\_\_\_. 1972. Physiological and biochemical deterioration of seeds, pp. 283-315. *In* T.T. Kozlowski, ed. **Seed Biology, Volume II. Germination Control, Metabolism, and Pathology.** Academic Press, Inc., New York.
- Acquaah, G. 2005. Seeds, seedlings, and seeding, pp. 467-494. *In* G. Acquaah, ed. **Principles of Crop Production, Theory, Techniques, and Technology.** Pearson Education, Inc., Upper Saddle River, New Jersey.
- Adebisi, M.A. 1999. **Effect of Chemical Seed Treatments on Vability and Vigor in Soybean Cultivars.** M. Agric Thesis, University of Agriculture, Abeokuta.
- \_\_\_\_\_. 2004. **Variation, Stability and Correlation Studies in Seed Quality and Yield Characters of Sesame.** Ph.D. Thesis, University of Agriculture, Abeokuta.
- \_\_\_\_\_ and M.O. Ajala. 2000. Effect of seed dressing chemicals and period of storage on soybean seed vigor. **J. Tropic. Forest Resources** 16:126-135.
- \_\_\_\_\_, J.A. Ola, D.A.C. Akintobi and I.O. Daniel. 2008. Storage life of sesame (*Sesamum indicum* L.) seeds under humid tropical conditions. **Seed Sci. & Technol.** 36:379-387.
- Agrwal, V.K., O.V. Singh, P.N. Thapliyal and B.K. Malhotra. 1974. Control of purple stain disease of soybean. **Indian J. Mycol. & Pl. Pathol.** 4: 1-4.

- Alvarez, P.J.C., F.C. Krzyzanowski, J.M.G. Mandarino and J.B. Franca Neto. 1997. Relationship between seed coat lignin content and resistance to mechanical damage. **Seed Sci. & Technol.** 25: 204-209.
- Amed, E.M. and C.T. Young. 1982. Composition, quality and flavor of peanuts, pp. 655-688. *In* H.E. Pattee and C.T. Young, eds. **Peanut Science and Technology.** American Peanut Research and Education Society, Inc., Yoakum, Texas.
- Amthor, J.S. 1989. **Respiration and Crop Productivity.** Springer-Verlag, Inc., New York, New York.
- Andrews, C.H. 1982. Pre-harvest environment: weathering, pp. 19-25. *In* J.B. Sinclair and J.A. Jackobs, eds. **Soybean Seed Quality and Stand Establishment.** International Agriculture Publications. University of Illinois, Urbana-Champaign, Illinois.
- \_\_\_\_\_. 1973. Influence of physiological quality of seed on performance of crops, pp. 49. **Agron. Abstr.** Annual Meeting, American Society of Agronomy, Las Vegas, Nevada.
- AOSA. 1983. Seed Vigor Testing Hand Book. **The Handbook on Seed Testing.** The Association of Official Seed Analysts.
- Aponte, A. 1973. Influence of different conditions of storage in the quality of seeds of ajonjoli (*Sesamum indicum* L.). **Tropic. Agron.** 23 (2): 129-148.
- Azevedo, M.R.Q.A., J.P.G. Gouveia, D.M.M Trovao and V.P. Queiroga. 2003. Influence of packing and storage conditions on the vigor of sesame seeds. **Revista Brasileira de Engenharia Agricola e Ambient** 7(3): 519-524.

- Barton, L.V. 1941. Relation of certain air temperatures and humidity to viability of seeds. **Contrib. Boyce Thompson Inst.** 12:85-102.
- Baskin, C.C. and E.H.N. Vieira. 1980. Predicting the storability of soybean seed lots. **J. Seed Technol.** 5(2): 1-6.
- Bennett, M.R. and I.M. Wood. 1995. Sesame seed, pp. 241- 257. *In Proc. of First Australian Sesame Workshop.* Northern Territory, Department of Primary Industry and Fisheries, Darwin.
- Bewley, J.D. and M. Black. 1978. **Physiology and Biochemistry of Seeds in Relation to Germination.** Springer-Verlag, New York.
- \_\_\_\_\_ and \_\_\_\_\_. 1985. Seeds germination, structure and composition, pp. 1-27. **Seeds: Physiology of Development and Germination.** Plenum Press, New York, New York.
- \_\_\_\_\_ and \_\_\_\_\_. 1994. **Seeds: Physiology of Development and Germination.** 2<sup>nd</sup> ed. Plenum Press, New York, New York.
- Byrd, H.W. and J.C. Delouche. 1971. Deterioration of soybean seeds in storage. **Proc. Assoc. Off. Seed Anal.** 61: 41-57.
- Chanprasert, W, S. Ondum, R. Kaveeta and S. Oupadissakoon. 1996 . Field deterioration and physical characteristics of seeds of 10 soybean varieties, pp. 296-302. *In Proc. of Sixth National Soybean Conference,* held at the Empress Hotel, Chiang Mai.

- Chanprasert, W, and S. Tungsakul. 2001. Changes in seed moisture content and germination during storage of 3 sesame cultivars under 4 different relative humidities, pp. 250-263. *In Proc. of The Second National Conference on Sesame, Sunflower, Castor and Safflower*, held at The Wangree Resort, Nakornnayok.
- Ching, T.M. 1972. Metabolism of germinating seeds, pp. 103-218. *In* T.T. Kozlowski, ed. **Seed Biology Volume II. Germination Control, Metabolism, and Pathology**. Academic Press, Inc., New York, New York.
- \_\_\_\_\_. 1973. Biochemical aspect of seed vigor. **Seed Sci. & Technol.** 1: 73-88.
- Chuntirapongsa, S. 1992. **Effects of Seed Coat Color on Storability of Soybean Seeds**. Ph.D. Dissertation, Mississippi State University, Mississippi State, Mississippi.
- Clark, L.E. 1975. Seed quality, pp. 10-18. **Peanut Production in Texas**. The Texas Agricultural Experiment Station, Vernon, Texas.
- Copeland, L.O. 1976. **Principles of Seed Science and Technology**. Burgess Publishing Company, Minneapolis, Minnesota.
- \_\_\_\_\_ and M.B. McDonald. 2001. **Principles of Seed Science and Technology**. 4th ed. Kluwer Academic Publishers, Norwell, Massachusetts.
- Delouche, J.C. 1968. Precepts for seed storage, pp. 85-119. *In Proc. 1972 Short Course for Seedsmen*. Seed Technology Laboratory, Mississippi State University, Mississippi State, Mississippi.
- \_\_\_\_\_. 1972. Harvesting, handling and storage of soybean seed, pp. 17- 21. *In Proc. 1972 Short Course for Seedsmen*. Seed Technology Laboratory, Mississippi State University, Mississippi State, Mississippi.

- Delouche, J.C. 1973. **Precepts of Seed Storage**, pp. 97-122. *In Proc. 1973 Short Course for Seedsmen*. Seed Technology Laboratory, Mississippi State University, Mississippi State, Mississippi.
- \_\_\_\_\_. 1974. Maintaining soybean seed quality, pp. 46-62. **Soybean Production, Marketing and Use**. Bulletin Y-69. National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Alabama.
- \_\_\_\_\_. and C.C. Baskin. 1973. Accelerated aging techniques for predicting the relative storability of seed lots. **Seed Sci. & Technol.** 1: 427-452.
- \_\_\_\_\_, R.K. Matthes, G.M. Dougherty, and A.H. Boyd. 1973. Storage of seed in sub-tropical and tropical regions. **Seed Sci. & Technol.** 1: 663-692.
- Dias, D.C.I.S., J. Marcos-Filho and Q.A. Camello. 1996. Potassium leakage test for the evaluation of vigor in soybean seeds. **Seed Sci. & Technol.** 25: 7-18.
- Dick, K.M. 1987. Pest Management in Stored Groundnuts. **ICRISAT Information Bulletin no. 22**. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh.
- Dornbos, D.L. 1988. **Soybean Seed Yield Viability and Vigor, and Chemical Composition Resulting from Drought and High Temperature Stress during Seed Fill**. Ph.D. Dissertation, Iowa State University, Ames, Iowa.
- Douglas, J.E. 1975. Seed storage and packaging, pp. 87-107. *In* W.P. Feistritz, ed. **Cereal Seed Technology**. A Manual of Seed Production, Quality Control, and Distribution. Plant Production and Protection Division, FAO. Rome.

- Duangpatra, J. 1984. Report on post of harvest technology of groundnut for 1983 Kasetsart University, pp. 371-386. *In Proc. of The Third Groundnut Research Workshop 1984*, held at Kasetsart University, Kampaengsaen Campus, Nakorn Pathom.
- \_\_\_\_\_. 1988. Storability of shelled and unshelled groundnut seeds under controlled storage and ambient temperature, pp. 617-624. *In Proc. of The Sixth Thailand National Groundnut Meeting*, held at Faculty of Natural Resources, Prince of Songkla University, Songkla.
- \_\_\_\_\_, and K. Boonkamjad. 2005. Seed quality and storage potential of five large-seeded peanut varieties. *In Prospects and Emerging Opportunities for Peanut Quality and Utilization Technology*. International Peanut Conference 2005. Kasetsart University, Bangkok.
- \_\_\_\_\_ and C. Kittitanasuan. 1990a. Storability of unshelled large-seeded groundnut under local ambient condition, pp. 392-395. *In Proc. of The Eighth Thailand National Groundnut Meeting*, held at the Maithai Hotel, Roi-et.
- \_\_\_\_\_ and \_\_\_\_\_. 1990b. Storability of large-seeded groundnut seeds produced by local farmers, pp. 396-401. *In Proc. of The Eighth Thailand National Groundnut Meeting*, held at the Maithai Hotel, Roi-et.
- \_\_\_\_\_, \_\_\_\_\_, and P. Srisurapon. 1990. Effects of seed vigor and seeding rate on field emergence, stand establishment, and yield of large-seeded groundnut, pp. 409-414. *In Proc. of The Eighth Thailand National Groundnut Meeting*, held at the Maithai Hotel, Roi-et.

Duangpatra, J. and P. Kuphotipan. 1986. Effects of maturity on storability of seed of groundnut cultivars SK 38, Tainan 9 and Aspergillus resistant lines, pp. 489-496. *In Proc. of The Fourth Thailand National Groundnut Research Meeting*, held at the Faculty of Agriculture, Khon Kaen University, Khon Kaen.

\_\_\_\_\_ and P. Promchote. 2000. Seed quality and aflatoxin contamination in different maturity of Tainan 9 and Kaset 1 peanut seed during storage, pp. 271-278. *In Proc. of The Fifteenth Thailand National Groundnut Meeting*, held at the Amity Green Hill Hotel, Chiang Mai.

\_\_\_\_\_, A. Tadakittisarn, U. Phruksanusak, and M. Nontarit. 1985. Effects of storage conditions on viability, vigor and field emergence of unshelled groundnut SK 38 and Tainan 9 seed, pp. 503-510. *In Proc. of The Fourth Thailand National Groundnut Research Meeting*, Khon Kaen University, Khon Kaen.

Egli, D.B. and D.M. TeKrony. 1979. Relationship between soybean seed vigor and yield. *Agron. J.* 71: 755-759.

\_\_\_\_\_ and \_\_\_\_\_. 1995. Soybean seed germination, vigor and field emergence. *Seed Sci. & Technol.* 23: 595-607.

\_\_\_\_\_, G.M. White, and D.M. TeKrony. 1978. Relationship between seed vigor and storability of soybean seed. *J. Seed Technol.* 3: 1-11.

Ellis, R.H. 1991. The longevity of seed. *Hort. Sci.* 26 (9): 1119-1125.

\_\_\_\_\_, K. Osci-Bonsu and E.H. Roberts. 1982. The influence of genotype, temperature and moisture on seed longevity in chickpea, cowpea and soybean. *Ann. Bot.* 50: 69-82.

- Ferguson, J.M., D.M. TeKrony, and D.B. Egli. 1990a. Changes in early soybean seed and axes deterioration: I. Seed quality and mitochondrial respiration. **Crop Sci.** 30: 175-179.
- \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_. 1990b. Changes during early soybean seed and axes deterioration. II. Lipids. **Crop Sci.** 30: 179-182.
- Filippone, P.T. 2006. **Sesame Seed Storage.** *Available Source:* <http://home.cooking.about.com/od/foodstorage/a/sesamestorage.htm>. May, 2008.
- Franca Neto, J.B., A.A. Henning, and F.C. Krzyzanowski. 1994. Seed production and technology for the tropics (*Glycine max*). **FAO Plant Production and Protection Series 27:** 217-240.
- Gomez, K.A. and A.A. Gomez. 1984. Statistical procedure for agricultural research. 2<sup>nd</sup> ed. **An International Rice Research Institute Book,** A Wiley Interscience Publication, John Wiley & Sons, Singapore.
- Gregg, B. 1982. Soybean seed quality and practical storage, pp. 52-56. *In* J. B. Sinclair and J.A. Jackobs, eds. **Soybean Seed Quality and Stand Establishment.** International Agriculture Publications, INSTOY Series Number 22.
- \_\_\_\_\_. 1983. Seed storage, pp. 34-52. *In* **Seed: Conditioning, Storage and Marketing.** Special Publication 1. The Seed Club of Thailand.
- Harrington, J.F. 1971. Drying, storage, and packaging- present status and future needs, pp. 14: 133-139. *In* **Proc. of 1971 Short Course for Seedsmen.** Seed Technology Laboratory, Mississippi State University, Mississippi State, Mississippi.

- Harrington, J.F. 1972. Seed storage and longevity, pp. 145-245. *In* T.T. Kozlowski, ed. **Seed Biology Volume III: Insects, and Seed Collection, Storage, Testing and Certification.** Academic Press, Inc., New York, New York.
- Henning, R.J., A.H. Allison and L.D. Tripp. 1982. Cultural Practices, pp. 123-138. *In* H.E. Pattee and C.T. Young, eds. **Peanut Science and Technology.** American Peanut Research and Education Society, Inc., Yoakum, Texas.
- Homdork, S. 1984. **Effect of Harvesting Time on Quality and Yield of Peanut Seeds.** M.S. Thesis. Kasetsart University.
- Ibrahim, A.E., D.M. TeKrony and D.B. Egli. 1993. Accelerated aging techniques for evaluating sorghum seed vigor. **J. Seed Technol.** 17(1): 29- 37.
- Isely, D. 1957. Vigor tests. **Proc. Assoc. Off. Seed Anal.** 47: 176 – 182.
- ISTA. 2004. **International Rules for Seed Testing.** International Seed Testing Association (ISTA), Zurich.
- Johnson, R.P. and L.M. Wax. 1978. Relationship of soybean germination and vigor tests to field performance. **Agron. J.** 70:273-278.
- Jothityangkoon, D., S. Joglay, S. Sansupho and N. Phakamas. 2002. Relationships between seed size and seed deterioration of Khon Kaen 60-3 large seeded type peanut, pp. 262-271. *In* **Proc. of The Sixteenth Thailand National Peanut Meeting,** held at Krungsri River Hotel, Ayuthaya.
- Justice, O.L. and L.N. Bass. 1979. **Principles and Practices of Seed Storage.** Castle House Publications Ltd., Beccles, London.

- Ketring, D.L. 1971. Physiology of oil seeds III. Response of initially high and low germinating Spanish-type peanut seeds to three storage environments. **Agron. J.** 63: 435-438.
- \_\_\_\_\_, R.H. Brown, G.A. Sullivan and B.B. Johnson. 1982. Growth physiology, pp. 411-457. *In* H.E. Pattee, and C.T. Young, eds. **Peanut Science and Technology**. American Peanut Research and Education Society, Inc., Yoakum, Texas.
- Khuentong, N. 2006. **Effect of Harvesting Time on Seed Quality of Sesame** (*Sesame indicum* L.). M.S. Thesis, Kasetsart University.
- Lewis, D.N., A.H. Marshall and D.H. Hides. 1998. Influence of storage conditions on seed germination and vigor of temperate forage species. **Seed Sci. & Technol.** 26: 643-655.
- Liklatchev, B.S., G.V. Zelensky, G.Y. Kiashko, and Z.N., Schevchenko. 1984. Modeling of seed ageing. **Seed Sci. & Technol.** 12:385-393.
- Loeffler, T.M., D.M. TeKrony and D.B. Egli. 1988. The bulk conductivity test as an indicator of soybean seed quality. **J. Seed Technol.** 12: 37-53.
- Marwanto, Marlin and D.M. Marlinda. 2003. The relationship between seed coat lignin content and seed quality of soybeans during storage. **JIPI.** 5(1): 12-17.
- McDonald, M.B. 1976. A review and evaluation of seed vigor tests. **Proc. Assoc. Official Seed Anal.** 65: 109-139.
- \_\_\_\_\_. 1999. Seed deterioration: Physiology, repair and assessment. **Seed Sci. & Technol.** 27: 177-237.

- McDonald, M.B. and L.O. Copeland. 1997. Drying and storage, pp. 106-126. *In* **Seed Production: Principles and Practices**. International Thomson Publishing, New York, New York.
- McKersie, B.D. and T. Senaratna. 1983. Membrane structure in germinating seed. **Recent Advances in Phytochemistry** 17: 29-52.
- Minor, H.C. and E.H. Paschal. 1982. Variation in storability of soybean under simulated tropical conditions. **Seed Sci. & Technol.** 10: 13- 139.
- Mohamad-Yasseen, Y., S.A. Barringer, W.E. Splittstoesser and S. Costanza. 2008. The role of seed coats in seed viability. **Botanical Review** 60 (4): 426-439.
- Myanma Agriculture in Brief. 2007. **Ministry of Agriculture and Irrigation**. Union of Myanmar.
- Namiki, M. 1995. The chemistry and physiological functions of sesame. **Food Reviews International** 11(2): 281-329.
- Nasreen, S., B.R. Khan and A.S. Mohmand. 2000. The effect of storage temperature, storage period and seed moisture content on seed viability of soybean. **Pakistan J. Biologic. Sci.** 3(12): 2003-2004.
- Navarro, S., E. Donahaye, R. Klein and H. Haham. 1989. The influence of temperature and moisture content on the germination of peanut seeds. **Peanut Sci.** 16: 6-9.
- Nkang. A. and E.O. Umoh. 1996. Six months storability of five soybean cultivars as influenced by stage of harvest, storage temperature and relative humidity. **Seed Sci. & Technol.** 25: 93-99.

- Oplinger, E.S., D.H. Putnam, A.R. Kaminski, C.V. Hanson, E.A. Oelke, E.E. Schulte, and J.D. Doll. 1997. Sesame. **Alternative Field Crops Manual**. Available Source: <http://www.hort.purdue.edu/newcrop/afcm/sesame.html>. August, 2008.
- Orthofer, F.T. 1978. Processing and utilization, pp. 220-227. In A.G. Norman, ed. **Soybean Physiology, Agronomy, and Utilization**. Academic Press Inc., New York, New York.
- Ortloff, S. 2002. Good manufacturing practices for shelled goods cold storage and shelled goods dry storage. **American Peanut Council Good Management Practices**, Clint Williams Company, Madill, Oklahoma.
- Owen, E.B. 1955. Factors affecting the viability of seed in storage, pp. 4-77. In **The Storage of Seeds for Maintenance of Viability**. Bulletin 43, Commonwealth Bureau of Pastures and Field Crops, Hurley, Berks.
- Panobianco, M., R.D. Vieira, F.C. Krzyzanowski and J.B. Franca Neto. 1999. Electrical conductivity of soybean seed and correlation with seed coat lignin content. **Seed Sci. & Technol.** 27: 945-949.
- Parde, S.R., R.T. Kausal, D.S. Jayas and N.D.G. White. 2002. Mechanical damage to soybean seeds during processing. **J. Stored Prod. Res.** 38 (4): 385-394.
- Perez, M.A. and J.A. Arguello. 1995. Deterioration in peanut (*Arachis hypogaea* L. cv. Florman) seeds under natural and accelerated aging. **Seed Sci. & Technol.** 23: 439-445.
- Peter, K.V. 2004. Sesame, pp. 257-270. In **Handbook of Herbs and Spices Vol. 2**. Woodhead Publishing Ltd., CRC press, Cambridge.

- Phyo, A.K., J. Duangpatra, W. Chanprasert and R. Kaveeta. 2004. Storage potential of three different types of in-shell peanut seeds under ambient and cold room conditions. **Kasetsart J. (Nat. Sci.)** 38: 21-30.
- Priestley, D.A and A.C. Leopold. 2006. Lipids changes during natural aging of soybean seeds. **Physiologia Plantarum** 59 (3): 467-470.
- Promchote, P. 2000. **Deterioration of Peanut Seeds with Different Maturity Levels**. M.S. Thesis, Kasetsart University.
- Promchote, P., J. Duangpatra and W. Chanprasert. 2005. Influence of maturity and lipid composition on seed deterioration in large-seeded and medium-seeded peanut. **In Prospects and Emerging Opportunities for Peanut Quality and Utilization Technology**. International Peanut Conference 2005. Kasetsart University, Bangkok.
- Ramamoorthy, V. 1989. **Maintenance of Vigor and Viability of Stored Gingelly (*Sesamum indicum* L.) Seeds**. M.Sc. Dissertation, Tami/Nada Agricultural University.
- Rao, N.K., D.V.S.S.R. Sastry and P.J. Bramel. 2002. Effects of shell and low moisture content on peanut seed longevity. **Peanut Sci.** 29: 122-125.
- Richharia, R.H. and D.R. Dhodapkar. 1939. Delayed germination in sesame, *Sesamum indicum*. **Indian Agric. Sci. J.** 10 (1): 93-95.
- Roberts, E.H. 1986. Quantifying seed deterioration, pp. 101-123. *In* M.B. McDonald, Jr. and C.J. Nelson, eds. **Physiology of Seed Deterioration**. Crop Science Society America Special Publication Number 11, Madison, Wisconsin.

- Romkaew, J. 1996. **Influence of Seed Vigor on Field Emergence, Growth, Yield and Storability of Large-Seeded Peanut Seed.** M.S. Thesis, Kasetsart University.
- Saenong, S. 1987. Maintenance of soybean seed viability and its relation to grain yield, pp. 227-235. *In Soybean Research and Development in Indonesia.* Proc. of a Workshop held in Cipayung, Indonesia. CGPRT Centre, Bogar.
- Sanders, T.H., A.M. Schubert and H.E. Pattee. 1982. Maturity methodology and postharvest physiology, pp. 624-654. *In H.E. Pattee and C.T. Young, eds. Peanut Science and Technology.* American Peanut Research and Education Society, Inc., Yoakum, Texas.
- Sanguansat, B. 1996. **Seed Deterioration during Field Storage in Some Cultivars of Soybean and Effect of Drying Method on Seed Quality.** M.S. Thesis, Kasetsart University.
- Sarawat, P. 2001. Peanut (*Arachis hypogaea* L.). **A Guide Book for Field Crops Production in Thailand.** Field Crops Research Institute. Department of Agriculture, Ministry of Agriculture and Co-operatives, Bangkok.
- Sattler, S.E., L.U. Gilliland, M. Magallanes-Lundback, M. Pollard and D. Dellspenna. 2004. Vitamin E is essential for seed longevity and for preventing lipid peroxidation during germination. **Plant Cell** 16: 1419-1432.
- Siddque, M.A. and P.B. Goodwin. 1985. Conductivity measurements on single seeds to predict the germinability of french beans. **Seed Sci. & Technol.** 13: 643- 652.
- Singh, R.K. and H.H. Ram. 1996. Inheritance study of soybean seed storability using an accelerated aging test. **Field Crop Res.** 13:89-98.

- Slay, W.O., W.G. Ferguson and J.A. Pomplin. 1985. Some effects of conventional and low-oxygen atmosphere storage and processing methods on Florunner peanut seed. **Peanut Sci.** 12: 8-11.
- Spears, J.F. 2000. Germination and vigor response to seed maturity, weight, and size within the Virginia-type peanut cultivar, VA-C92R. **J. Seed Technol.** 22(1): 23-33.
- Srisombun, S. and S. Kaewmeechai. 2001. Soybean (*Glycine max* (L.) Merrill). **A Guide Book for Field Crops Production in Thailand.** Field Crops Research Institute. Department of Agriculture. Ministry of Agriculture and Cooperatives, Bangkok.
- Stonsaovapak, P. and C. Veeranishpong. 1986. Effect of containers on storability of groundnut seed, pp. 543-548. **In Proc. of The Fifth National Groundnut Conference**, held at The Faculty of Agriculture, Chiang Mai University, and the Sameng Upland Rice and Temperate Cereals Experiment Station, Chiang Mai.
- Suddhiyam, P. and S. Kritjanarat . 2003. Effect of the temperature for breaking seed dormancy on seed storability, pp. 226-232. **In Proc. of The Third National Conference on Sesame, Sunflower, Castor and Safflower**, held at Maejo University, Chiang Mai.
- \_\_\_\_\_, P. Prompunjai, O. Wannawong and S. Kritjanarat. 2007. Sesame seed storability in vacuum packages, pp. 74-83. **In Proc. of The Fifth National Conference on Sesame, Sunflower, Castor and Safflower**, Rajamangala University of Technology Lanna Nan, Lompong.
- Sung, J.M. 2008. Lipid peroxidation and peroxide-scavenging in soybean seeds during aging. **Physiologia Plantarum** 97(1): 85-89.

- Sung, J.M. and T.L. Jeng. 2006. Lipid peroxidation and peroxide-scavenging enzymes associated with accelerated aging of peanut seed. **Physiologia Plantarum** 91(1): 51-55.
- Tao, J.K. 1978. Factors causing variations in the conductivity test for soybean seeds. **J. Seed Technol.** 3: 10-18.
- Taweekul, N., W. Sangsit, A. Bandithwong and P. Ramsiri. 1994. Effects of shelling methods on quality of peanut seed cv Khon Kaen 60-1 and Khon Kaen 60-2, pp. 273- 279. *In Proc. of The Twelfth Thailand National Peanut Meeting*, held at The Charoen Hotel, Udon Thaini.
- \_\_\_\_\_, \_\_\_\_\_ and S. Sirisuntorn. 2002. Effect of pod drying by small dryer on germination and vigor of peanut seed, pp. 330-341. *In Proc. of The Sixteenth Thailand National Peanut Meeting*, held at Krungsri River Hotel, Ayutthaya.
- Teingtham, K and J. Duangpatra. 2005. Quality and storability of peanut seed produced by local farmer in rainfed area, pp. 39. *In Prospects and Emerging Opportunities for Peanut Quality and Utilization Technology*. International Peanut Conference 2005, Kasetsart University, Bangkok.
- TeKrony, D.M.and D.B. Egli. 1977. Relationship between laboratory indices of soybean seed vigor and field emergence. **Crop Sci.** 17: 573-577.
- \_\_\_\_\_, \_\_\_\_\_, A.D. Philips and T.W. Still. 1974. Effect of fungicide seed treatment on soybean germination and field emergence. **Proc. Assoc. Off. Seed Anal.** 64: 80-89.
- \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_. 1980. Effect of field weathering on viability and vigor of soybean seed. **Agron. J.** 72: 749-753.

- Torres, R.M., R.D. Vieira and M. Panobianco. 2004. Accelerated aging and seedling field emergence in soybean. **Sci. Agric. (Piracicaba, Braz.)**. 61 (5): 476-480.
- Turnipseed, E.B. 1993. **Deteriorative Changes in Soybean and Cotton Seed**. Ph.D. Dissertation. Mississippi State University.
- Vieira, R.D., J.A. Paiva A. and D. Perecin. 1999. Electrical conductivity and field performance of soybean seeds. **J. Seed Technol.** 21(1): 15-24.
- \_\_\_\_\_, A.S. Neto, S.R.M. Bittencourt and M. Panobianco. 2004. Electrical conductivity of the seed soaking solution and soybean seedling emergence. **Sci. Agric. (Piracicaba, Braz.)**. 6 (2): 164-168.
- \_\_\_\_\_, D.M. TeKrony, D.B. Egli, W.P. Bruenning and M. Panobianco. 2008. Temperature during soybean seed storage and the amount of electrolytes of soaked seeds solution. **Sci. Agric. (Piracicaba, Braz.)**. 65(5): 496-501.
- Wallace, S.U. 1988. Soybean seedlings emergence at high temperatures. **Plant and Soil J.** 109 (1): 139-140.
- Weiss, E.A. 2000. **Oilseed Crop**. 2<sup>nd</sup> ed. In E.A. Weiss, ed. Blackwell Science Pty Ltd., Carlton, Victoria.
- Whitty, E.B., B.L. Tillman and D.L. Wright. 2006. **Producing Quality Peanut Seed**. <http://edis.ifas.ufl.edu>. 27. 04.2009.
- Yin- adsavaphan, P., L. Supa and V. Bamrungsawat. 1986. A study on storability of groundnut seeds of the farm level, pp. 533-538. In **Proc. of The Fifth National Groundnut Conference**, held at The Faculty of Agriculture, Chiang Mai University and The Sameng Upland Rice and Temperate Cereals Experiment Station, Chiang Mai.

Zhang, M., M. Yoshiyama, T., Nagashima, Y. Nakagawa, T. Yoshioka, and Y. Esashi. 1995. Aging of soybean seeds in relation to metabolism at different relative humidities. **Plant and Cell Physio.** 36(7): 1189-1195.

**APPENDIX**

**Appendix Table 1** Analysis of variance of seed moisture contents of sesame, peanut and soybean stored under ambient condition for a period of 4 months

Source of Variation	d f	Mean Square
Replication	3	0.04
Storage Periods	2	35.88**
Error (a)	6	0.05
Treatment Combinations	14	44.20**
Storage Periods*Treatment combinations	28	1.18**
Error (b)	126	0.08
Total	179	

C. V. (a) = 3.45 %    C. V. (b) = 4.22 %

\*\* = Significantly different at  $P < 0.01$

**Appendix Table 2** Analysis of variance of germination percentages of sesame, peanut and soybean stored under ambient condition for a period of 4 months

Source of Variation	d f	Mean Square
Replication	3	74.33
Storage Periods	2	2371.76**
Error (a)	6	25.89
Treatment Combinations	14	2428.59**
Storage Periods*Treatment combinations	28	1405.85**
Error (b)	126	93.72
Total	179	

C. V. (a) = 7.33 %    C. V. (b) = 13.94 %

\*\* = Significantly different at  $P < 0.01$

**Appendix Table 3** Analysis of variance of first count germination (%) of sesame, peanut and soybean stored under ambient condition for a period of 4 months

Source of Variation	d f	Mean Square
Replication	3	31.70
Storage Periods	2	9472.20**
Error (a)	6	232.62
Treatment Combinations	14	4494.94**
Storage Periods*Treatment combinations	28	1568.20**
Error (b)	126	189.22
Total	179	

C. V. (a) = 29.48 %    C. V. (b) = 26.59 %

\*\* = Significantly different at  $P < 0.01$

**Appendix Table 4** Analysis of variance of germination index of sesame, peanut and soybean stored under ambient condition for a period of 4 months

Source of Variation	d f	Mean Square
Replication	3	9.15
Storage Periods	2	1718.15**
Error (a)	6	16.19
Treatment Combinations	14	813.35**
Storage Periods*Treatment combinations	28	130.09**
Error (b)	126	17.56
Total	179	

C. V. (a) = 20.21 %    C. V. (b) = 21.9 %

\*\* = Significantly different at  $P < 0.01$

**Appendix Table 5** Analysis of variance of after accelerated aging (%) of sesame, peanut and soybean stored under ambient condition for a period of 4 months

Source of Variation	d f	Mean Square
Replication	3	301.77*
Storage Periods	2	4544.07**
Error (a)	6	195.24*
Treatment Combinations	14	10728.50**
Storage Periods*Treatment combinations	28	1290.04**
Error (b)	126	87.38
Total	179	

C. V. (a) = 26.1 %    C. V. (b) = 17.5 %

\* = Significantly different at  $P < 0.05$

\*\* = Significantly different at  $P < 0.01$

**Appendix Table 6** Analysis of variance of electrical conductivities of sesame, peanut and soybean stored under ambient condition for a period of 4 months

Source of Variation	d f	Mean Square
Replication	3	1927.46
Storage Periods	2	97030.4**
Error (a)	6	1159.28
Treatment Combinations	14	504379.0**
Storage Periods*Treatment combinations	28	14386.9**
Error (b)	126	1469.15
Total	179	

C. V. (a) = 16.25 %    C. V. (b) = 18.3 %

\*\* = Significantly different at  $P < 0.01$

**Appendix Table 7** Analysis of variance of field emergence (%) at 7 DAS of sesame, peanut and soybean stored under ambient condition for a period of 4 months

Source of Variation	d f	Mean Square
Replication	3	7.61
Storage Periods	1	12297.0**
Error (a)	3	3.71
Treatment Combinations	14	198.32**
Storage Periods*Treatment combinations	14	175.04*
Error (b)	84	28.89
Total	119	

C. V. (a) = 93.9 %    C. V. (b) = 44.35 %

\* = Significantly different at  $P < 0.05$

\*\* = Significantly different at  $P < 0.01$

**Appendix Table 8** Analysis of variance of field emergence (%) at 14 DAS of sesame, peanut and soybean stored under ambient condition for a period of 4 months

Source of Variation	d f	Mean Square
Replication	3	68.69
Storage Periods	1	10233.5**
Error (a)	3	83.09
Treatment Combinations	14	2944.27**
Storage Periods*Treatment combinations	14	1742.9*
Error (b)	48	54.7
Total	119	

C. V. (a) = 21.27 %    C. V. (b) = 17.26 %

\* = Significantly different at  $P < 0.05$

\*\* = Significantly different at  $P < 0.01$

**Appendix Table 9** Analysis of variance of field emergence (%) at 21 DAS of sesame, peanut and soybean stored under ambient condition for a period of 4 months

Source of Variation	d f	Mean Square
Replication	3	38.69
Storage Periods	1	11227.6**
Error (a)	3	71.96
Treatment Combinations	14	3518.56**
Storage Periods*Treatment combinations	14	1952.92**
Error (b)	84	62.90
Total	119	

C. V. (a) = 18.21 %    C. V. (b) = 17.03 %

\*\* = Significantly different at  $P < 0.01$

**Appendix Table 10** Analysis of variance of field emergence (%) at 28 DAS of sesame, peanut and soybean stored under ambient condition for a period of 4 months

Source of Variation	d f	Mean Square
Replication	3	96.02
Treatment Combinations	14	3614.47**
Error	42	
Total	59	

C. V. = 22.8 %

\*\* = Significantly different at  $P < 0.01$

**Appendix Table 11** Analysis of variance of field emergence index at 21 DAS of sesame, peanut and soybean stored under ambient condition for a period of 4 months

Source of Variation	d f	Mean Square
Replication	3	50.15
Storage Periods	1	7929.35**
Error (a)	3	63.25
Treatment Combinations	14	6150.07**
Storage Periods*Treatment combinations	14	279.99**
Error (b)	84	65.51
Total	119	

C. V. (a) = 26.48 %    C. V. (b) = 26.93 %

\*\* = Significantly different at  $P < 0.01$

**Appendix Table 12** Analysis of variance of field emergence index at 28 DAS of sesame, peanut and soybean stored under ambient condition for a period of 4 months

Source of Variation	d f	Mean Square
Replication	3	30.38
Treatment Combinations	14	2419.35**
Error	42	42.59
Total	59	

C. V. = 29.6 %

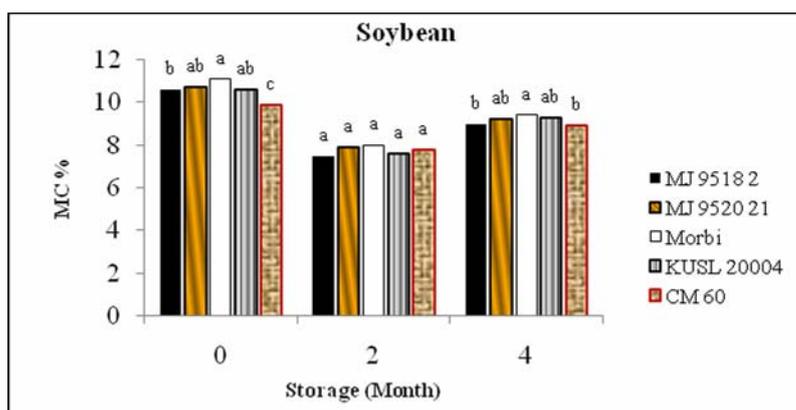
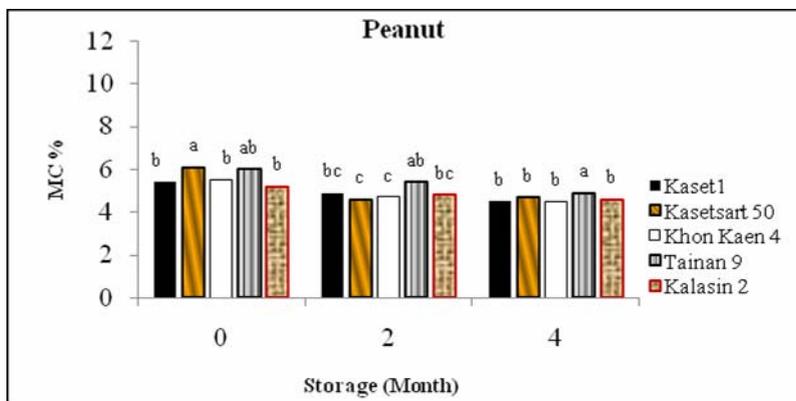
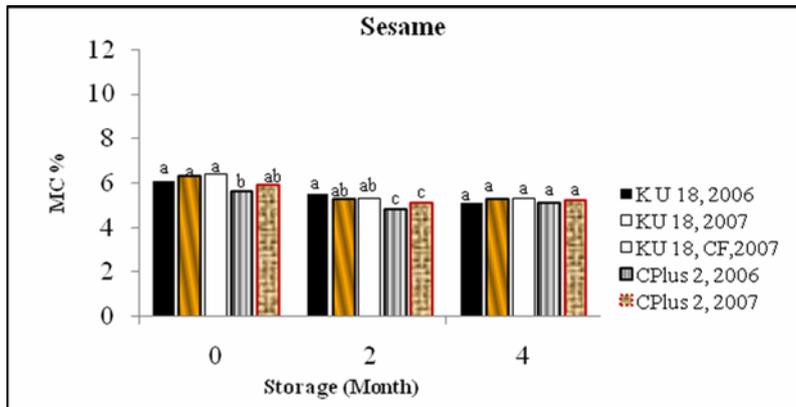
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**Appendix Table 13** Analysis of variance of seed yield (Kg/ha) of sesame, peanut and soybean stored under ambient condition for a period of 4 months

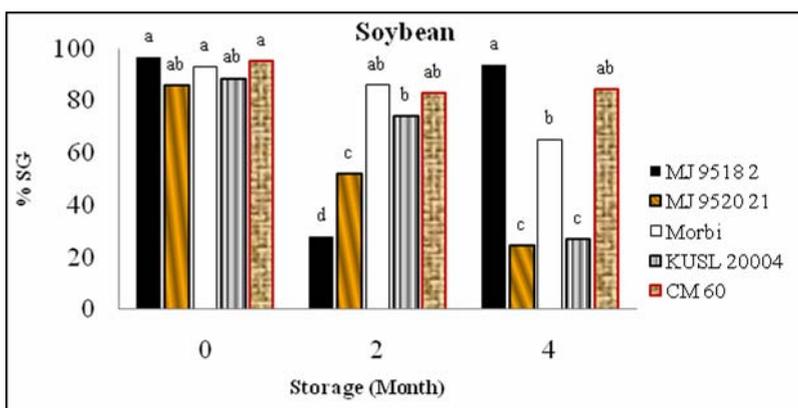
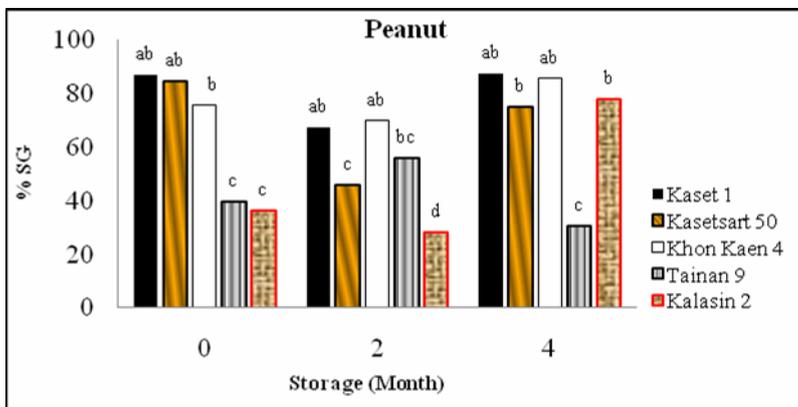
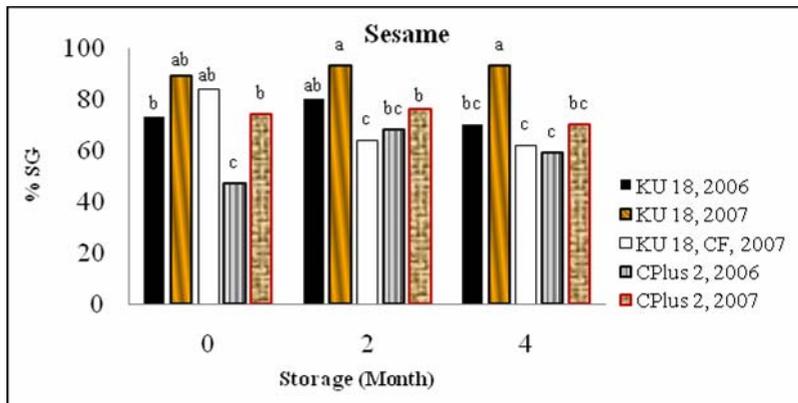
Source of Variation	d f	Mean Square
Replication	3	106677
Storage Periods	1	51240000**
Error (a)	3	73072
Treatment Combinations	14	4243100**
Storage Periods*Treatment combinations	14	2432380**
Error (b)	84	157591
Total	119	

C. V. (a) = 19.05 %    C. V. (b) = 27.98 %

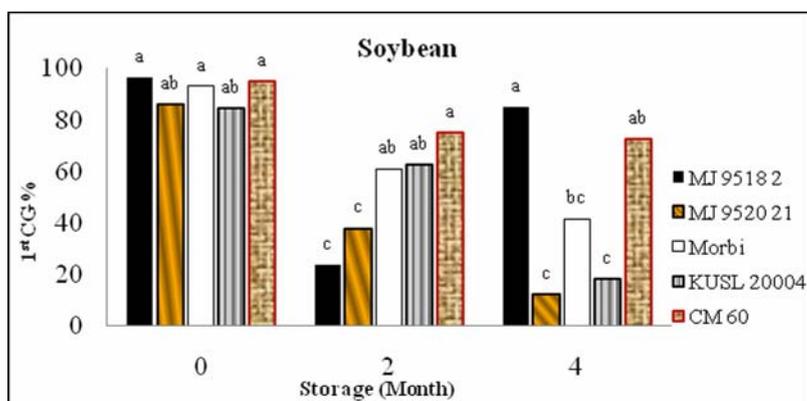
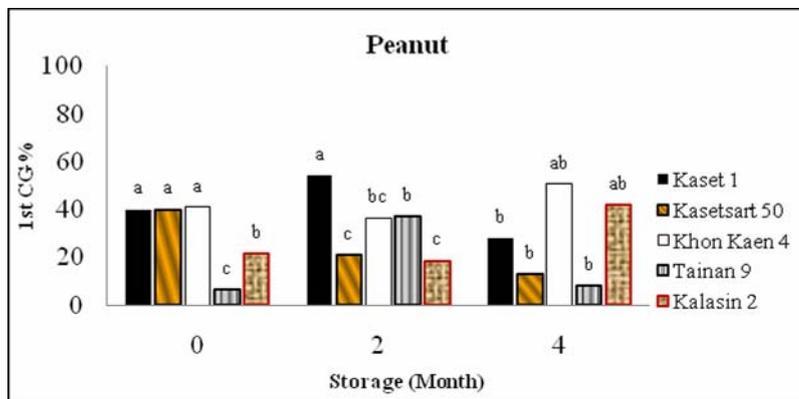
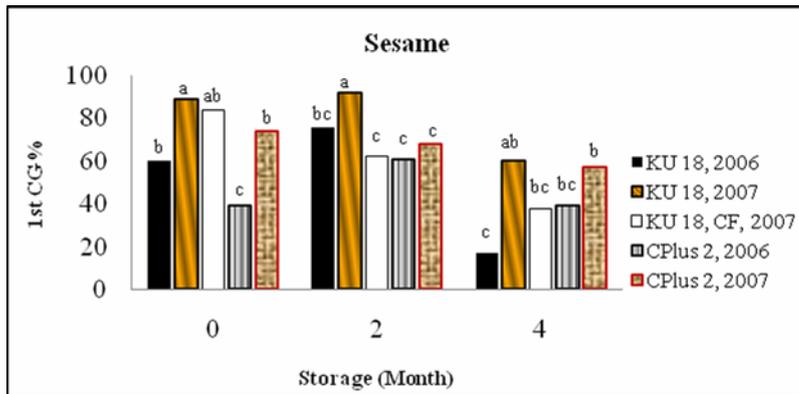
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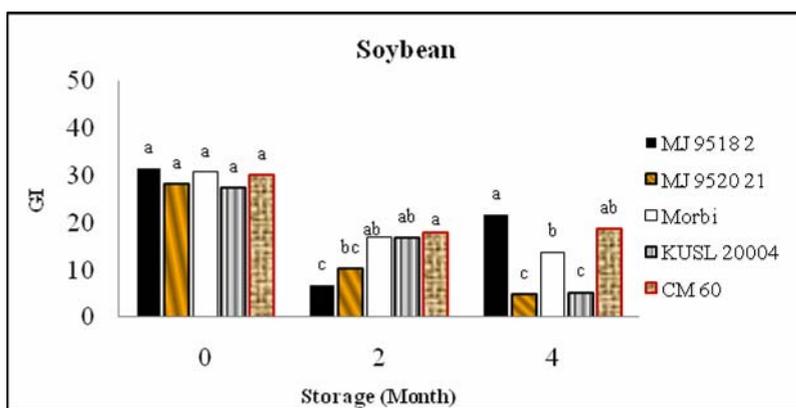
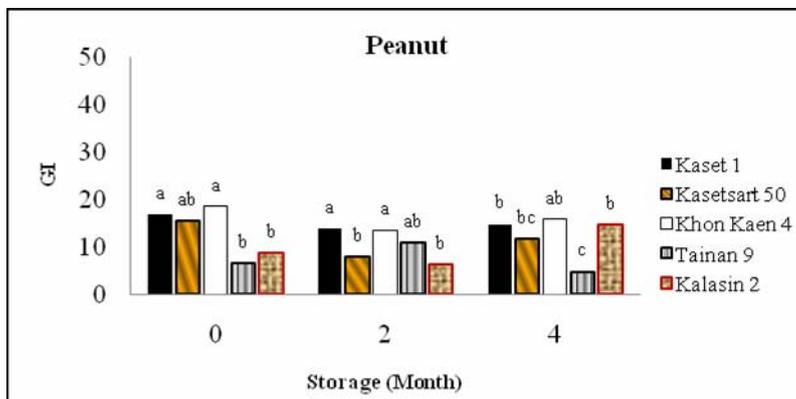
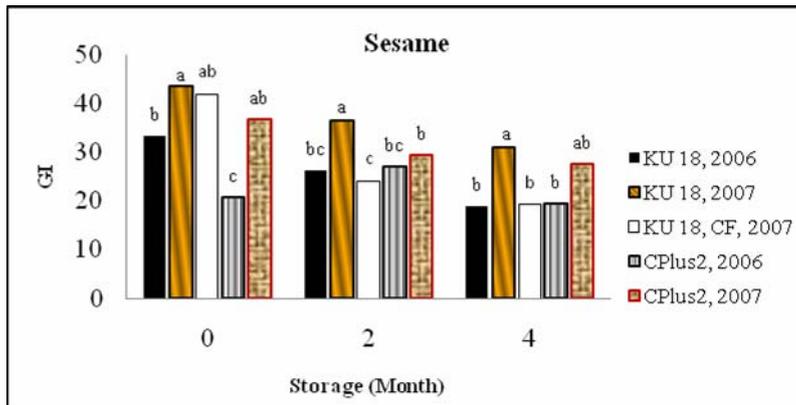
**Appendix Figure 1** Moisture content (%) of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.



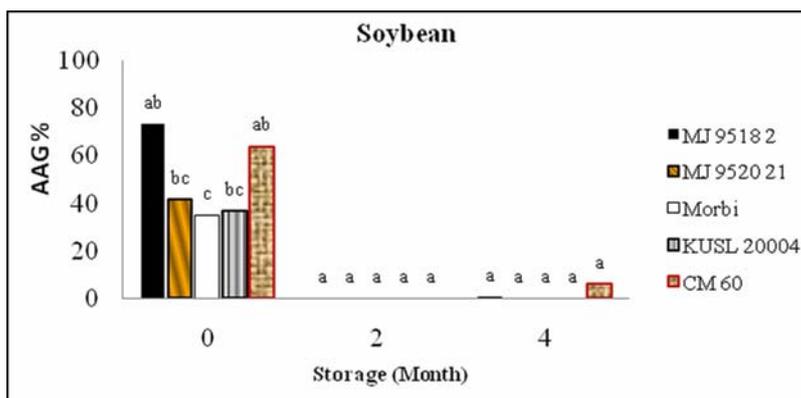
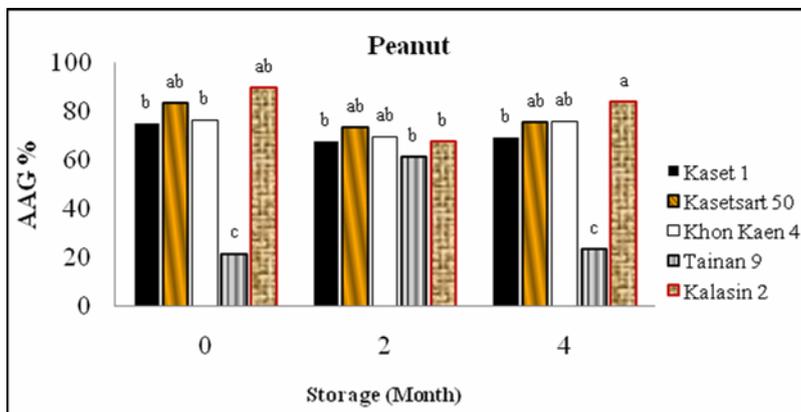
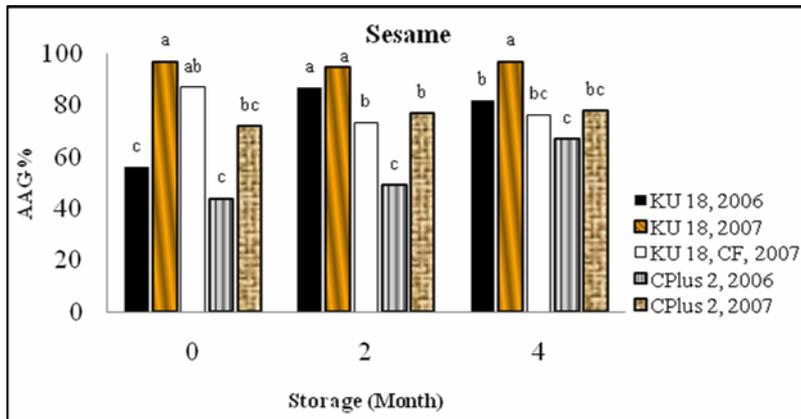
**Appendix Figure 2** Germination (%) of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.



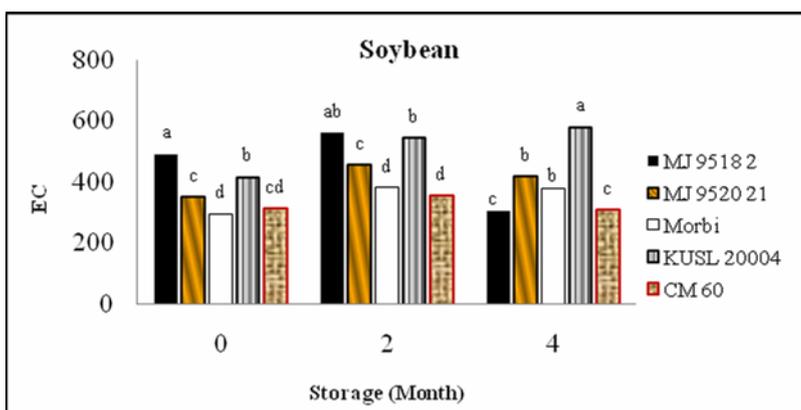
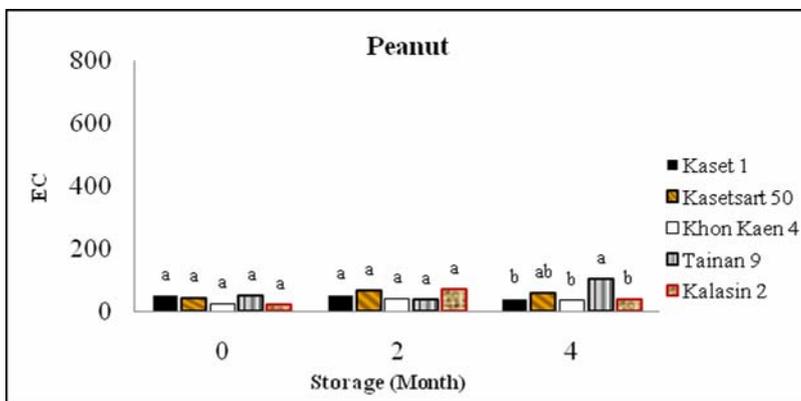
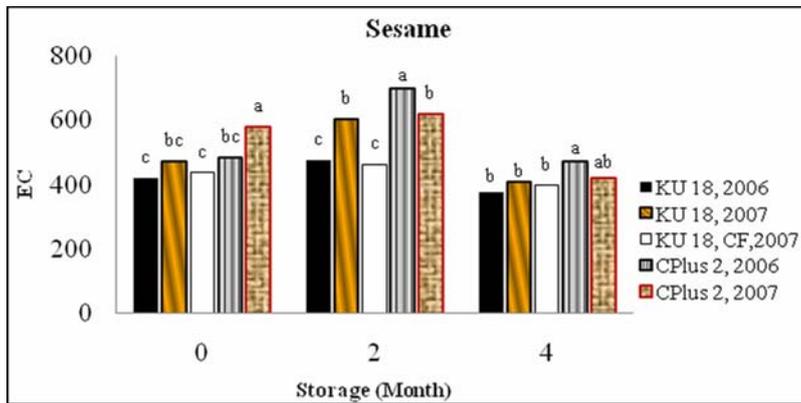
**Appendix Figure 3** First count germination (%) of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.



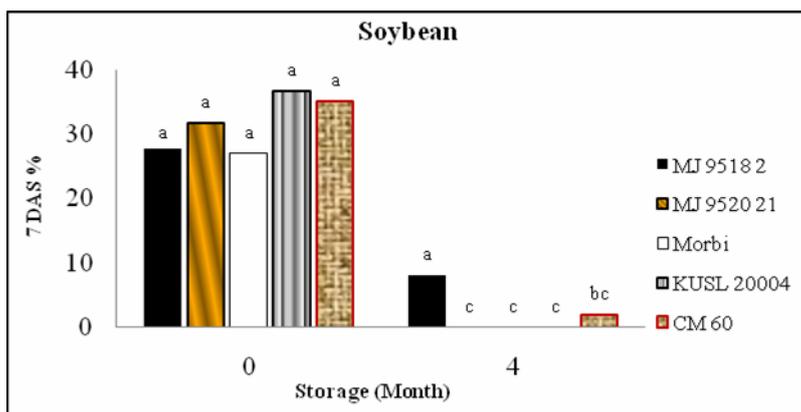
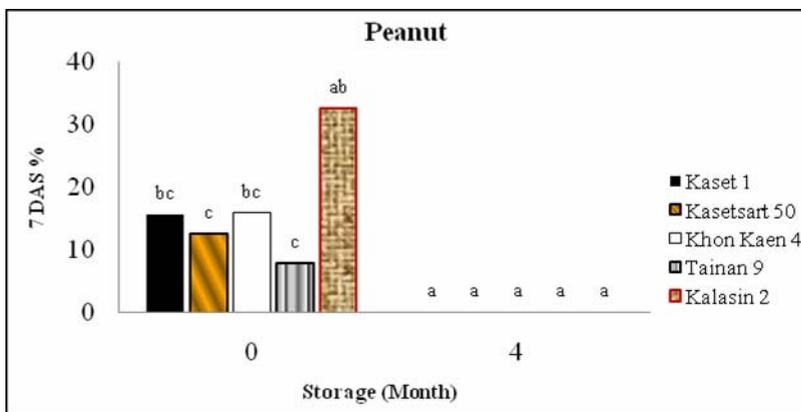
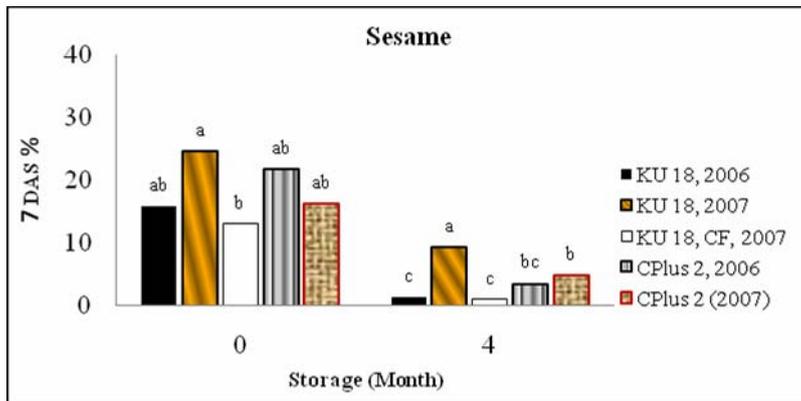
**Appendix Figure 4** Germination index of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.



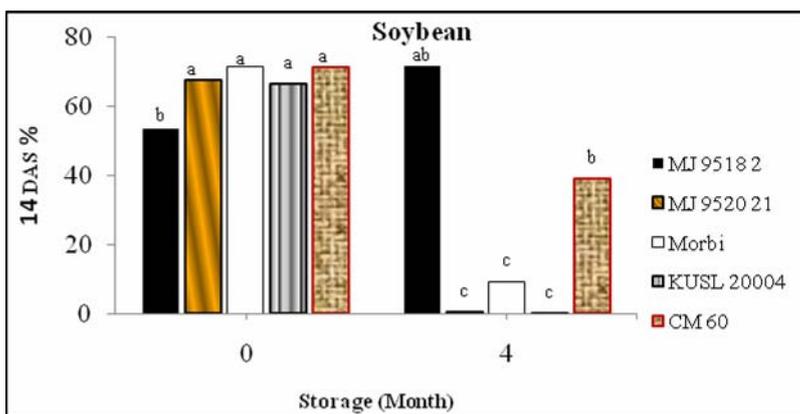
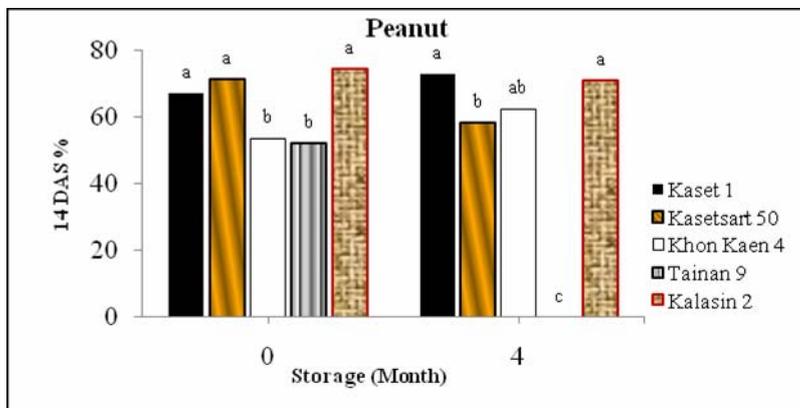
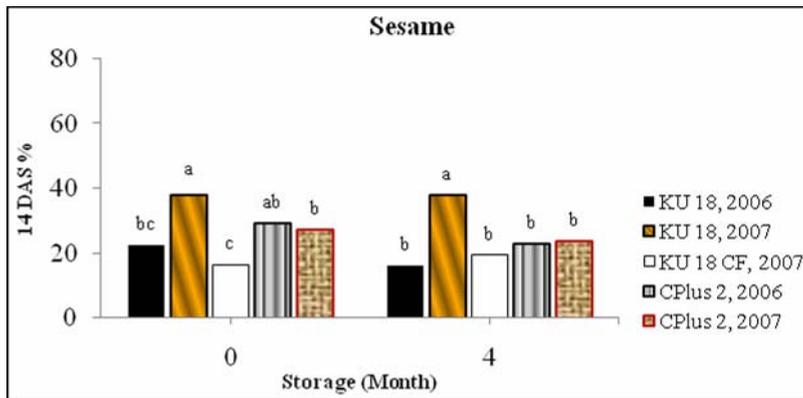
**Appendix Figure 5** Germination (%) after accelerated aging of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.



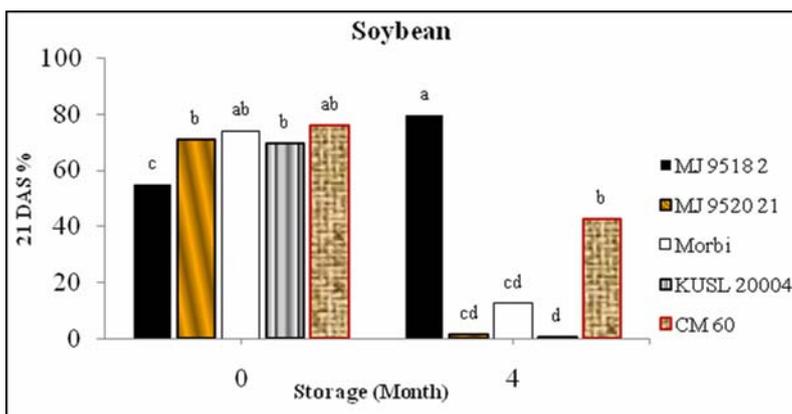
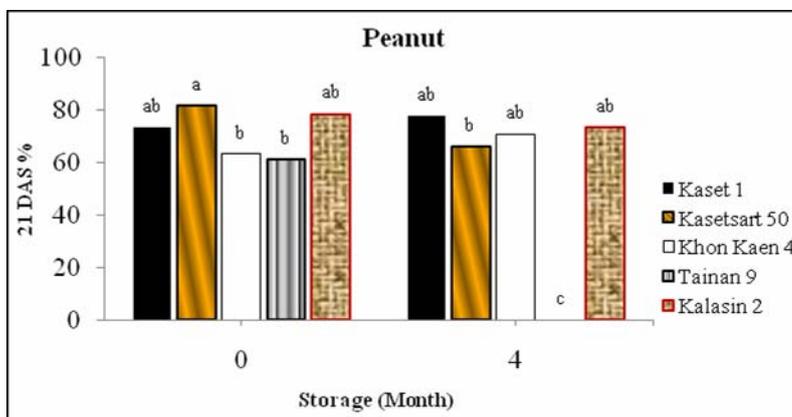
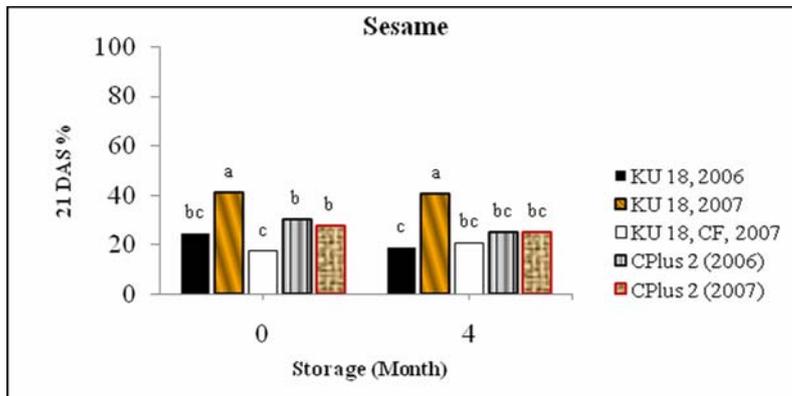
**Appendix Figure 6** Electrical conductivity ( $\mu\text{S cm}^{-1}\text{g}^{-1}$ ) of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.



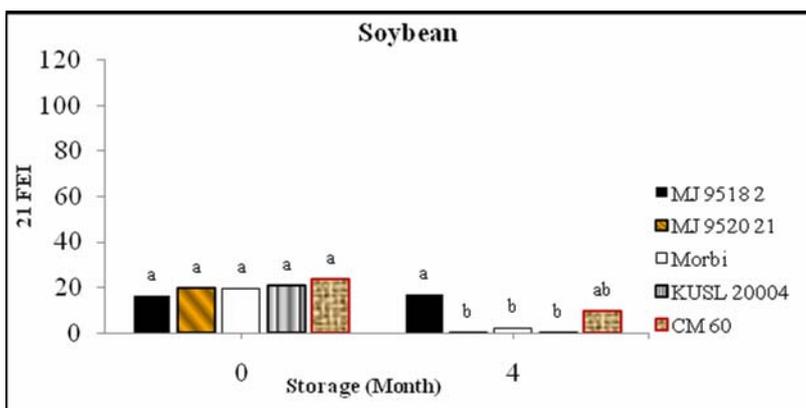
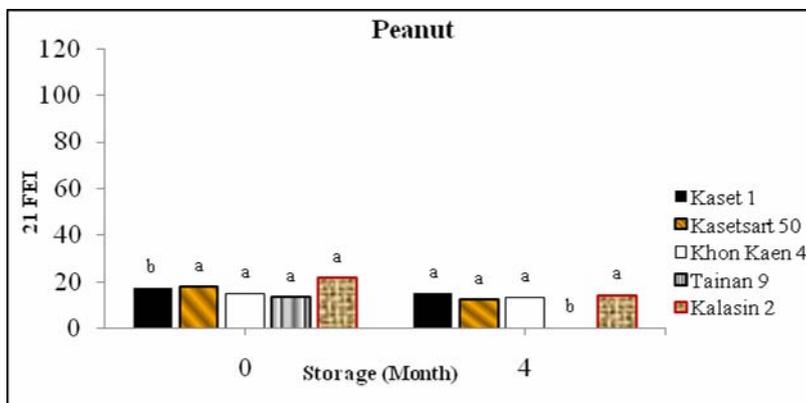
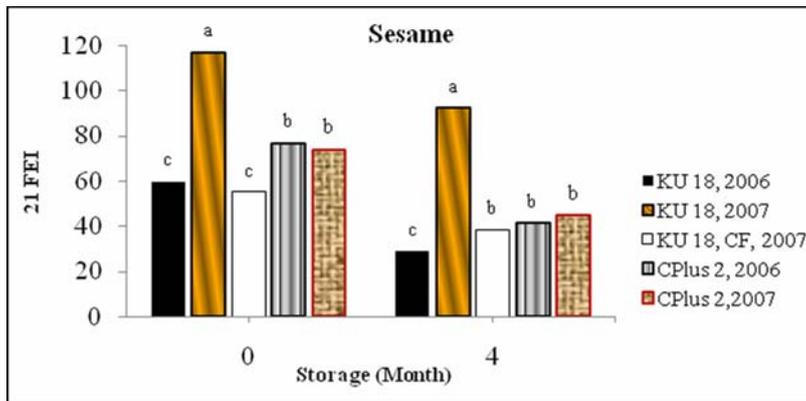
**Appendix Figure 7** Field emergence (%) at 7 DAS of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.



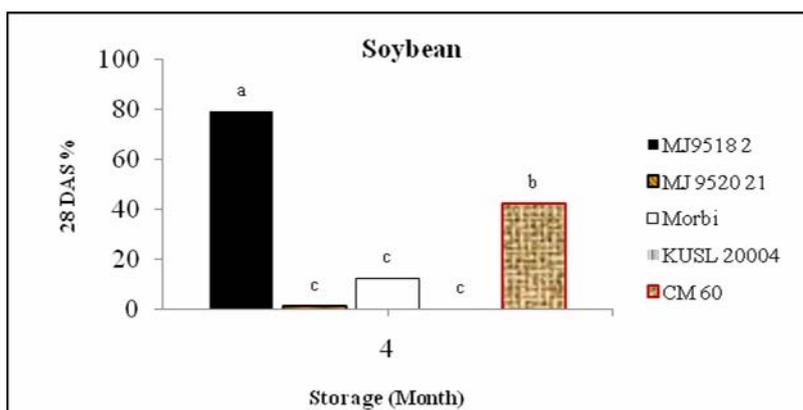
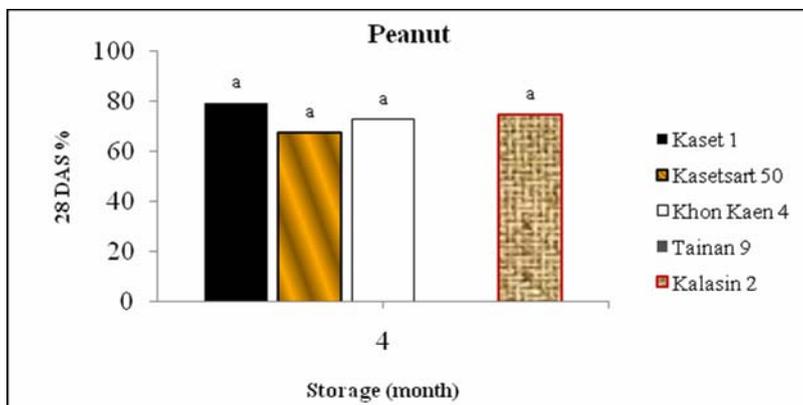
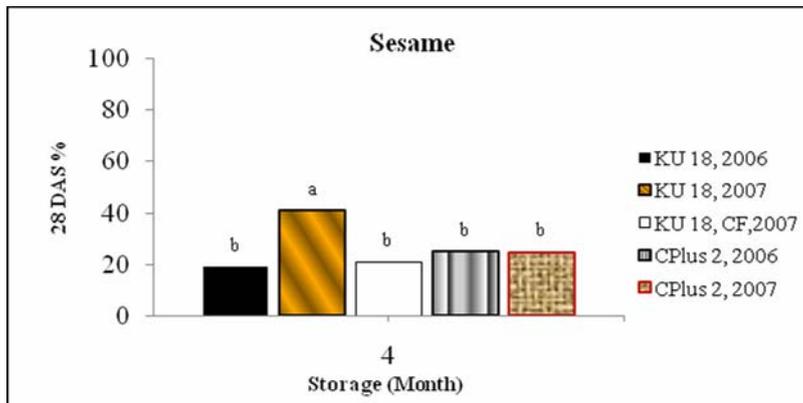
**Appendix Figure 8** Field emergence (%) at 14 DAS of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.



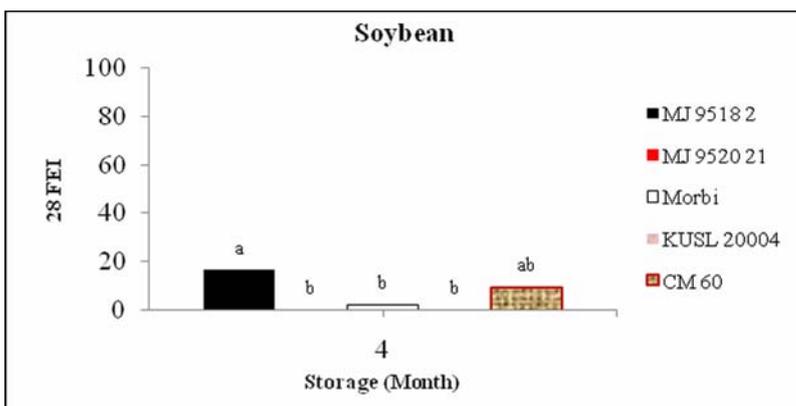
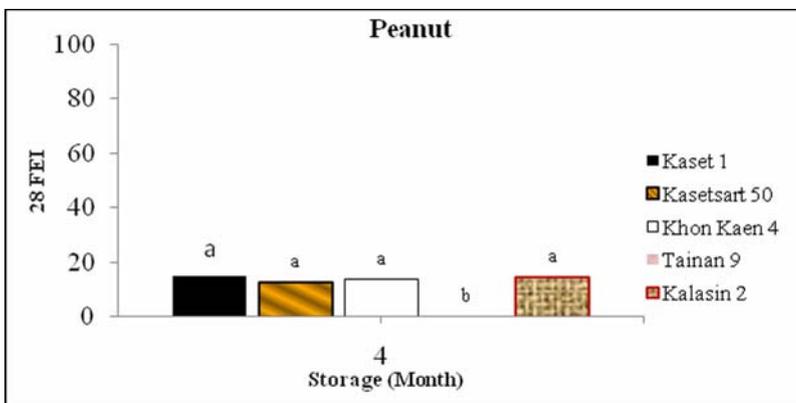
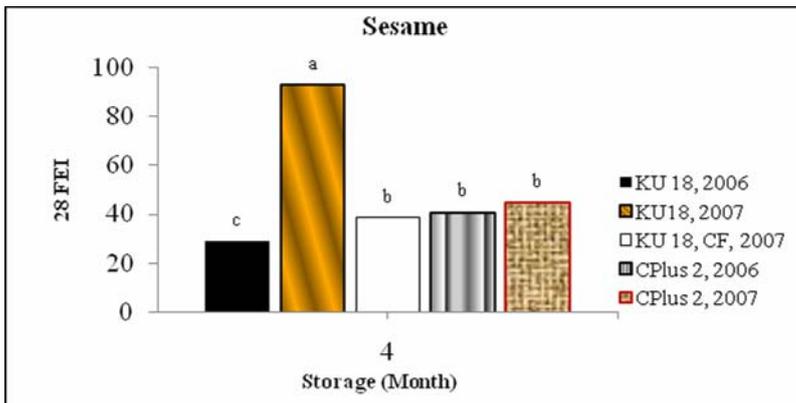
**Appendix Figure 9** Field emergence (%) at 21 DAS of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.



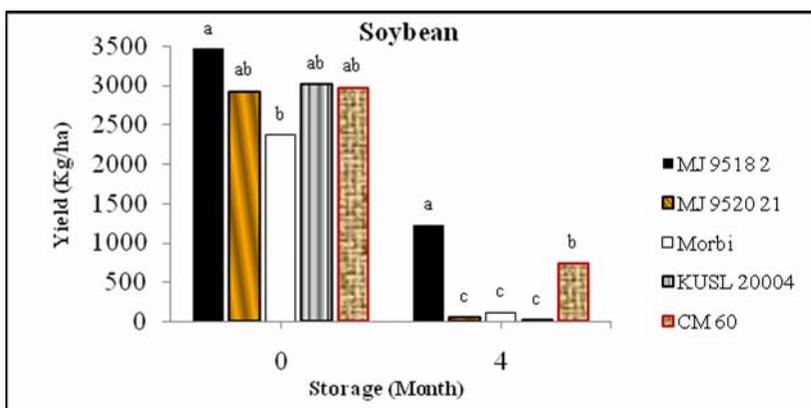
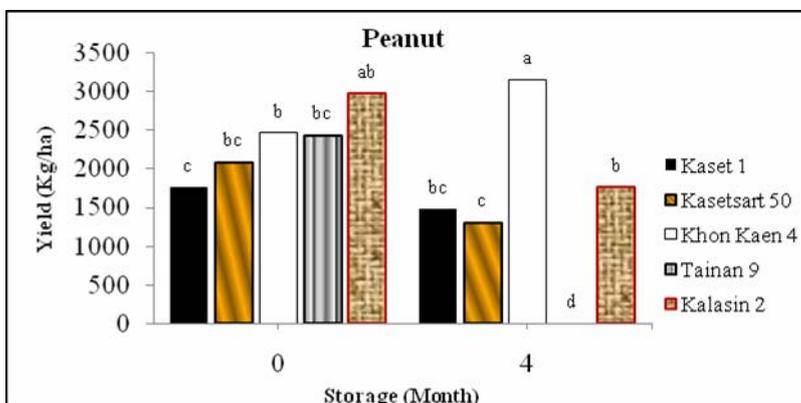
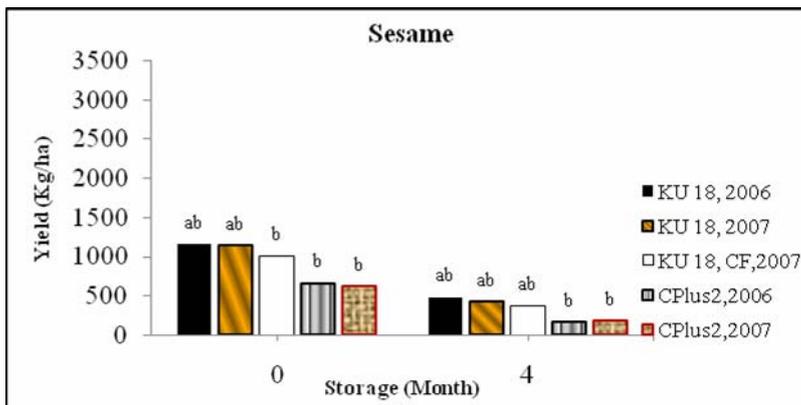
**Appendix Figure 10** Field emergence index at 21 DAS of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.



**Appendix Figure 11** Field emergence (%) at 28 DAS of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.



**Appendix Figure 12** Field emergence index at 28 DAS of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.



**Appendix Figure 13** Yield (Kg/ha) of sesame, peanut and soybean stored under ambient condition for the periods of 4 months.

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