SAFE STORAGE GUIDELINES FOR RYE AND CANOLA

BY

SATHYA GUNASEKARAN

A Thesis
Submitted to the Faculty of Graduate Studies in
Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE

Department of Biosystems Engineering
University of Manitoba
Winnipeg, Manitoba

THE UNIVERSITY OF MANITOBA

FACULTY OF GRADUATE STUDIES

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MASTER OF SCIENCE

DEDICATED TO

Miss Thivya Gunasekaran

ABSTRACT

Canada produces 0.32 million tonnes of rye and 6.9 million tonnes of canola annually. Moisture content and storage temperature are the two major physical factors that influence the deterioration of grain after harvest. The objectives of this work were to determine the rate of deterioration of rye and canola (sometimes referred to as grains) at various moisture and temperature conditions; and to develop safe storage guidelines. Rye and canola with different initial moisture contents (10.0, 12.5, 15.0, and 17.5% (wet basis, wb) for rye and 7.5, 10.0, 12.5 and 15.0% (wb) for canola) were stored at four different temperatures (10, 20, 30 and 40°C) for 16 weeks. Germination, moisture content and appearance of visible mould were measured every week; fatty acid values were measured once every two weeks; and invisible moulds were identified once every four weeks. Moisture content, temperature and storage period had significant effects on germination rate of both the grains (α=0.05). Germination rate of the 17.5% moisture content rye samples and 15.0% moisture content canola samples stored at 40°C reached 0% during the 5th and 4th week, respectively. But it remained above 80% for the lowest moisture samples (10.0% for rye and 7.5% for canola) stored at 10°C even after the 16th week. Moisture content of the samples stored at 10°C increased slightly over time and there were no significant changes in the moisture contents of the samples stored at 20°C. But that of the samples stored at 30°C reached 10.0-13.0% (rye) and 5.0-7.0% (canola); and at 40°C, it decreased to 5.0-6.0% (rye) and 2.0-4.0% (canola) by the 16th week of the study. High moisture samples lost moisture rapidly with increased storage temperature and time. The visible mould started appearing during the first week of storage in the high moisture samples (15 and 17.5% for rye; and 12.5 and 15% for canola) stored at 40°C.

Appearance of visible mould increased with increasing moisture content and storage temperature. All the samples stored at 40°C showed visible mould irrespective of the moisture content, similarly all the highest moisture samples (17.5% for rye and 15.0% for canola) also showed visible mould regardless of the storage temperature. *Aspergillus* and *Penicillium* species occurred predominantly in both the grains throughout the study. Initially, the fatty acid values (FAV) of rye and canola samples were 14.74 ± 1.3 and 22.05 ± 1.5 mg KOH/100 g of dry grain, respectively. The values increased with increasing temperature and time. At the end, the FAV of the 17.5% moisture content rye samples stored at 40°C, had increased to the maximum of 42 mg KOH/100 g of dry grain and that of the 15.0% moisture content canola samples stored at 30°C was 590 mg KOH/100 g of dry grain by the 4th week. Moisture content, storage temperature and time had significant effects on the FAV of both the grains. Rye with <15% moisture content and canola with <10% moisture content can be stored at ≤20°C for more than 15 weeks without any considerable quality loss, whereas rye with 17.5% moisture content and canola with 15% moisture content stored at 40°C would have only less than week for post harvest treatments. The available time for the post harvest treatments decreases with increased moisture content and storage temperature.

Keywords: rye, canola, temperature, moisture content, safe storage period.

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1. INTRODUCTION

1.1 Harvesting and post harvest operations of grains in Canada

Canada produces around 57 million tonnes of grains (including cereals, oilseeds and pulses) annually, and exports 70% of its total production (CWB 2005). Most of the grains in Canada are seeded in April or May and harvested in the fall. Weather patterns during harvesting sometimes cause the crop to be harvested at high moisture levels which are not suitable for safe storage or the farmers may not even have the chance to harvest the grain before winter which leads to a large amount of grain spoilage. In 1996, only 50% of the cultivated wheat crop was harvested, because of the wet autumn weather (Anonymous 1997). In 2002, the unexpected weather conditions during harvest delayed the harvest of the canola crop and the harvest could not be completed till 2003 (DeClercq and Daun 2003). In general, the crop is harvested when the moisture content of the grain is about 20-35% and the temperature ranges between 10-35°C. The grain can not be stored safely under these conditions. So, post harvest operations like drying and cooling of the grain at the farm before and during storage is not an uncommon practice in Canada (CWB 2005).

1.2. Rye

Rye (*Secale cereale* L.) accounts for 1.2% of the total world cereal production. Canada cultivates about 0.12 million ha of rye annually with an average production of 0.32 million tonnes. Rye is considered to be the second major raw material for the bread industry next to wheat. Rye has no virtual dormancy which leads to pre-harvest sprouting. Swathing of rye is carried out at 45% moisture content followed by threshing at around 22% moisture content (Hartman 1999). Therefore, it is necessary to go for early

harvesting and proper drying before storage. Traditionally rye has been used in the bread industry and its usage in feed mills has increased in importance. Rye which goes for milling and baking needs has to meet specified commercial and hygienic demands. It should be of good quality and have low moisture content (14% or less) and for long term storage it needs to be dried further to 12% moisture content (Weipert 1996).

1.3 Canola

Canola (*Brassica napus* L.) is the second largest oil seed crop in the world next to soybean and it accounts for 13% of the world's oilseed supply (Raymer 2002). Canola ranks first in Canada's oilseed production. Canada cultivates 4.52 million ha of canola and produces 6.9 million tonnes every year. Swathing of canola is done when the average seed moisture is 35-40%. Under good weather conditions, the canola seeds can lose 1-2% moisture every day. Threshing the swathed crop is carried out at approximately 12% moisture content or slightly more (Mills 2001). Canola is mainly used for oil extraction and according to the Canadian Grain Commission the standard moisture content for canola oil extraction is 8.5%. So, the threshed canola needs to be dried further for crushing. Freshly harvested canola maintains a high rate of respiration up to six weeks before becoming dormant. This high respiration process is called sweating of canola, which is considered to be a very unstable condition and needs careful monitoring. When fresh, wet canola is held under dry and cool conditions the effect of sweating is reduced considerably. Canola grain harvested at greater than 8% moisture content at 25°C must be dried immediately to avoid spoilage (Anonymous 2005).

1.4 Post harvest treatments

Moisture content and temperature of the grain during harvest determine the safe storage period. Conditioning the freshly harvested moist warm grain is an important operation before it goes for processing or further storage, to make sure that the grain meets the requirements of processes like baking, milling, oil extraction or safe storage. Conditioning refers to the movement of air through the grain bulk to ensure safe storage over a period of time. Conditioning systems dry and cool the freshly harvested moist and warm grain and prevent spoilage during storage. The conditioning step permits long term storage of grains without any quality loss, increases the quality and marketability of the grain, and also reduces the field losses by allowing early harvest (Bala 1997).

Drying and cooling are the two important post-harvest treatments which immediately follow the harvest. According to Schroth (1996), once the grain is harvested the farmer can have the following options to bring it to safe storage conditions. The grain can be dried in a heated air dryer and cooled; or ambient air can be used to dry and cool the grain. The choice of either of the conditioning systems depends on the grain condition and the weather conditions. If the harvested grain can be kept for a long enough period at the harvested moisture and temperature conditions without any spoilage, then the farmer can go for ambient air drying and can reduce the energy cost. However, use of ambient air takes a longer time than the heated-air drying method. So, the period for which the grain can be kept safely at the given condition influences the choice of the post-harvest treatment options. Rate of drying and rate of cooling also depend on the available time limit for that particular operation. High moisture grain at high temperature may need to

be dried and cooled more quickly than lower moisture grain at lower temperature. The harvested warm moist grain must be cooled and dried before spoilage starts occurring. The farmer can keep the fresh grain only for a specific period of time to do post harvest conditioning operations. As mentioned, it varies with respect to grain moisture content and the temperature. So, guidelines must be developed for all the common grains at all possible moisture contents and temperatures to provide farmers information on the number of days available for completion of post harvest operations before grain deterioration occurs.

Safe storage of grain may be defined as the time period during which the grain can be stored safely without any significant loss in its quality and quantity. According to Jayas (1995), seed maturity and condition; moisture content, storage temperature, storage time, molds, insects, mites, dockage, climate; and the storage and handling methods are the factors that affect the quality of the stored grain. Muir (2001) reported that rate of germination, fat acidity value (FAV), mould growth, physical appearance and nutritive values are the factors, all or some of which need to be monitored continuously to access the condition of the stored grain.

1.5 Objectives

1. To determine the rate of deterioration of rye at 10.0, 12.5, 15.0 and 17.5% initial moisture contents (wb) stored at 10, 20, 30 and 40°C.
2. To determine the rate of deterioration of canola at 7.5, 10.0, 12.5 and 15.0% initial moisture contents (wb) stored at 10, 20, 30 and 40°C.
3. To develop safe storage guidelines for both the grains.

2. LITERATURE REVIEW

2.1 Rye

Canada has a major share in the world's rye trade although it is not a major producer. It exports more than half of its production every year. Rye can be grown in areas which are not suitable for other cereal grains due to its extreme hardiness drought resisting property and its ability to grow in sandy soils of low fertility. Swathing of fall rye may begin at around 45% seed moisture content, which is called milk stage. Under dry growing conditions this stage occurs 9-10 days prior to straight combining. Generally to avoid sprouting problems, swathing is carried out when there is no longer any green tinge to the crop. Delayed swathing may increase the risk of shattered grain heads. So, judgment must be made to balance the risks of sprouting and shattering (Hartman 1999).

2.2 Canola

The Canadian oilseed sector consists of canola, flaxseed, soybean, sunflower seed, mustard and safflower seed. In Western Canada, canola is the dominant oilseed which is considered as the second most valuable crop next to wheat. Seed production of canola depends on the weather patterns, crop rotation requirements and international commodity prices. Harvesting of canola is carried out at higher seed moisture levels and field drying is done before storage. Even though 8% moisture content is considered a safe moisture level for storing canola over a prolonged period, it is considered dry and assigned straight grade at 10% moisture content (Raymer 2002).

2.3 Need of drying

Harvested wet grain has to be dried to a safe moisture level before it enters the storage structure. According to Bala (1997) drying the grain has the following advantages:

1. it extends the available harvest period;
2. it reduces the field loss by promoting earlier harvest;
3. it reduces the risk of spoilage in storage;
4. it improves the marketability and acceptability of the grain;
5. it affords alternative markets for the grain; and
6. it eliminates necessary swathing by obtaining dry grain.

Drying can be carried out by forcing near-ambient or heated air through the grain. The choice of near ambient or heated air drying, and rate of drying depend on the available time period to dry the grain before spoilage occurs. The available drying time varies from grain to grain depending on the grain condition and weather patterns. For example, high moisture grain (>25% for rye) spoils faster and must be dried using heated air but rye at 16-18% moisture can be dried using ambient air in most years under Western Canadian weather conditions.

2.4 Factors influencing safe storage

Jayas (1995) reported that temperature, moisture, carbon dioxide (CO_2), oxygen (O_2), grain characteristics, microorganisms, insects, mites, rodents, birds, geographical location and granary structure are the important factors to be considered during grain storage. Mills (1996) classified the above listed factors into two broad categories as biotic and abiotic factors. Abiotic factors include moisture content and temperature of the stored

grain, storage period, intergranular atmospheric composition, engineering properties of the grain and types of storage structure. Biotic factors include the grain itself, physical seed characteristics, microorganisms, insects, mites, rodents, and birds. There is a strong correlation between the biotic variables and their abiotic environment. There are interrelations among the stored grain bulk, biotic and abiotic variables. The abiotic variables influence the presence and development of biotic variables (Sinha 1973; Wallace et al. 1983) and the improper interaction among biotic and abiotic variables causes grain deterioration.

2.4.1 Moisture and temperature

Water content and temperature of the stored grain are the primary physical factors which influence the deterioration of stored grain. High moisture content of the stored grain is the first and most important factor that speeds up the deterioration followed by high temperature (Jayas and White 2003). When the storage temperature and moisture exceeds a particular level, microflora and mites will multiply and the grain will spoil quickly (Sinha 1973; Wallace et al. 1983). White (1995) studied the insects, mites and insecticides in stored-grain ecosystems and reported that moisture and temperature are the primary factors influencing the survival and multiplication of biological materials in a grain bulk. White and Sinha (1980) reported that, in moist and warm grain, insects, mites and fungi can increase rapidly and produce moisture, heat and carbon dioxide by respiration, which further leads to deterioration of the grain bulk. Mills and Sinha (1979) studied the safe storage period of rapeseed at different temperatures and found that mould needs at least 70% RH to grow.

Tipples (1995) reported that moisture content, water activity, and relative humidity (RH) affect the respiration rate of the stored grain and influence the growth and development of moulds and insects. If the moisture content of the stored grain can be maintained at a sufficiently low level, then that grain can be stored for many years without any significant loss in quality. Muir (2001) reported that higher moisture pockets inside the grain bulk can get spoiled and act as a niche for an infestation of mites and insects to multiply. White et al. (1999a) studied the effect of storage conditions on quality loss of hull-less and hulled oats and barley and they concluded that the rate of deterioration is higher under high temperature and moisture conditions than under cool and dry conditions. White et al. (1999b) studied the quality changes in stored solin, high linolenic acid and standard flax seed and concluded that there was slight change in the oil composition during six months of storage of flax seed, when stored at high moisture content. They also found that free fatty acid levels increased with increasing moisture content, temperature and time. They reported that at 8 % moisture content all the cultivars stored well without any significant spoilage. The rate of deterioration was higher in the grains stored at high temperature and high moisture content than when stored at low temperature and low moisture. Pixton et al. (1975) studied the changes in the quality of wheat during sixteen years of storage and found that dry wheat (11.9% moisture content) was not affected by any microorganisms even after a very long time of storage (more than 10 years), which explains that high moisture content is the main factor which influences the deterioration of the grain.

Zia-Ur-Rehman et al. (2002) studied the effect of storage temperature on nutritional changes in corn and found significant changes in the pH and titrable acidity values at higher temperatures. Increase in acidity leads to increase in free fatty acid values, which means increased grain deterioration. They also found that there was a gradual decrease in moisture content of the stored grain if the temperature was kept higher. Grain stored at higher temperatures (25 and 45°C) lost a considerable amount of total soluble sugars and lysine. There was also significant protein and starch degradation. They also reported that the biochemical changes occurred to various extents which mainly depended on the storage temperature and time of storage. Storage conditions had a significant effect on important nutritional values of stored rice, wheat and maize; and the change was severe at elevated storage temperatures. There were no considerable changes in the nutritional qualities of the grains stored at 10°C (Zia-Ur-Rehman 2006).

2.4.2 Storage period

Storage period also plays an important role in deterioration. Mills (1996) reported that the duration of the intended storage period influences the maximum moisture level of the stored product that can be tolerated for safe storage. Figure 1 shows the safe storage period of wheat at different moisture and temperature combinations.

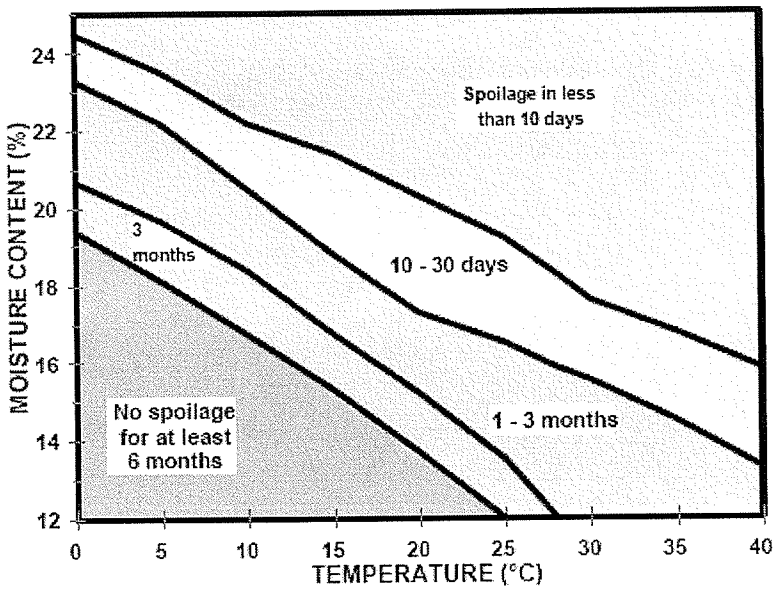


Fig.1. Estimated storage life of fresh, sound wheat (Mills 1989).

Wheat with high moisture content (18%) and at high temperature (25°C) can be stored for about 10-30 days without any visible spoilage. Farmers have to dry the grain and/or cool the grain before the spoilage occurs. This type of guideline gives farmers information regarding the number of days they have for drying and/or cooling the stored grain bulk to have safe storage.

2.4.3 Respiration

The grain itself is considered a biotic variable in a stored grain bulk as it respires and produces heat, moisture and CO_2, especially at high moisture contents. Freshly harvested and/or high moisture grains have a high respiration rate. Grain respiration is a self-accelerating process which influences the intergranular gas composition and the growth of insects and microorganisms as well. From the following respiration equation, the cumulative amount of CO_2 generated can be used to calculate the dry matter loss.

$$C_6H_{12}O_6 + 6\,O_2 \longrightarrow 6\,CO_2 + 6\,H_2O + \text{heat}$$

Aerobic respiration breaks down the carbohydrates, fats and proteins to CO_2, water and energy (heat). The released energy is used to fuel metabolic processes and further heat is produced. As the respiration rate of the freshly harvested, wet grains will be much higher, the grains may be heated up quickly. This kind of heating is known as self heating which occurs in two phases; biological heating, which is caused by the grain respiration and chemical heating, which is caused by the oxidation processes. Mills (1996) reported that the seed coat protects the grain embryo and the endosperm from oxidative and enzymatic reactions to a certain extent. So, the initial condition of the grain is an important factor which influences the future storage quality. If the grain is sound, whole, and matured then the rate of deterioration during storage will be less even under moderately adverse storage conditions.

2.4.4 Intergranular gas composition

Many researchers have studied the relationship between deterioration of stored grain and increased levels of CO_2 production. Muir et al. (1985) monitored grain stored in several farm bins by measuring CO_2 levels in grain bulks. White et al. (1982a) studied the CO_2 production and O_2 consumption in stored canola at different temperature and moisture combinations under laboratory conditions. They measured the intergranular CO_2 and O_2 levels and correlated the measured CO_2 with the rate of deterioration of the stored seed. White et al. (1982b) studied the CO_2 production inside stored wheat as well, and concluded that cumulative CO_2 is a good indicator of storage potential of stored wheat. Pronyk et al. (2004) reported that there is a strong correlation between the CO_2

production and spoilage of respiring canola. Steele et al. (1969) used cumulative CO_2 production by shelled corn as an indicator for safe storage time.

2.4.5 Fungi

Wallace et al. (1983) studied the effect of abiotic variables such as temperature, moisture content and storage time on the biotic variables such as the seed and its microflora. They used seed germination, grain condition and grade; and free fatty acid values as the indicators. They found that all the seeds having visible mould smelledd musty although all the musty seeds did not necessarily show appearance of visible mould. Mustiness and off-odors are often associated with increased storage fungi and decreased germination rate. Degradation was not directly related to germination rate but was to fat acidity value. Table 1 shows the effects and consequences of fungi on stored grain.

As fungi cause deterioration in stored grain quality, it is important to quantify the presence of fungi which will give some indication of the magnitude of deterioration that has occurred. According to Sorger-Domenigg et al. (1955), if the moisture content of the stored grain is at a level which might indicate the possibility of present or future danger, then a combination of many tests has to be carried out to know the level of spoilage such as change in germinability, FAV and percentage of the number seeds affected by mould. There are two groups of fungi; field fungi and storage fungi. Field fungi are commonly present in the freshly harvested grain. They invade the grains before harvest or after cutting and swathing but before threshing. Storage fungi will develop on the grain if the storage conditions are poor (Christensen and Kaufmann 1969).

Measuring the number and kinds of mould present on the grain will indicate whether an invasion had already occurred. Many studies have tried several methods of quantifying fungi, some of which include: counting the propagules of fungi through dilution plating (Bottomley et al. 1952; Friday et al. 1986), grading the mould in the infested grain by visual inspection (Friday et al. 1986) and measuring ergosterol or chitin content in the grain (Golubchuck et al. 1960, Pronyk et al. 2006); and by placing a representative sample of seeds on filter paper saturated with 7.5% sodium chloride and counting the percentage of kernels infected with fungi, which is the common and simple method of quantifying fungi (Wallace and Sinha 1962; Sinha 1983; Friday et al. 1986). *Alternaria* spp.are the predominant field fungi, whereas *Penicillium* spp. and *Aspergillus* spp. are the predominant storage fungi (Wallace and Sinha 1962; Christensen and Kaufmann 1969).

Table 1. Effects and consequences of microorganisms on stored grain.

Type of damage	Consequence
Dull appearance	Downgrading
Musty odors	Downgrading
Visible moulds	Downgrading
Reduced germination	Rejection for seed purpose
Increased free fatty acids	Rejection for seed purpose
Binburning	Damage to product and premises
Mycotoxins	Feed refusal, illness, death

Source: Mills (1986)

Many researchers reported that the enumeration of fungi is difficult and quantifying them alone is not enough to define the deterioration level. By-products of fungi have to be measured to determine the exact effect of fungi on grain, which includes measurement of: decrease in germination rate of the grain (Kreyger 1972; Wallace et al. 1983), increase in mould respiration (White et al 1982a), increase in electrical conductivity of the stored grain (Sinha et al. 1981), increase in mycotoxin levels (Abramson et al. 1990), decrease in falling number in flour milling of cereal grains (Bason et al. 1993), change in free fatty acid values (FFA) (Christensen and Kaufmann 1969) and change in chitin and ergosterol levels (Donald and Mirocha, 1977; Pronyk et al. 2006).

2.4.6 Fatty acid values (FAV)

Biochemical changes cause a loss in the nutritive value (change in carbohydrates, proteins, lipids and vitamins) of the grain (Pomeranz 1992). Oxidative or hydrolytic changes occur in the lipids over time. In whole grain, hydrolytic changes are more common. Free fatty acids (FFA) are produced by breakdown of lipids by the process of hydrolysis caused by enzymatic secretions from the associated microorganisms of the grain. Free fatty acid value increases with increased deterioration. So, it has been used as an index to monitor the condition of the stored grain. Christensen and Kaufmann (1969) reported that the increase in mould population in the stored product has a direct correlation with CO_2 production and FFA value. According to Wallace et al. (1983), FFA content has a positive correlation with moisture and *Penicillium* spp. and a negative correlation with temperature. Fatty acid value is expressed in mg KOH required to neutralize the free fatty acids present in 100 g of moisture-free seeds. As there is no

absolute value to correlate with deterioration, many researchers have expressed the relative change in FFA value (Sinha 1983), which helps associate the change in FFA with relative change in deterioration.

2.4.7 Germinability

The germinability of the grain is considered as the first and foremost factor used to assess the viability of the stored product (Pomeranz 1992). If the germination rate decreases below 90% of the initial germination rate, then the storage condition has to be considered as unsafe and protective measures need to be taken (Schroth et al. 1998; Karunakarn et al. 2001). Wallace and Sinha (1962) reported that germination had no correlation with moisture content, a positive correlation with field fungi; and a negative correlation with temperature and storage fungi.

Quality measurements must be simple enough to be used by the farmers at the farm level and fast enough to determine the condition of the grain bulks. Other quality measurements such as determination of FFA, mycotoxins, chitin, and ergosterol content, and identification of microflora species, need training and expensive equipment. Moreover, germination can be affected even before the appearance of visible mould. Hence, germination is considered to be the best and most sensitive method of measuring grain quality during storage.

3. MATERIALS AND METHODS

3.1 Grain samples

Fall rye and canola grains were selected for the experimental study and the grain samples were obtained from Agriculture and Agri-Food Canada, Winnipeg. Initial moisture contents of the samples were determined using the hot air oven method by drying approximately 10 g of whole seed samples at 130± 2°C for a particular period (16 h for rye and 4 h for canola) and the results were expressed in percentage wet mass basis (ASAE 2003). Grain samples were conditioned to the required moisture contents (7.5, 10.0, 12.5 and 15.0% for canola; and 10.0, 12.5, 15.0 and 17.5% for rye (±0.2% for all the moisture levels)) by adding a calculated quantity of distilled water and rotating grain in a mixer for 30 min. The grain samples were then stored in polythene bags in a freezer at -5 ±2°C for 72 h, for uniform moisture distribution. Samples were mixed thoroughly within the polythene bags every 3 h during the day for 3 days to ensure uniformity in moisture distribution. Final moisture contents of the samples were verified by the hot air oven method. The samples were kept in polythene bags at -5°C untill used for the experiments.

3.2 Storage temperature

The temperature range for the safe storage study was based on the possible temperatures the grain would undergo during harvest and storage. According to Muir and Jayas (1997) the average 24 h daily temperature of the Canadian prairies is around 25°C during normal harvesting periods. The grain in the swath has shown higher temperatures than the ambient temperature. Canola seeds maintain about 5°C above the ambient temperature,

whereas the cereal grains maintain about 8°C above the air temperature (Prasad et al. 1978). So, 10, 20, 30 and 40°C were chosen for this deterioration study.

3.3 Grain moisture

The average moisture contents of rye and canola during harvest across the prairies are not available. So, the moisture contents were chosen based on the other available information. According to Hartman (1999) fall rye may be swathed, followed by field drying without any quality loss, but it should not be artificially dried after combining until the kernel moisture is less than 20%. So, the moisture content can be anywhere below 20% before it goes for any post harvest treatment. Rye with 14% moisture content is considered as straight grade, whereas ≤ 13% moisture content is considered safe for storage. Therefore, 10, 12.5, 15 and 17.5 % were chosen for rye for this storage study. Canola is commonly swathed at 35-40% moisture content, then field dried and threshed. Even though 10% moisture content canola seeds are considered as straight grade, 8% moisture content is the safe storage moisture content (Anonymous 2005). So, 7.5, 10, 12.5 and 15% moisture contents were chosen for canola.

3.4 Relative humidity

Relative humidity (RH) of the grain samples of different moisture contents were maintained using potassium hydroxide (KOH) solutions of different concentrations (Solomon 1951). Potassium hydroxide solutions of specific gravities 1.285, 1.211, 1.147 and 1.108 were used to maintain 60, 75, 85 and 90% RH (60, 75, 85 and 90% are the equilibrium relative humidities for 10, 12.5, 15 and 17.5% moisture content rye; and 7.5,

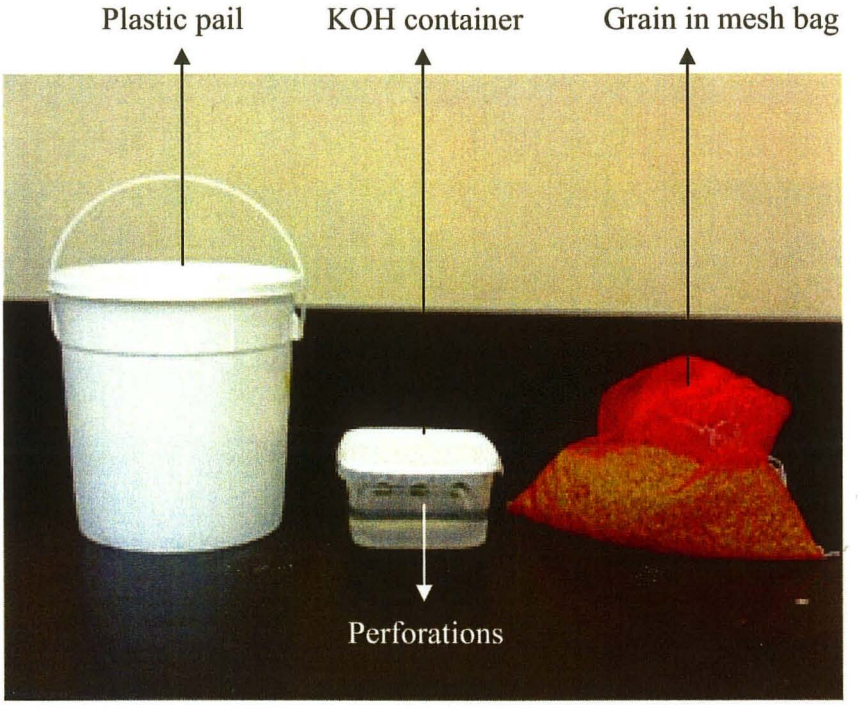
10, 12.5 and 15% moisture content canola, respectively), respectively. The RH inside the environmental chambers was maintained in the range of 50-60% throughout the study.

3.5 Experimental apparatus and setup

All the experiments were conducted under controlled environmental conditions. Four environmental chambers (E15 and C1010, CONVIRON, Controlled Environments Limited, Winnipeg, MB) were used to maintain 10, 20, 30 and 40°C within ± 2°C. About 400 ml of KOH solution was taken in a sealed plastic container with perforations on the outer surface above the solution level, and placed inside a plastic pail. Two kilogram of conditioned grain was taken in a mesh bag and placed over the KOH filled container inside the pail, which had a lid on the top (Fig. 2). Three replications were made for each temperature and moisture combination, for both the grains. The grain in the mesh bag was mixed thoroughly and samples were taken at regular intervals for quality analysis.

3.6 Germination rate

About 10 g of grain samples were taken out every week and the germination rates were assessed by placing 25 seeds on Whatman no. 3 filter paper in a 9 cm diameter Petri-dish saturated with 5.5 ml of distilled water (Wallace and Sinha 1962). The plates were stacked in a vertical stand and covered with a polythene bag to prevent desiccation of filter papers and incubated at 20°C for 4 d and then the bags were removed. Exactly on the seventh day, the number of germinated seeds was counted.



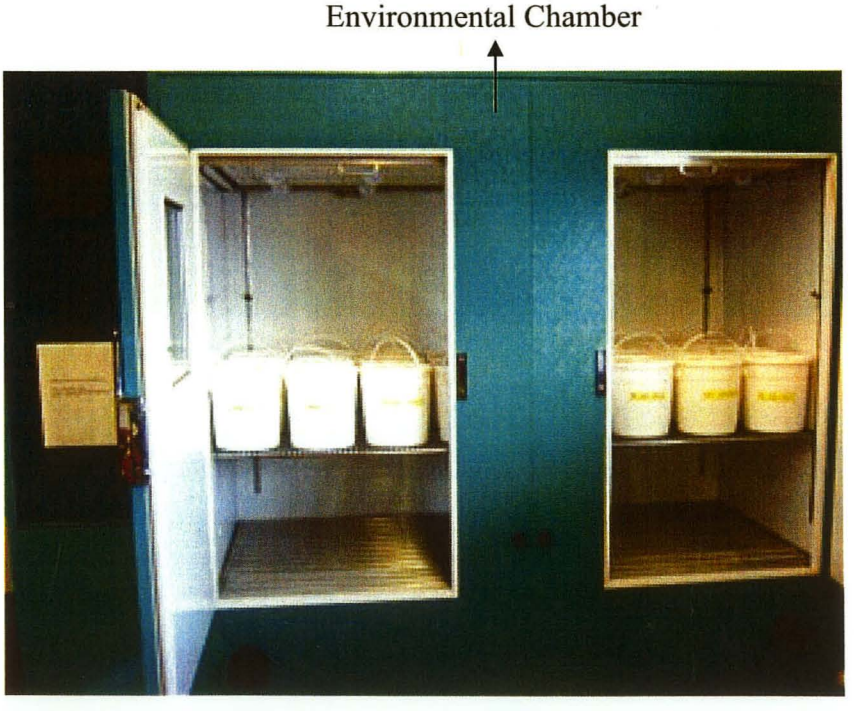


Fig. 2. Experimental setup.

3.7 Moisture content

Moisture contents of the samples were determined every week by the hot air oven method (70DM (6555/6556), Thermo Electron Corporation, Marietta, OH) where approximately 10 g of grain sample was dried at 130± 2°C for a particular period (16 h for rye and 4 h for canola) and expressed in percentage wet mass basis (ASAE 2003).

3.8 Visible and invisible mould

Appearance of visible mould was monitored every week by visually inspecting the samples. Invisible microflora was identified at four week interval by plating 25 seeds on a Whatman no.3 filter paper in a 9 cm diameter Petri-dish saturated with 5.5 ml of 7.5% aqueous sodium chloride (NaCl) solution (Mills et al. 1978). The plates were stacked in a vertical stand and covered with a polythene bag to prevent desiccation of filter papers and incubated at 25°C. On the fourth day the polythene bag was removed and on the seventh day the seeds that were affected by micro floral species were identified with reference to the following specification using a dissection microscope (C-PS, SMZ 1000, Nikon, Melville, NY) (N.D.G. White, Dr, Research Scientist, Cereal Research Centre, Agricultural and Agri-Food Canada, Winnipeg, MB, Canada – R3T 2M9):

Penicillium: Bright blue to blue-gray color, branching, feathery nature.

A. glaucus group: Blue-gray in color, often found on seeds of fairly low moisture content, crystalline structure.

A. candidus: Bright white in color.

A. wentii: Brownish yellow.

A. ochraceus: Pale yellow.

Hormodendrum: Feather-like or tree-like nature, gray-green in color.

Bacteria: Creamy yellow in color and sticky.

Rhizopus: Relatively large, black in color, spread rapidly over plate, hyphae usually seen emerging from a crack in the seed coat and plenty of mycelia.

Fusarium: White in color, granular (Sugar like), many branches, small pore; seed and mycelium often slightly pink or red.

3.9 Fatty acid value (FAV)

Fatty acid values were measured at two week intervals. Approximately 10 g of grain samples were collected, dried at 130± 2°C (16 h for rye and 4 h for canola), stored in moisture proof plastic bags at -5±2°C for 3 months and then the samples were ground in a grinder (M-2, Fred Stein Laboratories, Inc, Atchison, KS). About 5 g of the ground samples were folded in a Whatman no. 5 filter paper and placed inside the fat extractors (Goldfisch Fat Extractor, Laboratory Construction Co, Kansas City, MO) with beakers containing 30 ml of petroleum ether as solvent. The solvent was boiled; the vapors were condensed and passed through the sample continuously for 6 h. Then the solvent was separated out from the extracted oil by evaporating the mixture. Twenty five milliliter of TAP solution (50% ethanol and 50% toluene with phenolphthalein as indicator) was added. This mixture was titrated against a KOH solution of known normality until the color turned light pink. The calculated FAV was then expressed as mg KOH/ 100 g of dry grain (Karunakaran 1999).

3.10 Statistical analysis

Statistical analysis was done to check the effect of moisture content, temperature and storage period on germination rate. Analysis of variance (ANOVA) was done using a three factorial design model (4 moisture contents x 4 temperatures x 16 weeks). A similar model was used to study the effect of moisture content, temperature and storage period on the FAV. Least significant difference (LSD) is a method to make pair wise comparisons between quantitative variables coming from three or more independent groups and was used to analyze the significant changes in the germination and fatty acid value of both the grains during storage trials. In both the analyses, the differences within each level under each variable were tested at a 95% confident interval. General linear models (GLM) procedure in Statistical Analysis System software (SAS version 9.1, Statistical Analysis Systems Institute, Inc., Cary, NC) was used for all the analyses.

4. RESULTS AND DISCUSSION

4.1 Germination

Changes in germination of rye with four different initial moisture contents stored at 10, 20, 30 and 40°C with respect to storage period are shown in Fig.3. Data and the results of least significant difference (LSD) of means are given in Appendix A.

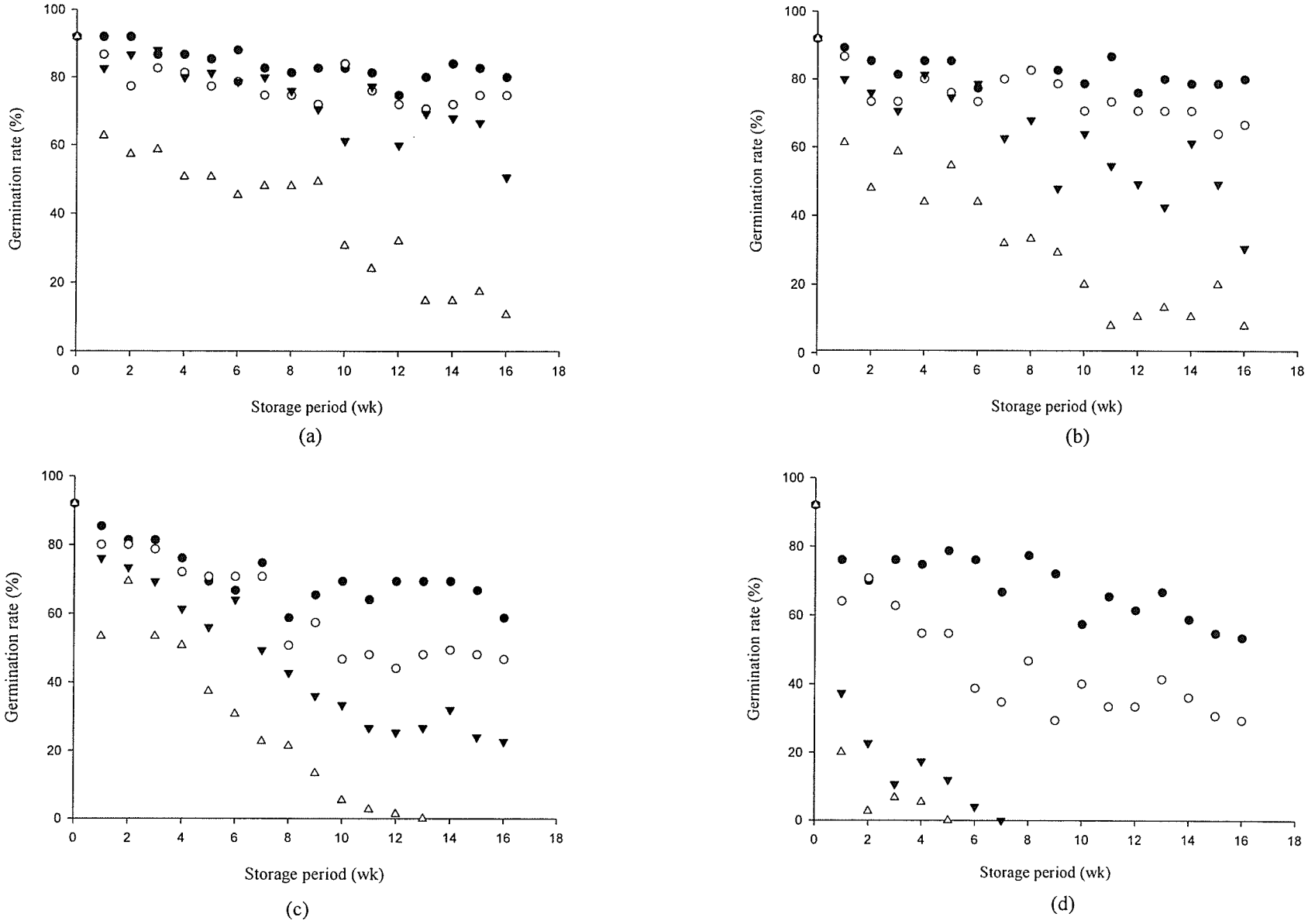


Fig. 3. Changes in germination of rye with respect to time (a) at 10°C, (b) at 20°C, (c) at 30°C, and (d) at 40°C.
(Initial moisture contents (%) ● 10.0 ○ 12.5 ▼ 15.0 △ 17.5)

The initial germination rate of rye was 92%. Changes in germination with respect to moisture contents and temperatures were noticed in the very first week of the analysis. At 10°C, the germination of the low moisture samples (10.0 and 12.5%) remained above 80 and 75%, respectively throughout the study, whereas that of the high moisture samples (15.0 and 17.5%) decreased over time and reached 50 and 11%, respectively by the 16th week. The 17.5% moisture content samples decreased to 62% germination in the very first week. At 20°C also, the 10% moisture content samples maintained about 80% germination rate for the entire period, but that of the higher moisture samples decreased rapidly with storage period. Germination rate of the 12.5, 15.0 and 17.5% moisture samples reached 67, 31 and 8%, respectively during the last week of analysis. Even at 20°C or below, the rye grain with 17.5% moisture or more has to be dried within a week's time to prevent spoilage. At 30°C, germination of the 10.0 and 12.5% samples remained above 80% for three weeks. However, by the end of storage trails, even for these samples germination decreased to 59 and 47%, respectively. The 17.5% moisture samples reached 0% germination during the 13th week of the study. At 40°C, the higher moisture samples (17.5 and 15.0%) reached 0% germination during the 5th and 7th week of storage, respectively. Germination of the 10.0 and 12.5% moisture samples also decreased dramatically and by the sixteenth week reached 53 and 30%, respectively. At 30 and 40°C, even the dry grain was susceptible to spoilage. The 10.0 and 12.5% moisture samples would have 3 weeks for conditioning at 30°C and less than a week at 40°C. Effects of initial moisture content, storage temperature and storage period on germination of rye were significant (α=0.05). These results support the results of Christensen and Kaufmann (1969), who reported that with increasing moisture content,

most types of grains become increasingly sensitive to injury or death by high storage temperature. These results also support the results of Wallace and Sinha (1962), who reported that germination of a grain has a negative correlation with storage temperature.

Changes in germination of canola with four different initial moisture contents stored at 10, 20, 30 and 40°C with respect to storage period are shown in Fig. 4. Data and the results of least significant difference (LSD) of means are given in Appendix A.

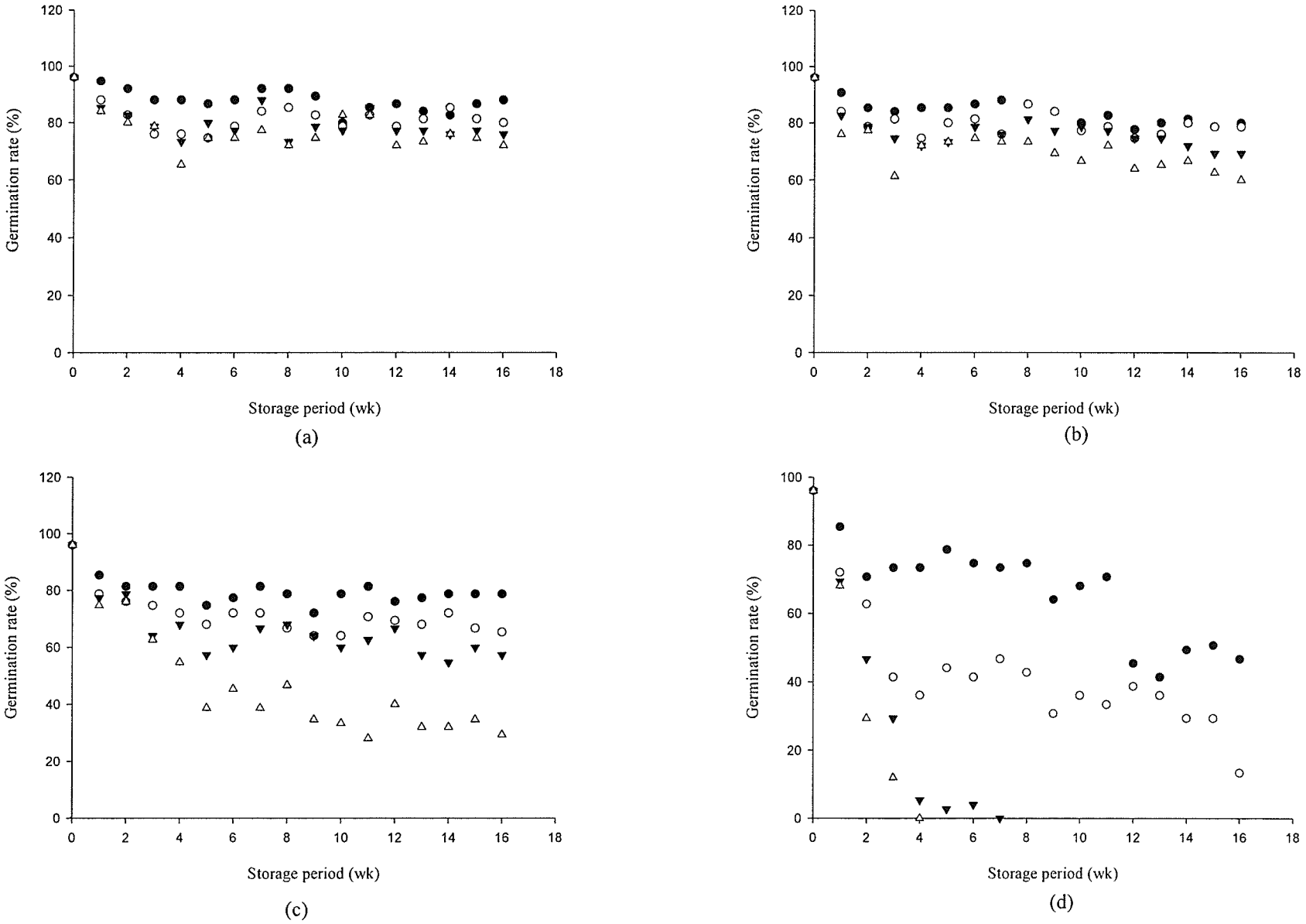


Fig. 4. Changes in germination of canola with respect to time (a) at 10°C, (b) at 20°C, (c) at 30°C, and (d) at 40°C.
(Initial moisture contents (%) ● 7.5 ○ 10.0 ▼ 12.5 △ 15.0)

Initially, the canola samples had a 96% germination rate. At 10°C, germination of all the samples remained above 70% throughout the storage study, and that of the 7.5 and 10.0% moisture samples remained above 80%. However, the germination rate decreased with storage time. The final germination rates of the 7.5, 10.0, 12.5 and 15.0% moisture samples by the 16th week of storage were 88, 80, 76 and 72%, respectively. At 20°C, germination of the 7.5% moisture samples alone remained above 80% throughout the entire 16 week period; other moisture samples had a rapid decrease in germination with respect to time. The 10.0, 12.5 and 15.0% moisture samples reached 79, 78 and 60% germination, respectively by the last week. At 30°C also, germination of all the samples decreased with time and only the 7.5% moisture sample remained around 80% germination throughout the entire 16 weeks. During the last week of storage at 30°C, none of the samples remained above 80% in germination and that of the 7.5, 10.0, 12.5 and 15.0% moisture samples decreased to 79, 65, 57 and 30%, respectively. Samples stored at 40°C had a dramatic decrease in germination with respect to increased initial moisture content and storage time. Germination of the 15.0 and 12.5% moisture samples reached 0% during 4th and 7th week of the study, respectively. By the 16th week, germination of the 7.5 and 10.0% moisture samples also decreased to 47 and 13%, respectively. The canola seeds with 7.5% moisture content can be stored safely at 10, 20 and even at 30°C. But the high moisture seeds have to be dried immediately to prevent loss in seed viability. At high storage temperatures, the high moisture samples (12.5 and 15.0%) would have less than a week for the post harvest operations like drying and cooling. Germination of canola samples was significantly affected by moisture content, temperature and storage period (α=0.05). This result is similar to the result obtained for

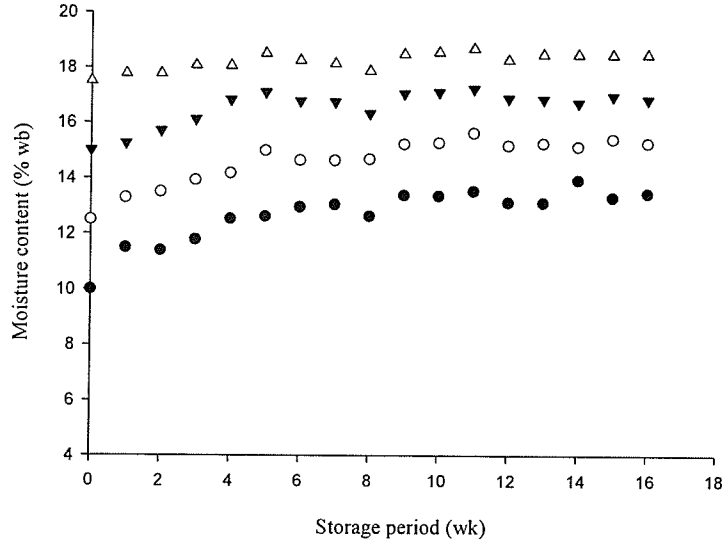
rye, in which the germination was significantly affected by both the moisture content and the storage temperature.

4.2 Moisture content

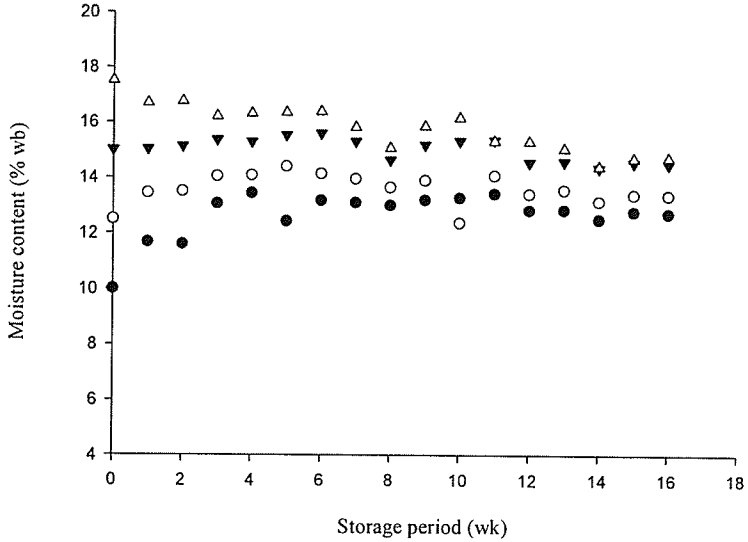
Potassium hydroxide solutions of different specific gravities were used to maintain the RH of the grain samples, so that the initial moisture contents (10.0, 12.5, 15.0 and 17.5% for rye; and 7.5, 10.0, 12.5 and 15.0% for canola) remain constant throughout the storage period. But the KOH solutions could not maintain the required RH values, which resulted in changes in the moisture content of the samples over time (Fig. 5).

According to Solomon (1951), controlling the RH in biological experiments using sulphuric acid or potassium hydroxide solutions has been in practice for a long time. Errors in the humidity control arise if the graded humidity solutions lose too much water through absorption of water vapor by materials enclosed with them or if they absorb water vapor from damp materials. Generally, solutions tend to give too low humidity at elevated temperatures. Furthermore, the equilibrium humidity will deviate from the expected value if the solution is at different temperature than the ambient air temperature above it. This might be the reason for the change in RH inside the storage containers and hence the change in moisture contents of the grain samples over time.

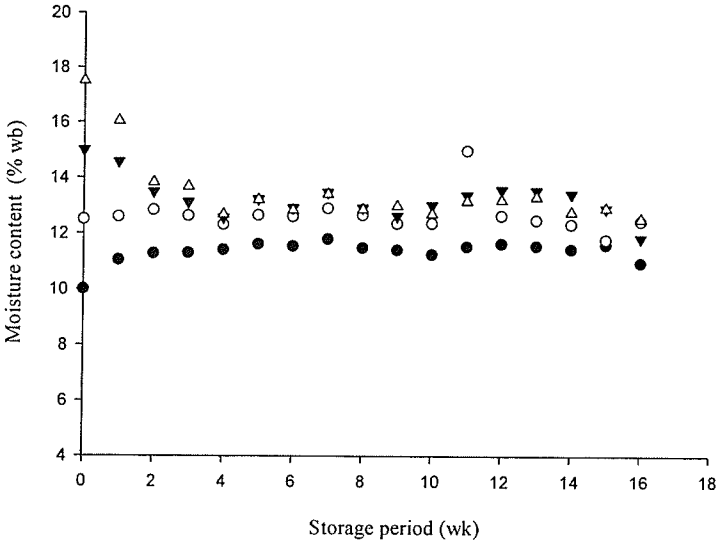
The changes in the initial moisture content of the rye samples stored at 10, 20, 30 and 40°C with respect to time are shown in Fig 5. and data are given in Appendix B.



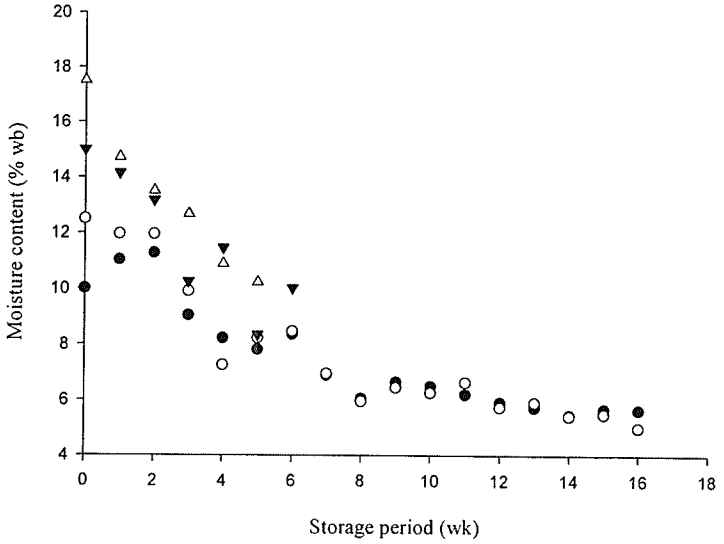
(a)



(b)



(c)

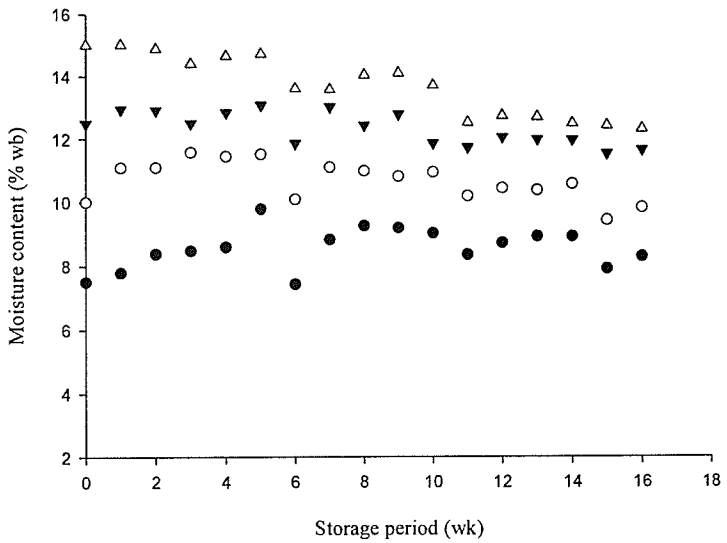


(d)

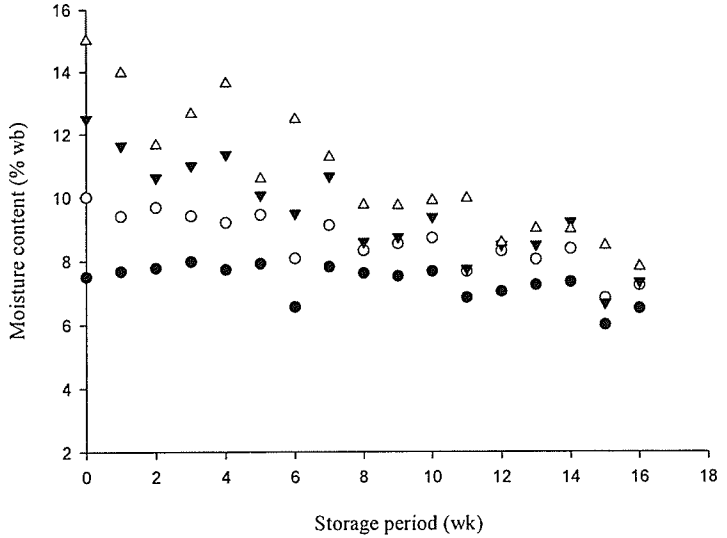
Fig. 5. Changes in moisture contents of rye with respect to time (a) at 10°C (b) at 20°C, (c) at 30°C, and (d) at 40°C.
(Initial moisture contents (%) ● 10.0 ○ 12.5 ▼ 15.0 △ 17.5)

Almost all the stored rye samples showed changes in their initial moisture content over time. At 10°C, moisture contents of all the rye samples increased slightly over time. The samples with initial moisture contents of 10.0, 12.5, 15.0 and 17.5% had increased to 13.45, 15.27, 16.87 and 18.48%, respectively by the 16th week. At 20°C, the highest initial moisture content (17.5%) samples lost moisture over time and decreased to 14.7% during the last week and the moisture content of the 15.0% moisture samples remained almost constant throughout the storage period. But the lower moisture samples (10.0 and 12.5%) had a slight increase in moisture content with time and reached 12.7 and 13.4%, respectively at the end. At 30°C, samples with lower initial moisture contents (10.0 and 12.5%) remained almost constant in moisture level throughout the study, but the higher moisture samples (15.0 and 17.5%) lost moisture over time and reached 11.9 and 12.5%, respectively by the 16th week. At 40°C, all the samples lost moisture over storage period. The 10.0 and 12.5% moisture samples decreased to about 5.0% at the end of the trial. No moisture measurement was carried out in the high moisture samples (15.0 and 17.5%) once the germination rate decreased to 0%. The high moisture samples (15.0 and 17.5%) also lost moisture and reached 10% moisture content during 6th and 5th week, respectively. In general, moisture contents of all the samples stored at 10°C increased with time. At 20°C, the low initial moisture samples increased in water content. At 30 and 40°C, nearly all the samples had a decrease in water content with time.

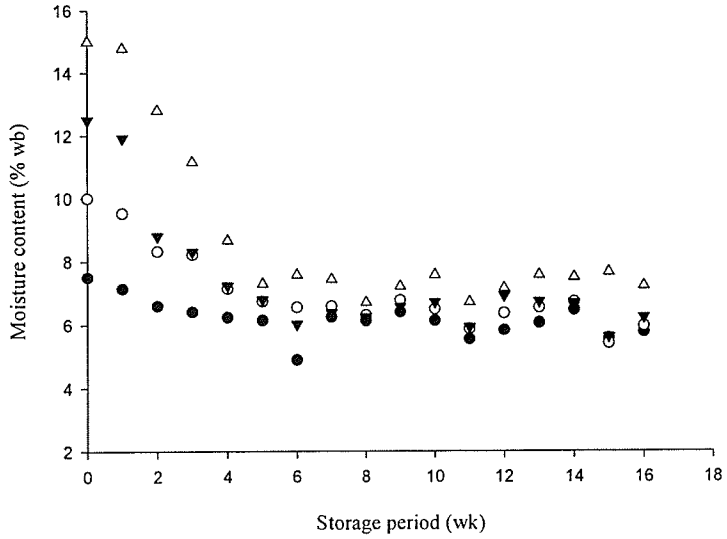
Changes in the initial moisture contents of canola samples stored at 10, 20, 30 and 40°C with respect to time are shown in Fig.6. and data are given in Appendix B.



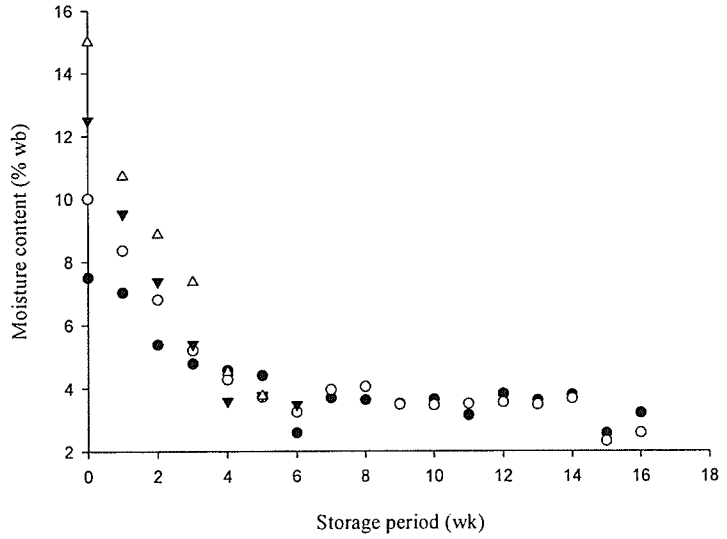
(a)



(b)



(c)



(d)

Fig. 6. Changes in moisture contents of canola with respect to time (a) at 10°C (b) at 20°C, (c) at 30°C, and (d) at 40°C.
(Initial moisture contents (%) ● 7.5 ○ 10.0 ▼ 12.5 △ 15.0)

In general, all the canola samples lost moisture over time, except the 7.5% moisture content samples stored at 10°C (Fig. 6). At 10°C, the lowest initial moisture samples (7.5%) had a slight increase in moisture content over time and reached 8.2% at the end. But the moisture content of the samples with 10.0, 12.5 and 15% initial moisture decreased with time and reached 9.8, 11.6 and 12.3%, respectively by the 16th week of storage. At 20°C, moisture contents of all the samples decreased with time and the final moisture contents of the 7.5, 10.0, 12.5 and 15.0% samples were 6.5, 7.2, 7.3 and 7.8%, respectively. At 30°C, moisture content of all the samples had decreased to 5.6, 5.9, 6.2 and 7.2% from 7.5, 10.0, 12.5 and 15.0% moisture, respectively during the last week of the study. At 40°C, there was a dramatic decrease in the moisture content of all the samples. The 7.5 and 10.0% moisture samples decreased to 3.2 and 2.6% at the end of the study, respectively. No moisture measurement was carried out in the high moisture samples, once the germination reached 0%. From the available moisture content data, the 10.0 and 12.5% moisture samples decreased to 3.5 and 3.8% moisture during 6th and 5th week, respectively.

Unlike the rye samples, even at the low storage temperatures, the canola samples lost moisture rapidly over time. As the high amounts of oil in canola seeds (about 43%) prevent water absorption, the seeds have higher equilibrium moisture content (EMC) than the cereal grains at a given relative humidity. This might be the reason why the canola samples dried more quickly than the rye samples stored at the same temperature.

4.3 Microflora

For both the grains, mould growth was first noticeable after the germination dropped well below 80% in all the conditions.

Table 2. Time of the first appearance of visible mould (wk) and respective germination (%) of rye.

Initial moisture content (% wb)		10	12.5	15	17.5
Temperature (°C)	Replicate				
10	a	–	–	–	2, 60
	b	–	–	–	2, 52
	c	–	–	–	2, 60
20	a	–	–	–	1, 60
	b	–	–	–	1, 56
	c	–	–	–	1, 68
30	a	–	9, 56	5, 56	1, 52
	b	–	9, 64	5, 48	1, 52
	c	–	9, 52	5, 64	1, 56
40	a	10, 64	5, 40	1, 36*	1, 16*
	b	10, 48	5, 52	1, 40*	1, 24*
	c	10, 60	5, 72	1, 36*	1, 20*

* Visible mould might have occurred before this time in these cases because of the length of time interval between sampling dates

Table 2 shows the time of appearance of visible mould (wk) and respective germination rate (%) of rye. Visible mould appeared in all the 17.5% moisture samples irrespective of the storage temperature; and it was noticeable in the first week of storage at 20, 30 and 40°C storage temperatures and in the second week of storage at 10°C. At 40°C, visible mould appeared in all the samples regardless of the moisture content and it was noticeable in the very first week of analysis in the high moisture samples (15.0 and 17.5%). At 30°C, both the 15.0 and 17.5% moisture samples showed appearance of

visible mould during 9th and 5th week of storage, respectively. Visible mould was noticeable in the 12.5 and 15.0% samples stored at 20, 30 and 40°C. No visible mould in the low moisture samples (10.0, 12.5 and 15.0%) stored at 10 and 20°C. The 10% moisture samples were safe even at 30°C. The storage temperature should be below 20°C and the moisture content should be below 15.0% to allow a long and safe storage of rye.

Quantification of the invisible mould species are given in Appendix C. Initially, the rye samples had a high number of seeds infected by *Penicillium* spp. *Aspergillus* and *Penicillium* spp. were predominant in all the samples throughout the storage study. At 10 and 20°C, *Penicillium* spp. was dominant during the early stages of storage and the number of seeds infected with *A. glaucus* group increased with storage time. *A. candidus* Link and *Hormodendrum* were present in almost all the samples but fewer in numbers. *A. ochraceus* Wilhelm increased with moisture content and storage period. At 20°C also, *Penicillium* was the dominating species followed by *A. glaucus* group and *Hormodendrum*. There were few numbers of seeds infected by *Fusarium* and the number of seeds infected with *Rhizopus* increased with storage time. At 30 and 40°C, *A. glaucus* group was the dominant species. Similar to the samples stored at low temperatures, at 30 and 40°C also, the number of seeds infected with *A. ochraceus* Wilhelm increased with moisture content and storage period. *A. wentii* Wehmer and *A. candidus* Link were the other two common *Aspergillus* spp. present in the samples.

Table 3 shows the time of first appearance of visible mould (wk) and respective germination rate (%) of canola. There was no visible mould on the 7.5 and 10.0%

moisture samples stored at 10 and 20°C. All the highest moisture samples (15.0%) showed visible mould regardless of the storage temperature. Similarly all the samples stored at 40°C showed visible mould irrespective of the sample moisture content. The 7.5% moisture samples were safe even at 30°C and at 10°C. The 12.5% moisture samples did not develop visible mould during the 16 week study at 10°C.

Table 3. Time of the first appearance of visible mould (wk) and respective germination (%) of canola

Initial moisture content (% wb)		7.5	10	12.5	15
Temperature (°C)	Replicate				
10	a	–	–	–	5, 80
	b	–	–	–	5, 72
	c	–	–	–	5, 72
20	a	–	–	15, 76	3, 60
	b	–	–	15, 68	3, 60
	c	–	–	15, 64	3, 64
30	a	–	8, 76	4, 72	1, 76
	b	–	8, 72	4, 72	1, 72
	c	–	8, 52	4, 60	1, 76
40	a	10, 52	2, 60	1, 64	1, 72
	b	10, 76	2, 76	1, 76	1, 60
	c	10, 76	2, 52	1, 68	1, 72

Penicillium spp. were the predominant species in all the canola samples. At 10°C, *A. glaucus* group was present in the low moisture samples and there was no *A. ochraceus* Wilhelm in any of the samples. Few seeds in the high moisture samples had *Fusarium*. At 20°C, the number of seeds infected with *A. glaucus* group increased with storage time. *A. candidus* Link and *Hormodendrum* were present in all the samples throughout the study but were few in occurrence. *Fusarium and A. wentii* Wehmer were present only in the early stages of storage. At 30°C also, *Fusarium* was found in the early stages of storage.

The number of seeds with *A. glaucus* group increased with storage time. At 40°C, *A. glaucus* group was predominant next to *Penicillium* spp. in all the samples followed by *A. candidus* Link. The seeds with 15.0% initial moisture content had the highest number of seeds infected with *A. ochraceus* Wilhelm. *Fusarium*, *Hormodendrum* and *A. wentii* Wehmer were present only during the early stages of storage.

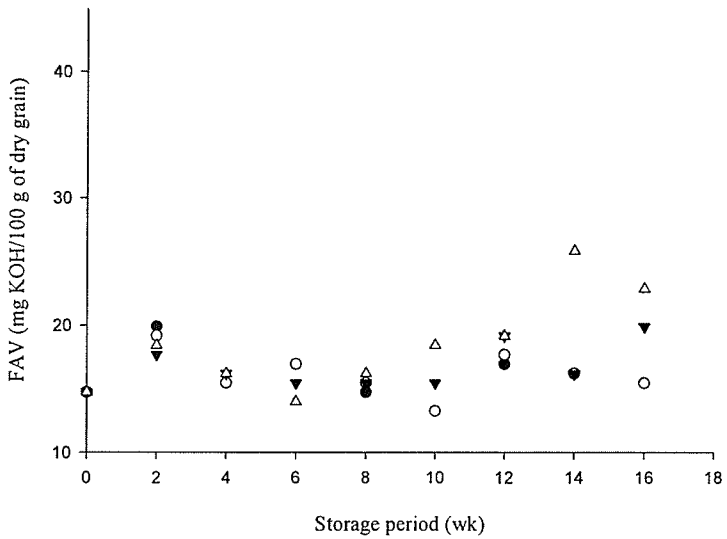
The results support the results of Christensen and Kaufmann (1969) who reported that the invasion of grains by storage fungi is a direct cause of germination loss and some kinds of grains can survive a long time at rather high moisture contents and moderate temperatures, if kept free of storage fungi. Field fungi may be present in the freshly harvested grain and storage fungi develop on the stored grain if the storage conditions are poor (Muir and White 2001).

4.4 Fatty acid value

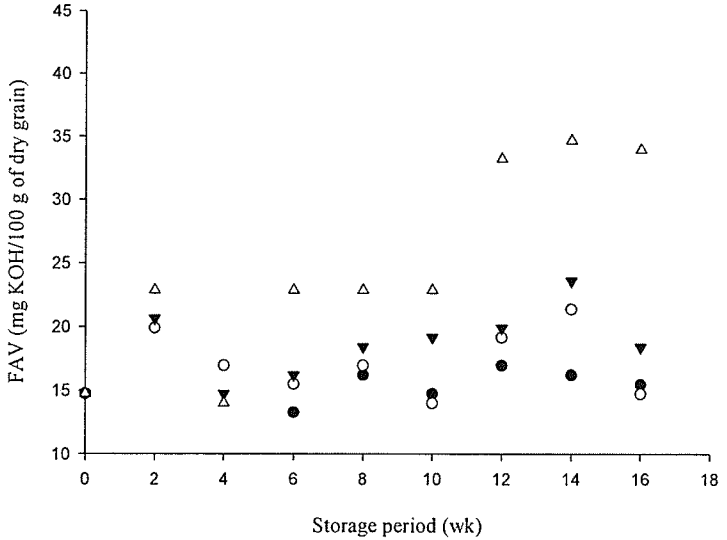
According to Christensen and Kaufmann (1969), spoilage of stored grains produces some intermediate products such as free fatty acids. The characteristic odors and flavors of the fatty acids make the fats rancid. At high moisture levels, where moulds proliferate, the stored grain may undergo drastic chemical changes approximately proportional to the moisture content. The production of fatty acids is also proportional to the moisture content of the stored grain and the extent of mould growth. Hence, the production of the fatty acids in stored grains depends on the microflora. In contrast, there are some research reports which conclude that there is no correlation between microfloral growth and rancidity. A given species may produce relatively large amounts of fatty acids and

consume a portion of it. It has been long known that deterioration of stored grains is accompanied by an increase in FAV and hence the FAV can be used as a measure of deterioration or the condition and the storability of grain.

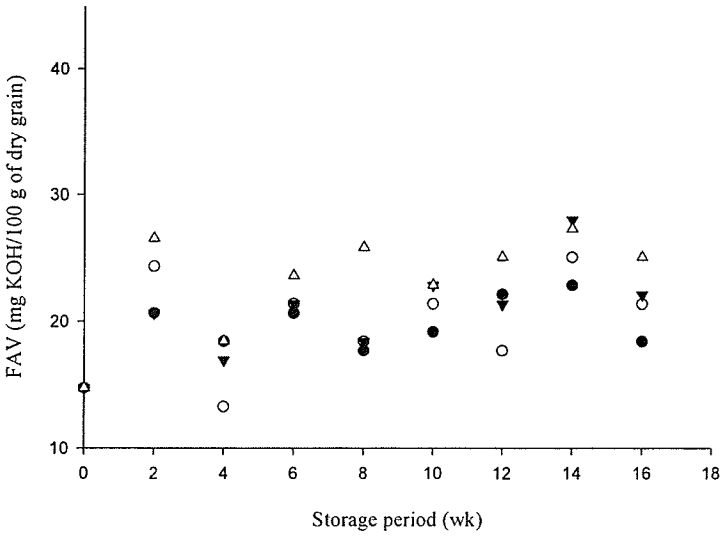
Changes in the FAV of rye samples stored at 10, 20, 30 and 40°C with respect to time are shown in Fig.7. Data and the results of least significant difference (LSD) of means are given in Appendix D.



(a)



(b)



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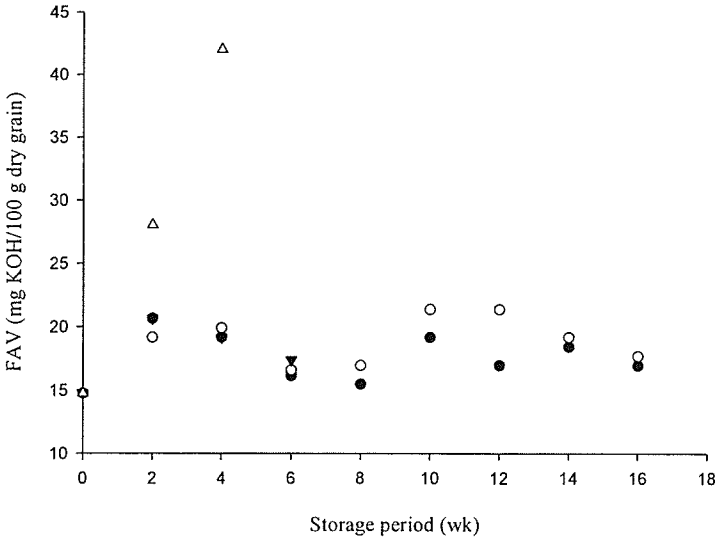
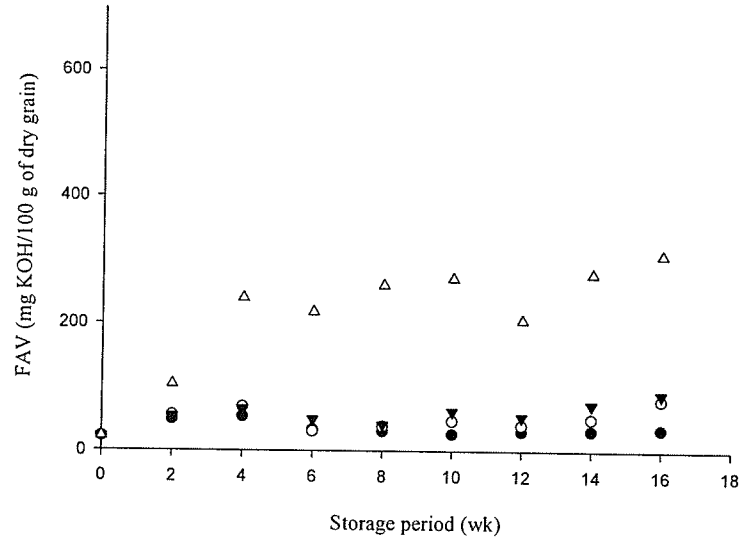


(d)

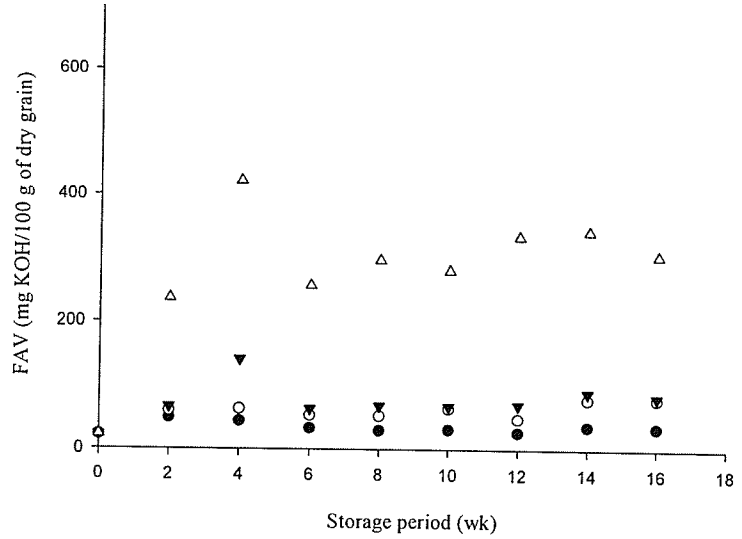
Fig. 7. Changes in FAV of rye with respect to time (a) at 10°C, (b) at 20°C, (c) at 30°C, and (d) at 40°C.
(Initial moisture contents (%) ● 10.0 ○ 12.5 ▼ 15.0 △ 17.5)

Initially, the FAV of rye was 14.74 mg KOH/100 g of dry grain. At 10°C, the FAV of the 10.0, 12.5, 15.0 and 17.5% moisture content rye samples remained nearly unchanged until week 10 and after it increased gradually over time and reached 15.5, 15.5, 19.9 and 22.9 mg KOH/100g of dry grain by 16 weeks storage. At 20°C also, there was a gradual increase in FAV of the samples with increasing moisture content and time. There was not much difference in the values of the 10.0, 12.5, 15.0 % moisture content samples stored at 10 and 20°C, but the FAV of the 17.5% moisture samples stored at 20°C increased to 34 mg KOH/100g of dry grain by the 16^{th} week. The FAV of the 10.0, 12.5, 15.0 and 17.5% moisture content samples stored at 30°C had increased to 18.5, 21.4, 22.1 and 25 mg KOH/100g of dry grain by the last week of analysis. The 17.5% moisture content samples stored at 40°C had the highest FAV of 42 mg KOH/100g of dry grain by the 4^{th} week of storage. No measurement was carried out once the germination of the samples reached 0%. At all the four storage temperatures, the FAV increased with moisture content and storage period. The effects of moisture content, temperature and storage period on the FAV of rye were significant (α=0.05).

Changes in FAV of canola samples stored at 10, 20, 30 and 40°C with respect to time are shown in Fig. 8. Data and the results of least significant difference (LSD) of means are given in Appendix D.



(a)



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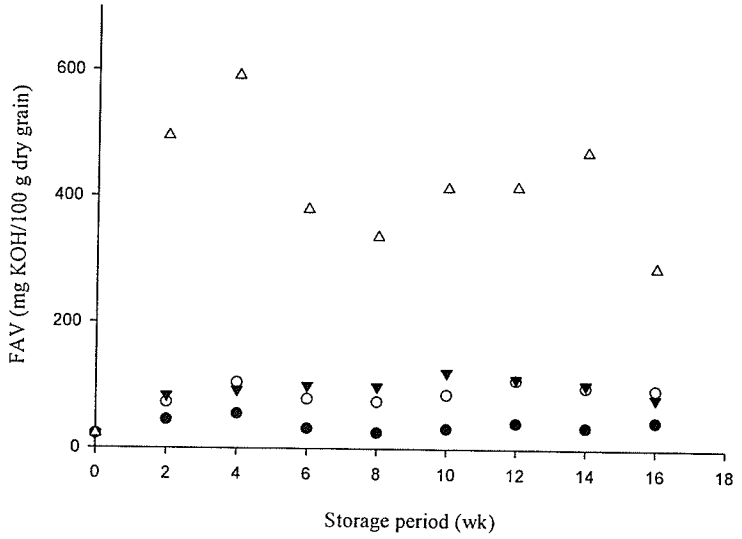
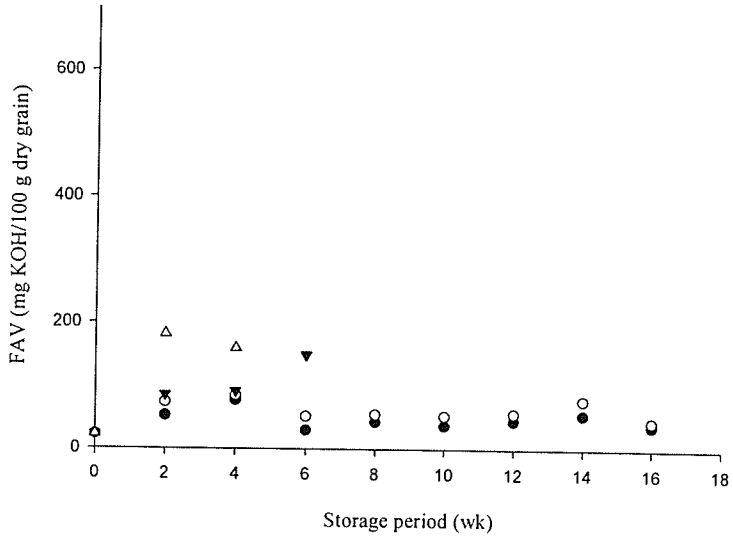


(c)



(d)

Fig. 8. Changes in FAV of canola with respect to time (a) at 10^{o}C, (b) at 20^{o}C, (c) at 30^{o}C, and (d) at 40^{o}C.
(Initial moisture contents (%) ● 7.5 ○ 10.0 ▼ 12.5 △ 15.0)

The initial FAV of canola samples was 22.02 mg KOH/100 g of dry grain. At all the storage temperatures, the FAV increased with moisture content and storage period. At 10 and 20°C, the FAV of the 7.5, 10.0, 12.5 and 15.0% moisture content canola samples at 16 weeks of storage were around 35, 80, 90 and 300 mg KOH/100 g of dry grain, respectively. At 30°C, the 15.0% moisture content samples had the highest FAV (above 400 mg KOH/100 g of dry grain) throughout the storage period and attained the maximum of 590 mg KOH/100 g of dry grain by the fourth week of storage. At 40°C, there were no measurements for the samples after they reached 0% germination. The maximum value was 182 mg KOH/100 g of dry grain for the 15.0% moisture grain during the first week. Moisture content, storage temperature and storage period had a significant effect on the FAV of canola (α=0.05). Canola seeds have a high oil content of 43%, which might be the reason for the high acidity during deterioration. Changes in the fat acidity values of all the samples stored at 40°C were less which may be due to the predominance of bacteria.

4.5 Estimated safe storage life

From the measured quality parameters, estimated safe storage periods for rye and canola were obtained (Figs. 9 and 10, respectively). The safe storage period was defined as the time for the germination rate of the grains dropped to 80% of their initial germination and there was no appearance of visible mould.

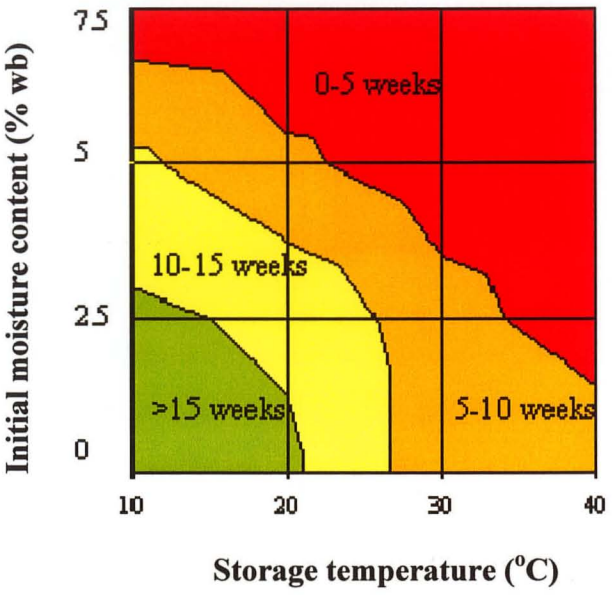


Fig. 9. Estimated safe storage life of rye.

Rye with ≤12.5% moisture content stored at ≤ 20°C would be safe for >15 weeks, whereas rye with 17.5% moisture content stored at 40°C would have only less than a week time for the post harvest treatments like drying and cooling. The available time decreased with increased moisture content and temperature.

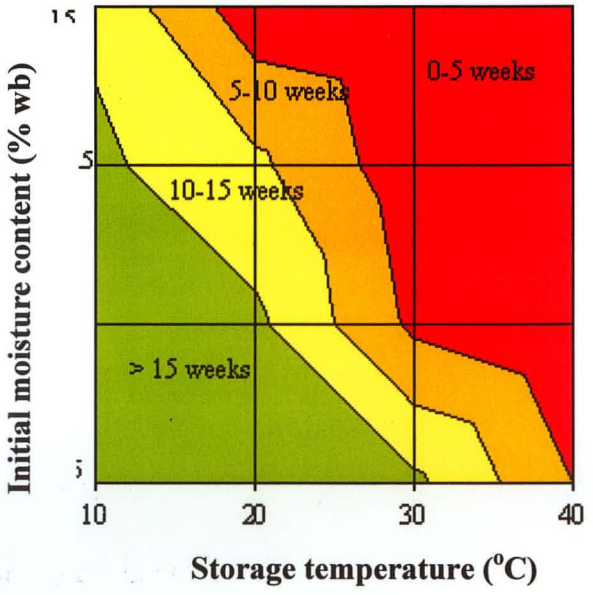


Fig. 10. Estimated safe storage life of canola.

Canola with ≤10% moisture content stored at ≤25°C would be safe for at least 15 weeks, whereas, canola with 15% moisture content stored at 40°C need to be dried and cooled with in a week to avoid loss in seed viability.

5. CONCLUSIONS

Germination rate of both grains was affected significantly by the grain moisture, storage temperature and time (α=0.05). Rye with 10.0% moisture content can be stored safely at 10 and 20°C for > 15 weeks without any considerable loss in germination. But at 30°C, even the 10.0% moisture grain has to be cooled within three weeks to avoid spoilage. The 17.5% moisture content grain has to be treated immediately to have a safe and prolonged storage. Canola seeds with 7.5 and 10.0% moisture content stored at 10, 20 and 30°C; and the 10.0% moisture samples stored at 10°C temperatures had more than 80% germination throughout the study. At 30 and 40°C, the 12.5 and 15.0% moisture samples have to be dried and cooled within a week period to prevent loss in seed viability.

Potassium hydroxide solutions could not maintain the required humidities inside the grain pails and hence there were changes in the initial moisture contents of the stored grain samples over time. In general, moisture contents of the samples stored at 10 and 20°C slightly increased with time, whereas moisture in the samples stored at 30 and 40°C decreased rapidly over time.

Visible mould was first noticeable in all the high moisture samples (15 and 17.5% rye; and 12.5 and 15% canola) and the samples stored at 40°C after the germination dropped well below 80%. Initially, both grains had a high number of seeds infected with *Penicillium* and *Aspergillus* spp. *Fusarium* was found in few seeds at early stages of storage. *A. glaucus* increased with storage time, whereas *A.ochraceus* increased with increasing moisture content and storage temperature.

Fat acidity values of both the grains were significantly affected by the seed moisture, storage temperature and time (α=0.05). The rate of change in FAV of rye was very low compared to canola. The maximum value for rye was 42 mg of KOH/100 g of dry grain at 17.5% moisture and at 40°C, whereas the maximum value for canola was 590 mg of KOH/ 100 g of dry grain at 15% moisture samples stored at 30°C (No FAV was measured for 15.0% moisture samples after the second week of storage because germination decreased to 0%).

The 10.0 and 12.5% moisture content rye samples could be stored safely at 10°C for more than 15 weeks. But at 20°C, only the 10.0% moisture contents samples remained safe throughout the study. The 10.0 and 12.5% moisture samples stored at 30°C would allow three weeks for post harvest treatments. But at 40°C, even the low moisture samples would have to be treated within a week's time to avoid spoilage.

The 7.5% moisture canola samples at 10, 20 and 30°C; and the 10.0% moisture samples at 10 and 20°C can be stored without considerable quality loss for more than 15 weeks. Even at 10 and 20°C, the high moisture samples (17.5% rye and 15% canola) would have only two weeks for conditioning. But the 12.5 and 15.0% moisture samples stored at 30 and 40°C had less than a week for post harvest treatments.

6. RECOMMENDATIONS FOR FUTURE RESEARCH

1. Other common grains under all possible storage conditions may also be studied to determine the rate of deterioration and hence to develop safe storage guidelines for all the grains.
2. Other quality parameters such as nutritional changes, milling and baking quality of cereal grains; and oil quality of oilseeds may also be determined to know the effect of storage conditions on the grain quality.
3. The study may be conducted for longer storage times to know the effects of long term storage on grain quality.

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APPENDIX A: Germination data

Table A1. Germination (%) of rye stored at 10°C.

Storage period (week)	Replicate	Moisture content (% wb) 10.0	12.5	15.0	17.5
1	a	92	88	80	64
	b	92	88	80	60
	c	92	84	88	64
	mean	92.00	86.67	82.67	62.67
	s.d.*	0.00	2.31	4.62	2.31
2	a	96	80	88	60
	b	92	72	92	52
	c	88	80	80	60
	mean	92.00	77.33	86.67	57.33
	s.d.	2.83	5.66	2.83	5.66
3	a	84	84	84	60
	b	88	80	92	56
	c	88	84	88	60
	mean	86.67	82.67	88.00	58.67
	s.d.	2.31	2.31	4.00	2.31
4	a	80	80	84	56
	b	92	80	76	52
	c	88	84	80	44
	mean	86.67	81.33	80.00	50.67
	s.d.	6.11	2.31	4.00	6.11

Storage period (week)	Replicate	Moisture content (% wb) 10.0	12.5	15.0	17.5
5	a	76	76	88	52
	b	92	80	80	52
	c	88	76	76	48
	mean	85.33	77.33	81.33	50.67
	s.d.	8.33	2.31	6.11	2.31
6	a	84	80	84	40
	b	96	72	80	52
	c	84	84	72	44
	mean	88.00	78.67	78.67	45.33
	s.d.	6.93	6.11	6.11	6.11
7	a	84	72	84	56
	b	84	80	84	36
	c	80	72	72	52
	mean	82.67	74.67	80.00	48.00
	s.d.	2.31	4.62	6.93	10.58
8	a	80	72	88	64
	b	80	76	64	44
	c	84	76	76	36
	mean	81.33	74.67	76.00	48.00
	s.d.	2.31	2.31	12.00	14.42

Storage period (week)	Replicate	Moisture content (% wb) 10.0	12.5	15.0	17.5
9	a	84	72	80	48
	b	84	72	64	56
	c	80	72	68	44
	mean	82.67	72.00	70.67	49.33
	s.d.	2.31	0.00	8.33	6.11
10	a	88	92	60	32
	b	80	80	60	32
	c	80	80	64	28
	mean	82.67	84.00	61.33	30.67
	s.d.	4.62	6.93	2.31	2.31
11	a	84	80	72	24
	b	80	76	80	32
	c	80	72	80	16
	mean	81.33	76.00	77.33	24.00
	s.d.	2.31	4.00	4.62	8.00
12	a	80	72	44	36
	b	68	72	68	36
	c	76	72	68	24
	mean	74.67	72.00	60.00	32.00
	s.d.	6.11	0.00	13.86	6.93

Storage period (week)	Replicate	Moisture content (% wb) 10.0	12.5	15.0	17.5
13	a	80	72	68	20
	b	76	72	76	12
	c	84	68	64	12
	mean	80.00	70.67	69.33	14.67
	s.d.	4.00	2.31	6.11	4.62
14	a	80	80	76	12
	b	84	68	60	12
	c	88	68	68	20
	mean	84.00	72.00	68.00	14.67
	s.d.	4.00	6.93	8.00	4.62
15	a	84	76	64	16
	b	80	80	68	12
	c	84	68	68	24
	mean	82.67	74.67	66.67	17.33
	s.d.	2.31	6.11	2.31	6.11
16	a	80	80	56	12
	b	76	72	48	8
	c	84	72	48	12
	mean	80.00	74.67	50.67	10.67
	s.d.	4.00	4.62	4.62	2.31

* Standard deviation of the replicates from the mean.

Table A2. Germination (%) of rye stored at 20°C.

Storage period (week)	Replicate	Moisture content (% wb) 10.0	12.5	15.0	17.5
1	a	92	88	84	60
	b	88	88	80	56
	c	88	84	76	68
	mean	89.33	86.67	80.00	61.33
	s.d.*	2.31	2.31	4.00	6.11
2	a	88	72	84	32
	b	88	68	64	60
	c	80	80	80	52
	mean	85.33	73.33	76.00	48.00
	s.d.	4.62	6.11	10.58	14.42
3	a	72	76	84	68
	b	84	68	60	56
	c	88	76	68	52
	mean	81.33	73.33	70.67	58.67
	s.d.	8.33	4.62	12.22	8.33
4	a	88	84	84	48
	b	92	72	76	40
	c	76	84	84	44
	mean	85.33	80.00	81.33	44.00
	s.d.	8.33	6.93	4.62	4.00

Storage period (week)	Replicate	Moisture content (% wb) 10.0	12.5	15.0	17.5
5	a	92	80	68	36
	b	84	84	80	60
	c	80	64	76	68
	mean	85.33	76.00	74.67	54.67
	s.d.	6.11	10.58	6.11	16.65
6	a	76	76	80	56
	b	76	72	76	36
	c	80	72	80	40
	mean	77.33	73.33	78.67	44.00
	s.d.	2.31	2.31	2.31	10.58
7	a	88	80	60	32
	b	72	84	64	28
	c	80	76	64	36
	mean	80.00	80.00	62.67	32.00
	s.d.	8.00	4.00	2.31	4.00
8	a	84	88	60	24
	b	84	80	76	40
	c	80	80	68	36
	mean	82.67	82.67	68.00	33.33
	s.d.	2.31	4.62	8.00	8.33

Storage period (week)	Replicate	Moisture content (% wb) 10.0	12.5	15.0	17.5
9	a	84	80	44	24
	b	80	76	40	40
	c	84	80	60	24
	mean	82.67	78.67	48.00	29.33
	s.d.	2.31	2.31	10.58	9.24
10	a	80	72	68	16
	b	76	68	64	20
	c	80	72	60	24
	mean	78.67	70.67	64.00	20.00
	s.d.	2.31	2.31	4.00	4.00
11	a	88	76	52	4
	b	84	72	60	4
	c	88	72	52	16
	mean	86.67	73.33	54.67	8.00
	s.d	2.31	2.31	4.62	6.93
12	a	76	84	48	8
	b	72	64	52	16
	c	80	64	48	8
	mean	76.00	70.67	49.33	10.67
	s.d.	4.00	11.55	2.31	4.62

Storage period (week)	Replicate	Moisture content (% wb) 10.0	12.5	15.0	17.5
13	a	76	76	44	8
	b	88	60	48	16
	c	76	76	36	16
	mean	80.00	70.67	42.67	13.33
	s.d.	6.93	9.24	6.11	4.62
14	a	80	80	64	4
	b	84	68	68	16
	c	72	64	52	12
	mean	78.67	70.67	61.33	10.67
	s.d.	6.11	8.33	8.33	6.11
15	a	80	56	44	20
	b	80	72	64	24
	c	76	64	40	16
	mean	78.67	64.00	49.33	20.00
	s.d.	2.31	8.00	12.86	4.00
16	a	76	60	20	4
	b	80	68	36	12
	c	84	72	36	8
	mean	80.00	66.67	30.67	8.00
	s.d.	4.00	10.11	19.35	23.35

* Standard deviation of the replicates from the mean.

Table A3. Germination (%) of rye stored at 30°C.

Storage period (week)	Replicate	Moisture content (% wb) 10.0	12.5	15.0	17.5
1	a	88	76	76	52
	b	84	80	76	52
	c	84	84	76	56
	mean	85.33	80.00	76.00	53.33
	s.d.*	2.31	4.00	0.00	2.31
2	a	80	76	68	76
	b	80	76	76	68
	c	84	88	76	64
	mean	81.33	80.00	73.33	69.33
	s.d.	2.31	6.93	4.62	6.11
3	a	84	76	64	52
	b	80	80	68	44
	c	80	80	76	64
	mean	81.33	78.67	69.33	53.33
	s.d.	2.83	2.83	2.83	5.66
4	a	80	68	60	56
	b	68	76	68	52
	c	80	72	56	44
	mean	76.00	72.00	61.33	50.67
	s.d.	6.93	4.00	6.11	6.11

Storage period (week)	Replicate	Moisture content (% wb)			
		10.0	12.5	15.0	17.5
5	a	68	68	56	40
	b	68	72	48	32
	c	72	72	64	40
	mean	69.33	70.67	56.00	37.33
	s.d.	2.31	2.31	8.00	4.62
6	a	68	72	72	36
	b	64	76	48	32
	c	68	64	72	24
	mean	66.67	70.67	64.00	30.67
	s.d.	2.31	6.11	13.86	6.11
7	a	76	72	52	24
	b	72	72	52	24
	c	76	68	44	20
	mean	74.67	70.67	49.33	22.67
	s.d.	2.31	2.31	4.62	2.31
8	a	56	52	32	16
	b	60	60	48	20
	c	60	40	48	28
	mean	58.67	50.67	42.67	21.33
	s.d.	2.31	10.07	9.24	6.11

Storage period (week)	Replicate	Moisture content (% wb) 10.0	12.5	15.0	17.5
9	a	76	56	40	12
	b	60	64	36	20
	c	60	52	32	8
	mean	65.33	57.33	36.00	13.33
	s.d.	9.24	6.11	4.00	6.11
10	a	64	48	36	8
	b	72	48	40	8
	c	72	44	24	0
	mean	69.33	46.67	33.33	5.33
	s.d.	4.62	2.31	8.33	4.62
11	a	68	52	36	4
	b	60	52	24	4
	c	64	40	20	0
	mean	64.00	48.00	26.67	2.67
	s.d.	4.00	6.93	8.33	2.31
12	a	68	48	36	4
	b	76	44	24	0
	c	64	40	16	0
	mean	69.33	44.00	25.33	1.33
	s.d.	6.11	4.00	10.07	2.31

Storage period (week)	Replicate	Moisture content (% wb) 10.0	12.5	15.0	17.5†
13	a	72	52	32	0
	b	64	48	32	0
	c	72	44	16	0
	mean	69.33	48.00	26.67	0.00
	s.d.	4.62	4.00	9.24	0.00
14	a	72	48	36	
	b	68	48	40	
	c	68	52	20	
	mean	69.33	49.33	32.00	
	s.d.	2.31	2.31	10.58	
15	a	68	48	28	
	b	64	44	24	
	c	68	52	20	
	mean	66.67	48.00	24.00	
	s.d.	2.31	4.00	4.00	
16	a	56	52	20	
	b	56	48	20	
	c	64	40	28	
	mean	58.67	46.67	22.67	
	s.d.	4.62	6.11	4.62	

* Standard deviation of the replicates from the mean.
† No samples were analyzed after the germination reached 0%.

Table A4.Germination of rye stored at 40°C.

		Moisture content (% wb)			
Storage period (week)	Replicate	10.0	12.5	15.0	17.5
1	a	80	64	36	16
	b	72	68	40	24
	c	76	60	36	20
	mean	76.00	64.00	37.33	20.00
	s.d.*	4.00	4.00	2.31	4.00
2	a	70	60	8	0
	b	76	80	20	8
	c	64	72	40	0
	mean	70.00	70.67	22.67	2.67
	s.d.	6.00	10.07	16.17	4.62
3	a	84	72	12	0
	b	80	52	8	4
	c	64	64	12	16
	mean	76.00	62.67	10.67	6.67
	s.d	10.58	10.07	2.31	8.33
4	a	80	48	24	4
	b	68	48	20	4
	c	76	68	8	8
	mean	74.67	54.67	17.33	5.33
	s.d.	6.11	11.55	8.33	2.31

Storage period (week)	Replicate	Moisture content (% wb) 10.0	12.5	15.0†	17.5†
5	a	88	40	0	0
	b	76	52	16	0
	c	72	72	20	0
	mean	78.67	54.67	12.00	0.00
	s.d.	8.33	16.17	10.58	0.00
6	a	80	40	4	
	b	80	28	4	
	c	68	48	4	
	mean	76.00	38.67	4.00	
	s.d.	6.93	10.07	0.00	
7	a	68	24	0	
	b	68	36	0	
	c	64	44	0	
	mean	66.67	34.67	0.00	
	s.d.	2.31	10.07	0.00	
8	a	76	40		
	b	76	48		
	c	80	52		
	mean	77.33	46.67		
	s.d.	2.31	6.11		

Storage period (week)	Replicate	Moisture content (% wb) 10.0	12.5	15.0	17.5
9	a	76	36		
	b	68	36		
	c	72	16		
	mean	72.00	29.33		
	s.d.	4.00	11.55		
10	a	64	28		
	b	48	48		
	c	60	44		
	mean	57.33	40.00		
	s.d	8.33	10.58		
11	a	68	28		
	b	68	40		
	c	60	32		
	mean	65.33	33.33		
	s.d.	4.62	6.11		
12	a	48	28		
	b	68	36		
	c	68	36		
	mean	61.33	33.33		
	s.d.	11.55	4.62		

Storage period (week)	Replicate	Moisture content (% wb) 10.0	12.5	15.0	17.5
13	a	64	44		
	b	68	36		
	c	68	44		
	mean	66.67	41.33		
	s.d.	2.31	4.62		
14	a	64	28		
	b	56	40		
	c	56	40		
	mean	58.67	36.00		
	s.d.	4.62	6.93		
15	a	52	40		
	b	56	24		
	c	56	28		
	mean	54.67	30.67		
	s.d.	2.31	8.33		
16	a	60	24		
	b	52	32		
	c	48	32		
	mean	53.33	29.33		
	s.d.	6.11	4.62		

* Standard deviation of the replicates from the mean.
† No samples were analyzed after the germination reached 0%.

Table A5. Germination of canola stored at 10°C.

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5	15.0
1	a	96	88	84	80
	b	96	88	88	84
	c	92	88	84	88
	mean	94.67	88.00	85.33	84.00
	s.d.*	43.62	39.00	36.47	34.65
2	a	92	76	84	84
	b	92	88	80	76
	c	92	84	84	80
	mean	92.00	82.67	82.67	80.00
	s.d.	0.00	6.11	2.31	4.00
3	a	88	72	76	84
	b	88	80	76	76
	c	88	76	84	76
	mean	88.00	76.00	78.67	78.67
	s.d.	0.00	4.00	4.62	4.62
4	a	92	72	72	64
	b	88	84	80	56
	c	84	72	68	76
	mean	88.00	76.00	73.33	65.33
	s.d.	4.00	6.93	6.11	10.07

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5	15.0
5	a	92	72	76	80
	b	88	76	84	72
	c	80	76	80	72
	mean	86.67	74.67	80.00	74.67
	s.d.	6.11	2.31	4.00	4.62
6	a	88	80	80	72
	b	88	76	72	80
	c	88	80	80	72
	mean	88.00	78.67	77.33	74.67
	s.d.	0.00	2.31	4.62	4.62
7	a	92	84	84	80
	b	96	88	92	80
	c	88	80	88	72
	mean	92.00	84.00	88.00	77.33
	s.d.	4.00	4.00	4.00	4.62
8	a	92	84	84	80
	b	96	92	64	68
	c	88	80	72	68
	mean	92.00	85.33	73.33	72.00
	s.d.	4.00	6.11	10.07	6.93

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5	15.0
9	a	88	88	76	76
	b	88	84	80	72
	c	92	76	80	76
	mean	89.33	82.67	78.67	74.67
	s.d.	2.31	6.11	2.31	2.31
10	a	80	80	76	84
	b	80	76	84	80
	c	80	80	72	84
	mean	80.00	78.67	77.33	82.67
	s.d.	0.00	2.31	6.11	2.31
11	a	84	84	88	80
	b	88	88	80	84
	c	84	76	88	84
	mean	85.33	82.67	85.33	82.67
	s.d.	2.31	6.11	4.62	2.31
12	a	84	76	76	72
	b	88	80	76	72
	c	88	80	80	72
	mean	86.67	78.67	77.33	72.00
	s.d.	2.31	2.31	2.31	0.00

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5	15.0
13	a	88	84	76	76
	b	84	80	76	72
	c	80	80	80	72
	mean	84.00	81.33	77.33	73.33
	s.d.	4.00	2.31	2.31	2.31
14	a	88	80	76	76
	b	80	88	76	76
	c	80	88	76	76
	mean	82.67	85.33	76.00	76.00
	s.d.	4.62	4.62	0.00	0.00
15	a	84	84	76	80
	b	88	80	80	72
	c	88	80	76	72
	mean	86.67	81.33	77.33	74.67
	s.d.	2.31	2.31	2.31	4.62
16	a	88	80	76	76
	b	88	80	76	68
	c	88	80	76	72
	mean	88	80	76	72
	s.d.	0	0	0	4

* Standard deviation of the replicates from the mean.

Table A6. Germination (%) of canola stored at 20°C.

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5	15.0
1	a	88	84	84	72
	b	92	88	80	76
	c	92	80	84	80
	mean	90.67	84.00	82.67	76.00
	s.d.	41.63	37.14	35.13	30.67
2	a	88	80	80	76
	b	84	84	84	76
	c	84	72	72	80
	mean	85.33	78.67	78.67	77.33
	s.d.	2.31	6.11	6.11	2.31
3	a	84	80	76	60
	b	84	88	84	60
	c	84	76	64	64
	mean	84.00	81.33	74.67	61.33
	s.d.	0.00	6.11	10.07	2.31
4	a	84	72	64	72
	b	88	72	76	68
	c	84	80	76	76
	mean	85.33	74.67	72.00	72.00
	s.d.	2.31	4.62	6.93	4.00

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5	15.0
5	a	92	84	68	72
	b	84	80	72	80
	c	80	76	80	68
	mean	85.33	80.00	73.33	73.33
	s.d.	6.11	4.00	6.11	6.11
6	a	88	88	80	80
	b	80	76	76	76
	c	92	80	80	68
	mean	86.67	81.33	78.67	74.67
	s.d.	6.11	6.11	2.31	6.11
7	a	88	80	80	80
	b	88	76	76	64
	c	88	72	72	76
	mean	88.00	76.00	76.00	73.33
	s.d.	0.00	4.00	4.00	8.33
8	a	84	88	84	80
	b	88	88	80	80
	c	88	84	80	60
	mean	86.67	86.67	81.33	73.33
	s.d.	2.31	2.31	2.31	11.55

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5	15.0
9	a	88	80	80	72
	b	84	88	76	68
	c	80	84	76	68
	mean	84.00	84.00	77.33	69.33
	s.d.	4.00	4.00	2.31	2.31
10	a	80	80	84	48
	b	84	72	80	76
	c	76	80	72	76
	mean	80.00	77.33	78.67	66.67
	s.d.	4.00	4.62	6.11	16.17
11	a	80	76	76	64
	b	84	84	72	72
	c	84	76	84	80
	mean	82.67	78.67	77.33	72.00
	s.d.	2.31	4.62	6.11	8.00
12	a	76	72	80	68
	b	81	76	72	64
	c	76	76	72	60
	mean	77.67	74.67	74.67	64.00
	s.d.	2.89	2.31	4.62	4.00

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5	15.0
13	a	80	76	80	68
	b	84	80	76	64
	c	76	72	68	64
	mean	80.00	76.00	74.67	65.33
	s.d.	4.00	4.00	6.11	2.31
14	a	80	80	80	64
	b	76	80	72	68
	c	88	80	64	68
	mean	81.33	80.00	72.00	66.67
	s.d.	6.11	0.00	8.00	2.31
15	a	80	80	76	56
	b	80	76	68	68
	c	76	80	64	64
	mean	78.67	78.67	69.33	62.67
	s.d.	2.31	2.31	6.11	6.11
16	a	80	80	72	60
	b	80	76	68	56
	c	80	80	68	64
	mean	80.00	78.67	69.33	60.00
	s.d.	0.00	2.31	2.31	4.00

* Standard deviation of the replicates from the mean.

Table A7. Germination (%) of canola stored at 30°C.

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5	15.0
1	a	80	80	72	76
	b	88	80	80	72
	c	88	76	80	76
	mean	85.33	78.67	77.33	74.67
	s.d.*	4.62	2.31	4.62	2.31
2	a	84	72	80	72
	b	76	76	80	80
	c	84	80	76	76
	mean	81.33	76.00	78.67	76.00
	s.d.	4.62	4.00	2.31	4.00
3	a	80	80	60	56
	b	84	68	60	56
	c	80	76	72	76
	mean	81.33	74.67	64.00	62.67
	s.d.	2.31	6.11	6.93	11.55
4	a	84	68	72	52
	b	84	76	72	52
	c	76	72	60	60
	mean	81.33	72.00	68.00	54.67
	s.d.	4.62	4.00	6.93	4.62

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5	15.0
5	a	72	60	60	56
	b	80	68	52	32
	c	72	76	60	28
	mean	74.67	68.00	57.33	38.67
	s.d.	4.62	8.00	4.62	15.14
6	a	80	76	60	44
	b	76	72	64	52
	c	76	68	56	40
	mean	77.33	72.00	60.00	45.33
	s.d.	2.31	4.00	4.00	6.11
7	a	80	68	68	36
	b	80	72	64	52
	c	84	76	68	28
	mean	81.33	72.00	66.67	38.67
	s.d.	2.31	4.00	2.31	12.22
8	a	84	76	80	56
	b	72	72	72	44
	c	80	52	52	40
	mean	78.67	66.67	68.00	46.67
	s.d.	6.11	12.86	14.42	8.33

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5	15.0
9	a	68	68	68	40
	b	80	60	60	20
	c	68	64	64	44
	mean	72.00	64.00	64.00	34.67
	s.d.	6.93	4.00	4.00	12.86
10	a	80	56	64	28
	b	76	64	56	48
	c	80	72	60	24
	mean	78.67	64.00	60.00	33.33
	s.d.	2.31	8.00	4.00	12.86
11	a	80	68	60	24
	b	84	80	52	40
	c	80	64	76	20
	mean	81.33	70.67	62.67	28.00
	s.d.	2.31	8.33	12.22	10.58
12	a	80	72	72	40
	b	72	72	72	36
	c	76	64	56	44
	mean	76.00	69.33	66.67	40.00
	s.d.	4.00	4.62	9.24	4.00

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5	15.0
13	a	76	76	64	36
	b	76	68	52	32
	c	80	60	56	28
	mean	77.33	68.00	57.33	32.00
	s.d.	2.31	8.00	6.11	4.00
14	a	80	68	44	20
	b	80	76	64	36
	c	76	72	56	40
	mean	78.67	72.00	54.67	32.00
	s.d.	2.31	4.00	10.07	10.58
15	a	80	64	64	32
	b	80	72	60	36
	c	76	64	56	36
	mean	78.67	66.67	60.00	34.67
	s.d.	2.31	4.62	4.00	2.31
16	a	76	64	56	32
	b	80	64	60	28
	c	80	68	56	28
	mean	78.67	65.33	57.33	29.33
	s.d.	2.31	2.31	2.31	2.31

* Standard deviation of the replicates from the mean.

Table A8. Germination (%) of canola stored at 40°C.

		Moisture content (% wb)			
Storage period (week)	Replicate	7.5	10.0	12.5	15.0
1	a	84	76	64	72
	b	84	72	76	60
	c	88.00	68.00	68.00	72
	mean	85.33	72.00	69.33	68.00
	s.d.*	2.31	4.00	6.11	6.93
2	a	72	60	44	32
	b	64	76	44	32
	c	76.00	52.00	52.00	24
	mean	70.67	62.67	46.67	29.33
	s.d.	6.11	12.22	4.62	4.62
3	a	76	52	32	12
	b	72	40	32	8
	c	72.00	32.00	24.00	16
	mean	73.33	41.33	29.33	12.00
	s.d	2.31	10.07	4.62	4.00
4	a	68	48	4	0
	b	80	28	0	0
	c	72.00	32.00	12.00	0
	mean	73.33	36.00	5.33	0.00
	s.d.	6.11	10.58	6.11	0.00

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5†	15.0†
5	a	80	32	4	
	b	76	48	0	
	c	80	52	4	
	mean	78.67	44.00	2.67	
	s.d.	2.31	10.58	2.31	
6	a	80	40	4	
	b	80	48	4	
	c	64	36	4	
	mean	74.67	41.33	4.00	
	s.d.	9.24	6.11	0.00	
7	a	80	40	0	
	b	72	60	0	
	c	68	40	0	
	mean	73.33	46.67	0.00	
	s.d.	6.11	11.55	0.00	
8	a	72	28		
	b	80	48		
	c	72	52		
	mean	74.67	42.67		
	s.d.	4.62	12.86		

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5	15.0
9	a	68	28		
	b	56	36		
	c	68	28		
	mean	64.00	30.67		
	s.d.	6.93	4.62		
10	a	52	32		
	b	76	36		
	c	76	40		
	mean	68.00	36.00		
	s.d.	13.86	4.00		
11	a	72	12		
	b	64	44		
	c	76	44		
	mean	70.67	33.33		
	s.d.	6.11	18.48		
12	a	44	36		
	b	36	40		
	c	56	40		
	mean	45.33	38.67		
	s.d.	10.07	2.31		

Storage period (week)	Replicate	Moisture content (% wb) 7.5	10.0	12.5	15.0
13	a	36	36		
	b	48	36		
	c	40	32		
	mean	41.33	34.67		
	s.d.	6.11	2.31		
14	a	48	24		
	b	44	32		
	c	56	32		
	mean	49.33	29.33		
	s.d.	6.11	4.62		
15	a	52	24		
	b	44	36		
	c	56	28		
	mean	50.67	29.33		
	s.d.	6.11	6.11		
16	a	48	12		
	b	44	16		
	c	48	12		
	mean	46.67	13.33		
	s.d.	2.31	2.31		

* Standard deviation of the replicates from the mean.
† No samples were analyzed after the germination reached 0%.

Table A9. Changes in germination of rye stored at 10°C (n=3).

MC (%)	Storage period (wk)																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
10.0	92.0^{a*} ±0.00**	92.00^{a} ±0.00	92.00^{a} ±2.83	86.67^{abc} ±2.31	86.67^{abc} ±6.11	85.33^{abc} ±8.33	88.00^{ab} ±6.93	82.67^{bc} ±2.31	81.33^{bcd} ±2.31	82.67^{bc} ±2.31	82.67^{bc} ±4.62	81.33^{bcd} ±2.31	74.67^{d} ±6.11	80.00^{cd} ±4.00	84.00^{bc} ±4.00	82.67^{bc} ±2.31	80.00^{cd} ±4.00
12.5	92.0^{a} ±0.00	86.67^{ab} ±2.31	77.33^{cdefg} ±5.66	82.67^{bcd} ±2.31	81.33^{bcde} ±2.31	77.33^{cdefg} ±2.31	78.67^{cdef} ±6.11	74.67^{efg} ±4.62	74.67^{efg} ±2.31	72.00^{fg} ±0.00	84.00^{bc} ±6.93	76.00^{defg} ±4.00	72.00^{fg} ±0.00	70.67^{g} ±2.31	72.00^{fg} ±6.93	74.67^{efg} ±6.11	74.67^{efg} ±4.62
15.0	92.0^{a} ±0.00	82.67^{abc} ±4.62	86.67^{abc} ±2.83	88.00^{ab} ±4.00	80.00^{bcde} ±4.00	81.33^{abcd} ±6.11	78.67^{bcdef} ±6.11	80.00^{bcde} ±6.93	76.00^{cdefg} ±12.00	70.67^{defgh} ±8.33	61.33^{hi} ±2.31	77.33^{bcdefg} ±4.62	60.00^{hi} ±13.86	69.33^{efgh} ±6.11	68.00^{fgh} ±8.00	66.67^{gh} ±2.31	50.67^{i} ±4.62
17.5	92.0^{a} ±0.00	62.67^{b} ±2.31	57.33^{bcd} ±5.66	58.67^{bc} ±2.31	50.67^{cde} ±6.11	50.67^{cde} ±2.31	45.33^{e} ±6.11	48.00^{de} ±10.58	48.00^{de} ±14.42	49.33^{cde} ±6.11	30.67^{f} ±2.31	24.00^{fg} ±8.00	32.00^{f} ±6.93	14.67^{gh} ±4.62	14.67^{gh} ±4.62	17.33^{gh} ±6.11	10.67^{h} ±2.31

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

Table A10. Changes in germination of rye stored at 20°C (n=3).

MC (%)	Storage period (wk)																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
10.0	92.0^{a*} ±0.00**	89.33^{ab} ±2.31	85.33^{abcd} ±4.62	81.33^{bcde} ±8.33	85.33^{abcd} ±8.33	85.33^{abcd} ±6.11	77.33^{de} ±2.31	80.00^{cde} ±8.00	82.67^{bcde} ±2.31	82.67^{bcde} ±2.31	78.67^{cde} ±2.31	86.67^{abc} ±2.31	76.00^{e} ±4.00	80.00^{cde} ±6.93	78.67^{cde} ±6.11	78.67^{cde} ±2.31	80.00^{cde} ±4.00
12.5	92.0^{a} ±0.00	86.67^{ab} ±2.31	73.33^{cdef} ±6.11	73.33^{cdef} ±4.62	80.00^{bcd} ±6.93	76.00^{cde} ±10.58	73.33^{cdef} ±2.31	80.00^{bcd} ±4.00	82.67^{abc} ±4.62	78.67^{bcd} ±2.31	70.67^{def} ±2.31	73.33^{cdef} ±2.31	70.67^{def} ±11.55	70.67^{def} ±9.24	70.67^{def} ±8.33	64.00^{f} ±8.00	66.67^{f} ±6.11
15.0	92.0^{a} ±0.00	80.00^{abc} ±4.00	76.00^{bcd} ±10.58	70.67^{bcdef} ±12.22	81.33^{ab} ±4.62	74.67^{bcde} ±6.11	78.67^{bc} ±2.31	62.67^{efg} ±2.31	68.00^{cdef} ±8.00	48.00^{i} ±10.58	64.00^{defg} ±4.00	54.67^{ghi} ±4.62	49.33^{hi} ±2.31	42.67^{ij} ±6.11	61.33^{fgh} ±8.33	49.33^{hi} ±12.86	30.67^{j} ±9.24
17.5	92.0^{a} ±0.00	61.33^{b} ±6.11	48.00^{cd} ±14.42	58.67^{bc} ±8.33	44.00^{de} ±4.00	54.67^{bcd} ±16.65	44.00^{de} ±10.58	32.00^{efg} ±4.00	33.33^{ef} ±8.33	29.33^{fg} ±9.24	20.00^{gh} ±4.00	8.00^{h} ±6.93	10.67^{h} ±4.62	13.33^{h} ±4.62	10.67^{h} ±6.11	20.00^{gh} ±4.00	8.00^{h} ±4.00

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

Table A11. Changes in germination of rye stored at 30°C (n=3).

MC (%)	Storage period (wk)																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
10.0	92.0^{a*} ±0.00**	85.33^{ab} ±2.31	81.33^{bc} ±2.31	81.33^{bc} ±2.83	76.00^{cd} ±6.93	69.33^{de} ±2.31	66.67^{e} ±2.31	74.67^{cd} ±2.31	58.67^{f} ±2.31	65.33^{ef} ±9.24	69.33^{de} ±4.62	64.00^{ef} ±4.00	69.33^{de} ±6.11	69.33^{de} ±4.62	69.33^{de} ±2.31	66.67^{e} ±2.31	58.67^{f} ±4.62
12.5	92.0^{a} ±0.00	80.00^{b} ±4.00	80.00^{b} ±6.93	78.67^{bc} ±2.83	72.0^{bc} ±4.00	70.67^{c} ±2.31	70.67^{c} ±6.11	70.67^{c} ±2.31	50.67^{de} ±10.07	57.33^{d} ±6.11	46.67^{e} ±2.31	48.00^{e} ±6.93	44.00^{e} ±4.00	48.00^{e} ±4.00	49.33^{de} ±2.31	48.00^{e} ±4.00	46.67^{e} ±6.11
15.0	92.0^{a} ±0.00	76.00^{b} ±0.00	73.33^{bc} ±4.62	69.33^{bc} ±2.83	61.33^{cde} ±6.11	56.00^{de} ±8.00	64.00^{bcd} ±13.86	49.33^{ef} ±4.62	42.67^{fg} ±9.24	36.00^{gh} ±4.00	33.33^{ghi} ±8.33	26.67^{hi} ±8.33	25.33^{h} ±10.07	26.67^{hi} ±9.24	32.00^{ghi} ±10.58	24.00^{hi} ±4.00	22.67^{i} ±4.62
17.5	92.0^{a} ±0.00	53.33^{c} ±2.31	69.33^{b} ±6.11	53.33^{c} ±5.66	50.67^{c} ±6.11	37.33^{d} ±4.62	30.67^{d} ±6.11	22.67^{e} ±2.31	21.33^{e} ±6.11	13.33^{f} ±6.11	5.33^{g} ±4.62	2.67^{g} ±2.31	1.33^{g} ±2.31	0.00^{g} ±0.00	-	-	-

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

Table A12. Changes in germination of rye stored at 40°C (n=3).

MC (%)	Storage period (wk)																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
10.0	92.0^{a*} ±0.00**	76.00^{bc} ±4.00	70.00^{bcd} ±6.00	76.00^{bc} ±10.58	74.67^{bcd} ±6.11	78.67^{b} ±8.33	76.00^{bc} ±6.93	66.67^{cdef} ±2.31	77.33^{b} ±2.31	72.0^{bcd} ±4.00	57.33^{f} ±8.33	65.33^{def} ±4.62	61.33^{efg} ±11.55	66.67^{cdef} ±2.31	58.67^{f} ±4.62	54.67^{g} ±2.31	53.33^{g} ±6.11
12.5	92.0^{a} ±0.00	64.00^{bc} ±4.00	70.67^{b} ±10.07	62.67^{bc} ±10.07	54.67^{cd} ±11.55	54.67^{cd} ±16.17	38.67^{ef} ±10.07	34.67^{ef} ±10.07	46.67^{de} ±6.11	29.33^{f} ±11.55	40.00^{e} ±10.58	33.33^{ef} ±6.11	33.33^{ef} ±4.62	41.33^{def} ±4.62	36.00^{e} ±6.93	30.67^{f} ±8.33	29.33^{f} ±4.62
15.0	92.0^{a} ±0.00	37.33^{b} ±2.31	22.67^{c} ±16.17	10.67^{cd} ±2.31	17.33^{c} ±8.33	12.00^{cd} ±10.58	4.00^{d} ±0.00	0.00^{d} ±0.00	-	-	-	-	-	-	-	-	-
17.5	92.0^{a} ±0.00	20.00^{b} ±4.00	2.67^{c} ±4.62	6.67^{c} ±8.33	5.33^{c} ±2.31	0.00^{c} ±0.00	-	-	-	-	-	-	-	-	-	-	-

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

Table A13. Changes in germination of canola stored at 10°C (n=3).

MC (%)	Storage period (wk)																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
7.50	96.0^{a}* ±0.00**	94.67^{a} ±2.31	92.00^{ab} ±0.00	88.00^{bcd} ±0.00	88.00^{bcd} ±4.00	86.67^{cde} ±6.11	88.00^{bcd} ±0.00	92.00^{ab} ±4.00	92.00^{ab} ±4.00	89.33^{bc} ±2.31	80.00^{f} ±0.00	85.33^{cde} ±2.31	86.67^{cde} ±2.31	84.00^{def} ±4.00	82.67^{ef} ±4.62	86.67^{cde} ±2.31	88.00^{bcd} ±0.00
10.0	96.0^{a} ± 0.00	88.00^{b} ±0.00	82.67^{bcd} ±6.11	76.00^{de} ±4.00	76.00^{de} ±6.93	74.67^{e} ±2.31	78.67^{cde} ±2.31	84.00^{bc} ±4.00	85.33^{bc} ±6.11	82.6^{bcd} ±6.11	78.67^{cde} ±2.31	82.67^{bcd} ±6.11	78.67^{cde} ±2.31	81.33^{bcde} ±2.31	85.33^{bc} ±4.62	81.33^{bcde} ±2.31	80.00^{bc} ±0.00
12.5	96.0^{a} ±0.00	85.33^{bc} ±2.31	82.67^{bcd} ±2.31	78.67^{cde} ±4.62	73.33^{e} ±6.11	80.00^{cde} ±4.00	77.33^{de} ±4.62	88.00^{b} ±4.00	73.33^{e} ±10.07	78.67^{cde} ±2.31	77.33^{de} ±6.11	85.33^{bc} ±4.62	77.33^{de} ±2.31	77.33^{de} ±2.31	76.00^{de} ±0.00	77.33^{de} ±2.31	76.00^{de} ±0.00
15.0	96.0^{a} ±0.00	84.00^{b} ±4.00	80.00^{bcd} ±4.00	78.67^{bcde} ±4.62	65.33^{f} ±10.07	74.67^{de} ±4.62	74.67^{de} ±4.62	77.33^{bcde} ±4.62	72.00^{ef} ±6.93	74.67^{de} ±2.31	82.67^{bc} ±2.31	82.67^{bc} ±2.31	72.00^{ef} ±0.00	73.33^{de} ±2.31	76.00^{cde} ±0.00	74.67^{de} ±4.62	72.00^{ef} ±4.00

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

Table A14. Changes in germination of canola stored at 20°C (n=3).

MC (%)	Storage period (wk)																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
7.50	96.0^{a}* ±0.00**	90.67^{ab} ±2.31	85.33^{bcde} ±2.31	84.00^{cdef} ±0.00	85.33^{bcde} ±2.31	85.33^{bcde} ±6.11	86.67^{bcde} ±6.11	88.00^{bc} ±0.00	86.67^{bcd} ±2.31	84.00^{cdef} ±4.00	80.00^{efg} ±4.00	82.67^{cdefg} ±2.31	77.67^{g} ±2.89	80.00^{efg} ±4.00	81.33^{defg} ±6.11	78.67^{fg} ±2.31	80.00^{efg} ±0.00
10.0	96.0^{a} ± .00	84.00^{bc} ±4.00	78.67^{cd} ±6.11	81.33^{bcd} ±6.11	74.67^{d} ±4.62	80.00^{bcd} ±4.00	81.33^{bcd} ±6.11	76.00^{d} ±4.00	86.67^{b} ±2.31	84.00^{bc} ±4.00	77.33^{cd} ±4.62	78.67^{cd} ±4.62	74.67^{d} ±2.31	76.00^{d} ±4.00	80.00^{bcd} ±0.00	78.67^{cd} ±2.31	78.67^{cd} ±2.31
12.5	96.0^{a} ±0.00	82.67^{b} ±2.31	78.67^{bcd} ±6.11	74.67^{bcde} ±10.07	72.00^{de} ±6.93	73.33^{cde} ±6.11	78.67^{bcd} ±2.31	76.00^{bcde} ±4.00	81.33^{bc} ±2.31	77.33^{bcde} ±2.31	78.67^{bcd} ±6.11	77.33^{bcde} ±6.11	74.67^{bcde} ±4.62	74.67^{bcde} ±6.11	72.00^{de} ±8.00	69.33^{e} ±6.11	69.33^{e} ±2.31
15.0	96.0^{a} ±0.00	76.00^{bc} ±4.00	77.33^{b} ±2.31	61.33^{fg} ±2.31	72.00^{bcdef} ±4.00	73.33^{bcde} ±6.11	74.67^{bcd} ±6.11	73.33^{bcde} ±8.33	73.33^{bcde} ±11.55	69.33^{bcdefg} ±2.31	66.67^{bcdefg} ±16.17	72.00^{bcdef} ±8.00	64.00^{defg} ±4.00	65.33^{cdefg} ±2.31	66.67^{bcdefg} ±2.31	62.67^{efg} ±6.11	60.00^{g} ±4.00

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

Table A15. Changes in germination of canola stored at 30°C (n=3).

MC (%)	Storage period (wk)																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
7.50	96.0^{a}* ±0.00**	85.33^{b} ±4.62	81.33^{bc} ±4.62	81.33^{bc} ±2.31	81.33^{bc} ±4.62	74.67^{de} ±4.62	77.33^{cde} ±2.31	81.33^{bc} ±2.31	78.67^{cd} ±6.11	72.00^{e} ±6.93	78.67^{cd} ±2.31	81.33^{bc} ±2.31	76.00^{cde} ±4.00	77.33^{cde} ±2.31	78.67^{cd} ±2.31	78.67^{cd} ±2.31	78.67^{cd} ±2.31
10.0	96.0^{a} ±0.00	78.67^{b} ±2.31	76.00^{bc} ±4.00	74.67^{bcd} ±6.11	72.00^{bcde} ±4.00	68.00^{cde} ±8.00	72.00^{bcde} ±4.00	72.00^{bcde} ±4.00	66.67^{cde} ±12.86	64.00^{e} ±4.00	64.00^{e} ±8.00	70.67^{bcde} ±8.33	69.33^{bcde} ±4.62	68.00^{cde} ±8.00	72.00^{bcde} ±4.00	66.67^{cde} ±4.62	65.33^{de} ±2.31
12.5	96.0^{a} ±0.00	77.33^{bc} ±4.62	78.67^{b} ±2.31	64.00^{de} ±6.93	68.00^{bcd} ±6.93	57.33^{de} ±4.62	60.00^{de} ±4.00	66.6^{cd} ±2.31	68.00^{bcd} ±14.42	64.00^{de} ±4.00	60.00^{de} ±4.00	62.67^{de} ±12.22	66.67^{cd} ±9.24	57.33^{de} ±6.11	54.6^{e} ±10.07	60.00^{de} ±4.00	57.33^{de} ±2.31
15.0	96.0^{a} ±0.00	74.67^{b} 2.31	76.00^{b} ±4.00	62.67^{bc} ±11.55	54.67^{cd} ±4.62	38.67^{efg} ±15.14	45.33^{def} ±6.11	38.67^{efg} ±12.22	46.67^{de} ±8.33	34.67^{efg} ±12.86	33.33^{efg} ±12.86	28.00^{g} ±10.58	40.00^{efg} ±4.00	32.00^{fg} ±4.00	32.00^{fg} ±10.58	34.67^{efg} ±2.31	29.33^{g} ±2.31

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

Table A16. Changes in germination of canola stored at 40°C (n=3).

MC (%)	Storage period (wk)																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
7.50	96.0^{a}* ±0.00**	85.33^{ab} ±2.31	70.67^{cd} ±6.11	73.33^{cd} ±2.31	73.33^{cd} ±6.11	78.67^{bc} ±2.31	74.67^{bcd} ±9.24	73.33^{cd} ±6.11	74.67^{bcd} ±4.62	64.00^{d} ±6.93	68.00^{cd} ±13.86	70.67^{cd} ±6.11	45.33^{e} ±10.07	41.33^{e} ±6.11	49.33^{e} ±6.11	50.67^{e} ±6.11	46.67^{e} ±2.31
10.0	96.0^{a} ±0.00	72.00^{b} ±4.00	62.67^{b} ±12.22	41.33^{cde} ±10.07	36.00^{cde} ±10.58	44.00^{cd} ±10.58	41.33^{cde} ±6.11	46.67^{c} ±11.55	42.67^{cde} ±12.86	30.67^{de} ±4.62	36.00^{cde} ±4.00	33.33^{cde} ±18.48	38.67^{cde} ±2.31	34.67^{cde} ±2.31	29.33^{e} ±4.62	29.33^{e} ±6.11	13.33^{e} ±2.31
12.5	96.0^{a} ±0.00	69.33^{b} ±6.11	46.67^{c} ±4.62	29.33^{d} ±4.62	5.33^{e} ±6.11	2.67^{e} ±2.31	4.00^{e} ±0.00	0.00^{e} ±0.00	-	-	-	-	-	-	-	-	-
15.0	96.0^{a} ±0.00	68.00^{b} ±6.93	29.33^{c} ±4.62	12.00^{d} ±4.00	0.00^{e} ±0.00	-	-	-	-	-	-	-	-	-	-	-	-

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

APPENDIX B: Moisture content data

Table B1. Moisture content of rye stored at 10°C.

Storage period (week)	Replicate	Initial moisture content (% wb)			
		10.0	12.5	15.0	17.5
1	a	12.13	13.03	15.27	18.03
	b	11.01	13.61	15.24	17.66
	c	11.35	13.23	15.23	17.61
	mean	11.50	13.29	15.25	17.77
	s.d.	0.58	0.30	0.02	0.23
2	a	11.40	13.50	15.86	17.75
	b	11.22	13.44	15.82	17.69
	c	11.56	13.57	15.46	17.87
	mean	11.39	13.50	15.71	17.77
	s.d.	0.17	0.06	0.22	0.09
3	a	11.67	13.86	16.28	18.12
	b	11.81	13.84	16.04	18.02
	c	11.87	14.08	16.05	18.10
	mean	11.79	13.93	16.12	18.08
	s.d.	0.10	0.13	0.13	0.06
4	a	12.79	14.44	17.27	18.26
	b	12.59	13.91	17.08	17.98
	c	12.23	14.21	16.16	17.96
	mean	12.54	14.18	16.84	18.06
	s.d.	0.28	0.26	0.59	0.17

Storage period (week)	Replicate	Initial moisture content (% wb)			
		10.0	12.5	15.0	17.5
5	a	12.39	15.77	17.29	18.76
	b	12.30	14.10	17.41	18.42
	c	13.17	15.10	16.63	18.37
	mean	12.62	14.99	17.11	18.52
	s.d.	0.48	0.84	0.42	0.21
6	a	12.92	15.23	16.50	18.38
	b	12.99	14.18	17.07	18.29
	c	12.96	14.53	16.81	18.14
	mean	12.96	14.65	16.79	18.27
	s.d.	0.03	0.53	0.29	0.12
7	a	13.30	14.88	17.26	18.27
	b	12.26	14.43	16.52	18.13
	c	13.61	14.61	16.50	18.04
	mean	13.05	14.64	16.76	18.15
	s.d.	0.70	0.23	0.43	0.12
8	a	12.65	15.41	16.39	17.67
	b	12.28	14.40	16.37	18.16
	c	12.98	14.26	16.30	17.79
	mean	12.64	14.69	16.35	17.88
	s.d.	0.35	0.62	0.04	0.26

Storage period (week)	Replicate	Initial moisture content (% wb) 10.0	12.5	15.0	17.5
9	a	13.38	15.83	17.07	18.57
	b	12.81	15.08	17.26	18.50
	c	13.97	14.78	16.88	18.40
	mean	13.39	15.23	17.07	18.49
	s.d.	0.58	0.54	0.19	0.08
10	a	13.25	15.82	17.41	18.72
	b	13.05	15.15	17.06	18.43
	c	13.78	14.86	16.91	18.54
	mean	13.36	15.28	17.13	18.57
	s.d.	0.38	0.49	0.26	0.15
11	a	13.50	16.15	17.34	18.27
	b	13.39	15.52	17.31	19.08
	c	13.70	15.25	17.09	18.77
	mean	13.53	15.64	17.25	18.71
	s.d.	0.16	0.46	0.13	0.41
12	a	13.13	15.67	16.95	17.85
	b	12.82	14.89	17.01	18.71
	c	13.43	15.00	16.74	18.30
	mean	13.13	15.18	16.90	18.29
	s.d.	0.30	0.42	0.14	0.43

Storage period (week)	Replicate	Initial moisture content (% wb) 10.0	12.5	15.0	17.5
13	a	13.05	15.85	16.90	18.25
	b	12.81	15.04	16.86	18.67
	c	13.48	14.89	16.84	18.54
	mean	13.12	15.26	16.87	18.49
	s.d.	0.34	0.52	0.03	0.21
14	a	12.99	15.58	16.87	18.68
	b	15.35	14.90	16.58	18.44
	c	13.47	14.94	16.78	18.33
	mean	13.93	15.14	16.74	18.49
	s.d.	1.25	0.38	0.15	0.18
15	a	13.18	15.80	17.06	18.23
	b	13.01	15.25	17.15	18.72
	c	13.74	15.22	16.75	18.47
	mean	13.31	15.42	16.99	18.47
	s.d.	0.38	0.33	0.21	0.24
16	a	13.28	15.84	16.79	18.01
	b	13.21	15.34	16.83	18.82
	c	13.87	15.24	16.86	18.83
	mean	13.45	15.47	16.83	18.55
	s.d.	0.36	0.32	0.03	0.47

* Standard deviation of the replicates from the mean.

Table B2. Moisture content of rye stored at 20°C.

		Initial moisture content (% wb)			
Storage period (week)	Replicate	10.0	12.5	15.0	17.5
1	a	11.75	13.53	15.03	16.65
	b	11.53	13.42	15.10	16.49
	c	11.75	13.38	14.95	16.93
	mean	11.68	13.44	15.03	16.69
	s.d.*	0.13	0.08	0.07	0.22
2	a	12.35	13.50	15.20	16.94
	b	10.31	13.60	15.01	16.53
	c	12.13	13.40	15.17	16.78
	mean	11.60	13.50	15.13	16.75
	s.d.	1.12	0.10	0.10	0.21
3	a	12.94	14.04	15.42	16.23
	b	13.13	14.09	15.20	16.15
	c	13.11	13.99	15.47	16.22
	mean	13.06	14.04	15.37	16.20
	s.d.	0.10	0.05	0.14	0.04
4	a				
	b	13.12	14.00	15.46	16.00
	c	13.46	14.12	15.21	15.85
	mean	13.73	14.13	15.20	17.05
	s.d.	13.43	14.08	15.29	16.30
		0.30	0.07	0.15	0.66

Storage period (week)	Replicate	Initial moisture content (% wb) 10.0	12.5	15.0	17.5
5	a	9.95	14.45	15.61	16.46
	b	13.83	14.39	15.42	15.95
	c	13.48	14.37	15.56	16.58
	mean	12.42	14.40	15.53	16.33
	s.d.	2.15	0.04	0.10	0.34
6	a	13.04	14.17	15.87	16.21
	b	13.32	14.11	15.31	16.26
	c	13.15	14.12	15.60	16.66
	mean	13.17	14.13	15.60	16.38
	s.d.	0.14	0.03	0.28	0.25
7	a	13.10	13.88	15.19	15.72
	b	13.33	13.87	15.61	15.69
	c	12.84	14.12	15.12	16.04
	mean	13.09	13.95	15.31	15.81
	s.d.	0.24	0.14	0.26	0.19
8	a	12.79	13.58	14.62	14.75
	b	12.70	13.45	14.65	14.92
	c	13.51	13.90	14.66	15.51
	mean	13.00	13.64	14.64	15.06
	s.d.	0.44	0.23	0.02	0.40

Storage period (week)	Replicate	Initial moisture content (% wb) 10.0	12.5	15.0	17.5
9	a	13.20	13.83	15.28	15.80
	b	13.32	13.74	15.24	16.18
	c	13.06	14.11	15.03	15.55
	mean	13.19	13.89	15.18	15.85
	s.d.	0.13	0.19	0.13	0.32
10	a	13.28	9.04	15.58	16.07
	b	13.36	14.04	15.25	16.37
	c	13.16	14.03	15.17	16.02
	mean	13.27	12.37	15.33	16.15
	s.d.	0.10	2.88	0.22	0.19
11	a	13.33	14.07	15.29	15.33
	b	13.51	14.06	15.43	15.28
	c	13.28	14.26	15.31	16.70
	mean	13.42	14.07	15.36	15.31
	s.d.	0.12	0.11	0.07	0.81
12	a	12.74	13.51	14.61	15.01
	b	12.91	13.03	14.42	14.65
	c	12.81	13.70	14.66	16.22
	mean	12.82	13.41	14.56	15.30
	s.d.	0.09	0.34	0.12	0.82

Storage period (week)	Replicate	Initial moisture content (% wb) 10.0	12.5	15.0	17.5
13	a	12.86	13.51	14.71	15.34
	b	12.89	13.50	14.54	14.48
	c	12.76	13.65	14.52	15.29
	mean	12.83	13.55	14.59	15.04
	s.d.	0.07	0.08	0.10	0.48
14	a	12.51	13.06	14.61	14.22
	b	12.53	13.17	14.26	14.23
	c	12.44	13.19	14.23	14.73
	mean	12.49	13.14	14.36	14.39
	s.d.	0.04	0.07	0.21	0.29
15	a	12.79	13.27	14.76	14.31
	b	12.79	13.40	14.46	14.31
	c	12.75	13.48	14.44	15.44
	mean	12.77	13.38	14.55	14.69
	s.d.	0.02	0.11	0.18	0.65
16	a	12.79	13.14	15.41	14.04
	b	12.65	13.30	14.18	15.38
	c	12.82	13.78	14.81	15.62
	mean	12.75	13.41	14.80	15.01
	s.d.	0.09	0.33	0.62	0.85

* Standard deviation of the replicates from the mean

Table B3. Moisture content of rye stored at 30°C.

Storage period (week)	Replicate	Initial moisture content (% wb) 10.0	12.5	15.0	17.5
1	a	11.01	12.69	14.71	16.45
	b	11.03	12.49	14.48	16.57
	c	11.07	12.60	14.52	15.10
	mean	11.04	12.59	14.57	16.04
	s.d.*	0.03	0.10	0.13	0.82
2	a	11.15	12.75	14.67	14.75
	b	11.43	13.34	13.26	13.94
	c	11.25	12.44	12.56	12.80
	mean	11.28	12.84	13.50	13.83
	s.d.	0.14	0.46	1.08	0.98
3	a	11.24	12.80	13.41	15.16
	b	11.43	12.61	12.52	13.16
	c	11.23	12.49	13.46	12.71
	mean	11.30	12.63	13.13	13.68
	s.d.	0.11	0.16	0.53	1.30
4	a	11.89	12.69	13.50	13.03
	b	11.24	12.12	12.19	12.64
	c	11.11	12.16	12.02	12.37
	mean	11.42	12.33	12.57	12.68
	s.d.	0.42	0.32	0.81	0.33

Storage period (week)	Replicate	Initial moisture content (% wb) 10.0	12.5	15.0	17.5
5	a	11.63	13.19	13.45	13.63
	b	11.66	12.38	12.81	12.95
	c	11.55	12.40	13.43	13.05
	mean	11.62	12.65	13.23	13.21
	s.d.	0.05	0.46	0.36	0.37
6	a	11.55	12.67	13.48	12.90
	b	11.57	12.64	12.75	12.73
	c	11.51	12.52	12.53	12.88
	mean	11.54	12.61	12.92	12.84
	s.d.	0.03	0.08	0.50	0.10
7	a	11.81	12.98	13.71	13.92
	b	11.81	12.92	13.55	13.33
	c	11.79	12.81	13.20	12.99
	mean	11.80	12.90	13.49	13.41
	s.d.	0.01	0.09	0.26	0.47
8	a	11.47	12.49	13.19	13.37
	b	11.55	13.25	12.97	12.40
	c	11.44	12.25	12.64	12.81
	mean	11.49	12.66	12.93	12.86
	s.d.	0.06	0.52	0.27	0.49

Storage period (week)	Replicate	Initial moisture content (% wb)			
		10.0	12.5	15.0	17.5
9	a	11.52	12.47	12.68	13.60
	b	11.44	12.45	13.04	12.60
	c	11.27	12.16	12.16	12.76
	mean	11.41	12.36	12.63	12.99
	s.d.	0.13	0.18	0.45	0.54
10	a	11.29	12.17	13.36	13.23
	b	11.22	12.51	13.73	12.15
	c	11.24	12.42	11.99	12.73
	mean	11.25	12.37	13.03	12.70
	s.d.	0.03	0.18	0.91	0.54
11	a	11.48	19.89	13.43	13.37
	b	11.62	12.75	14.40	12.62
	c	11.51	12.33	12.34	13.50
	mean	11.54	14.99	13.39	13.16
	s.d.	0.07	4.25	1.03	0.47
12	a	11.69	12.52	13.81	13.75
	b	11.66	13.05	14.53	12.66
	c	11.57	12.36	12.46	13.21
	mean	11.64	12.64	13.60	13.21
	s.d.	0.06	0.36	1.06	0.54

Storage period (week)	Replicate	Initial moisture content (% wb) 10.0	12.5	15.0	17.5
13	a	11.58	12.30	13.90	13.62
	b	11.52	12.88	14.66	13.71
	c	11.57	12.28	12.14	12.62
	mean	11.56	12.48	13.57	13.31
	s.d.	0.03	0.34	1.29	0.60
14	a	11.45	12.02	13.42	13.40
	b	11.34	12.82	14.55	12.33
	c	11.54	12.18	12.37	12.60
	mean	11.44	12.34	13.45	12.78
	s.d.	0.10	0.42	1.09	0.56
15	a	11.54	11.70	13.06	13.11
	b	11.45	11.41	13.86	12.89
	c	11.83	12.25	11.86	12.75
	mean	11.61	11.79	12.93	12.92
	s.d.	0.20	0.43	1.01	0.18
16	a				
	b	10.97	11.59	13.43	13.18
	c	10.92	12.21	14.43	11.58
	mean	10.95	12.45	11.86	12.53
	s.d.	0.03	0.44	0.71	1.13

* Standard deviation of the replicates from the mean

Table B4. Moisture content of rye stored at 40°C.

Storage period (week)	Replicate	Initial moisture content (% wb) 10.0	12.5	15.0	17.5
1	a	11.09	11.64	14.02	14.56
	b	11.02	11.93	14.42	14.60
	c	10.97	12.28	14.03	14.99
	mean	11.03	11.95	14.16	14.72
	s.d.*	0.06	0.32	0.23	0.24
2	a	11.22	11.92	13.01	13.38
	b	11.38	11.88	13.33	13.84
	c	11.22	12.04	13.18	13.31
	mean	11.27	11.95	13.17	13.51
	s.d.	0.09	0.08	0.16	0.29
3	a	9.04	10.34	10.54	12.76
	b	9.20	9.64	10.13	12.50
	c	8.89	9.75	10.11	12.75
	mean	9.04	9.91	10.26	12.67
	s.d.	0.15	0.38	0.24	0.15
4	a	7.58	7.94	12.62	11.31
	b	7.33	6.86	10.46	10.79
	c	9.77	6.98	11.32	10.56
	mean	8.23	7.26	11.47	10.89
	s.d.	1.34	0.59	1.09	0.39

Storage period (week)	Replicate	Initial moisture content (% wb)			
		10.0	12.5	15.0†	17.5†
5	a	7.42	8.27	8.28	10.63
	b	7.52	8.26	7.80	9.21
	c	8.50	8.13	8.96	10.84
	mean	7.81	8.22	8.35	10.23
	s.d.*	0.60	0.08	0.58	0.89
6	a	6.32	6.91	7.98	
	b	7.63	7.46	8.44	
	c	7.66	8.29	7.28	
	mean	7.20	7.55	7.90	
	s.d.	0.77	0.70	0.58	
7	a	6.05	6.91		
	b	6.97	7.38		
	c	7.67	6.56		
	mean	6.90	6.95		
	s.d.	0.81	0.41		
8	a	5.72	6.20		
	b	5.78	5.69		
	c	6.66	5.97		
	mean	6.05	5.95		
	s.d.	0.53	0.25		

Storage period (week)	Replicate	Initial moisture content (% wb) 10.0	12.5	15.0	17.5
9	a	6.28	5.89		
	b	6.04	6.26		
	c	7.61	7.20		
	mean	6.64	6.45		
	s.d.	0.84	0.67		
10	a	6.56	5.62		
	b	5.98	6.75		
	c	6.95	6.41		
	mean	6.49	6.26		
	s.d.	0.49	0.58		
11	a	5.69	5.93		
	b	6.19	6.62		
	c	6.72	7.36		
	mean	6.20	6.63		
	s.d.	0.52	0.71		
12	a	5.40	5.09		
	b	6.27	5.63		
	c	6.06	6.50		
	mean	5.91	5.74		
	s.d.	0.46	0.71		

Storage period (week)	Replicate	Initial moisture content (% wb) 10.0	12.5	15.0	17.5
13	a	5.42	5.33		
	b	5.16	5.65		
	c	6.60	6.76		
	mean	5.73	5.91		
	s.d.	0.77	0.75		
14	a	4.95	4.73		
	b	4.93	5.35		
	c	6.49	6.19		
	mean	5.45	5.42		
	s.d.	0.89	0.74		
15	a	5.20	4.71		
	b	5.36	5.08		
	c	6.49	6.72		
	mean	5.68	5.50		
	s.d.	0.70	1.07		
16	a	5.51	4.70		
	b	4.77	4.70		
	c	6.65	5.61		
	mean	5.64	5.00		
	s.d.	0.95	0.52		

* Standard deviation of the replicates from the mean.
† No samples were analyzed after the germination reached 0%.

Table B5. Moisture content of canola stored at 10°C.

Storage period (week)	Replicate	Initial moisture content (% wb) 7.5	10.0	12.5	15.0
1	a	7.96	11.03	12.84	14.81
	b	7.79	11.34	12.94	15.08
	c	7.60	10.89	13.06	15.14
	mean	7.78	11.09	12.95	15.01
	s.d.*	0.14	0.19	0.09	0.14
2	a	8.50	11.01	12.81	14.62
	b	8.49	11.25	12.85	14.89
	c	8.12	11.02	13.08	15.11
	mean	8.37	11.09	12.91	14.87
	s.d.	0.18	0.11	0.12	0.20
3	a	8.72	11.67	12.36	14.01
	b	8.32	11.65	12.94	14.68
	c	8.36	11.39	12.19	14.48
	mean	8.47	11.57	12.50	14.39
	s.d.	0.22	0.16	0.39	0.35
4	a	8.50	11.16	12.62	14.44
	b	8.95	11.59	12.85	14.86
	c	8.32	11.57	13.06	14.62
	mean	8.59	11.44	12.84	14.64
	s.d.	0.32	0.24	0.22	0.21

Storage period (week)	Replicate	Initial moisture content (% wb)			
		7.5	10.0	12.5	15.0
5	a	9.91	11.44	13.11	14.49
	b	9.91	11.48	12.97	14.86
	c	9.52	11.61	13.15	14.78
	mean	9.78	11.51	13.07	14.71
	s.d.	0.23	0.09	0.09	0.19
6	a	7.42	10.10	11.70	13.15
	b	7.33	9.79	11.78	13.96
	c	7.53	10.35	12.09	13.68
	mean	7.43	10.08	11.85	13.60
	s.d.	0.10	0.28	0.21	0.41
7	a	8.89	10.83	12.87	13.37
	b	8.86	11.08	13.01	13.72
	c	8.69	11.37	13.17	13.59
	mean	8.81	11.09	13.02	13.56
	s.d.	0.10	0.27	0.15	0.18
8	a	9.21	10.81	12.22	13.90
	b	9.25	11.08	12.56	13.90
	c	9.28	11.04	12.49	14.26
	mean	9.25	10.98	12.42	14.02
	s.d.	0.03	0.15	0.18	0.20

Storage period (week)	Replicate	Initial moisture content (% wb) 7.5	10.0	12.5	15.0
9	a	9.33	10.60	12.75	14.28
	b	9.09	10.98	12.86	13.39
	c	9.12	10.83	12.71	14.59
	mean	9.18	10.80	12.77	14.08
	s.d.	0.13	0.19	0.08	0.62
10	a	8.86	10.66	11.60	13.76
	b	9.32	11.00	12.09	13.64
	c	8.86	11.15	11.86	13.68
	mean	9.01	10.94	11.85	13.69
	s.d.	0.27	0.25	0.25	0.07
11	a	8.01	9.69	11.58	12.80
	b	8.55	10.41	11.98	12.52
	c	8.46	10.43	11.59	12.21
	mean	8.34	10.18	11.72	12.51
	s.d.	0.29	0.42	0.23	0.30
12	a	8.40	10.09	11.83	12.33
	b	8.87	10.64	11.99	12.99
	c	8.86	10.55	12.31	12.84
	mean	8.71	10.43	12.04	12.72
	s.d.	0.27	0.30	0.24	0.34

Storage period (week)	Replicate	Initial moisture content (% wb)			
		7.5	10.0	12.5	15.0
13	a	8.75	10.08	12.15	12.73
	b	9.09	10.41	12.06	12.84
	c	8.90	10.58	11.69	12.46
	mean	8.91	10.36	11.97	12.68
	s.d.	0.17	0.25	0.25	0.19
14	a	8.78	10.13	11.85	12.21
	b	8.97	10.80	12.02	12.62
	c	8.97	10.75	11.99	12.57
	mean	8.91	10.56	11.95	12.47
	s.d.	0.11	0.37	0.09	0.23
15	a	7.75	9.15	11.18	12.19
	b	7.95	9.51	11.76	12.43
	c	7.99	9.60	11.61	12.59
	mean	7.90	9.42	11.52	12.40
	s.d.	0.13	0.24	0.30	0.20
16	a	8.10	9.48	11.52	12.01
	b	8.41	9.95	11.87	12.41
	c	8.32	10.00	11.50	12.46
	mean	8.28	9.81	11.63	12.29
	s.d.	0.16	0.29	0.21	0.25

* Standard deviation of the replicates from the mean.

Table B6. Moisture content of canola stored at 20°C.

Storage period (week)	Replicate	Initial moisture content (% wb)			
		7.5	10.0	12.5	15.0
1	a	7.71	9.10	11.35	13.45
	b	7.69	9.41	11.24	13.80
	c	7.78	9.09	11.49	13.58
	mean	7.67	9.40	11.64	13.96
	s.d.*	0.12	0.43	0.58	0.71
2	a	7.88	9.69	10.41	11.66
	b	7.78	9.71	10.60	11.77
	c	7.65	9.64	10.88	11.49
	mean	7.77	9.68	10.63	11.64
	s.d.	0.12	0.04	0.24	0.14
3	a	8.09	9.20	10.95	12.68
	b	7.92	9.76	11.08	12.90
	c	7.93	9.26	10.98	12.36
	mean	7.98	9.40	11.01	12.64
	s.d.	0.09	0.31	0.07	0.27
4	a	7.71	9.10	11.35	13.45
	b	7.69	9.41	11.24	13.80
	c	7.78	9.09	11.49	13.58
	mean	7.72	9.20	11.36	13.61
	s.d.	0.05	0.18	0.13	0.18

Storage period (week)	Replicate	Initial moisture content (% wb)			
		7.5	10.0	12.5	15.0
5	a	7.95	9.28	9.92	10.35
	b	7.84	9.70	9.94	10.87
	c	7.96	9.34	10.34	10.50
	mean	7.92	9.44	10.07	10.57
	s.d.	0.07	0.23	0.24	0.27
6	a	6.64	7.92	9.03	12.02
	b	6.44	8.13	9.64	12.71
	c	6.58	8.17	9.79	12.67
	mean	6.55	8.07	9.49	12.46
	s.d.	0.10	0.13	0.40	0.39
7	a	7.85	9.07	10.71	11.06
	b	7.77	9.32	10.54	11.30
	c	7.81	8.94	10.73	11.42
	mean	7.81	9.11	10.66	11.26
	s.d.	0.04	0.19	0.10	0.18
8	a	7.66	8.49	8.78	9.98
	b	7.60	8.23	8.57	9.32
	c	7.58	8.24	8.43	9.91
	mean	7.61	8.32	8.59	9.73
	s.d.	0.04	0.14	0.18	0.36

Storage period (week)	Replicate	Initial moisture content (% wb)			
		7.5	10.0	12.5	15.0
9	a	7.53	8.52	8.95	9.71
	b	7.53	8.62	8.35	9.56
	c	7.48	8.46	8.92	9.89
	mean	7.52	8.53	8.74	9.72
	s.d.	0.03	0.08	0.34	0.17
10	a	7.67	8.57	9.33	10.10
	b	7.62	8.92	9.20	9.81
	c	7.72	8.64	9.58	9.73
	mean	7.67	8.71	9.37	9.88
	s.d.	0.05	0.18	0.19	0.19
11	a	6.80	7.73	7.84	10.07
	b	6.81	7.71	7.59	10.24
	c	6.92	7.58	7.82	9.53
	mean	6.84	7.67	7.75	9.95
	s.d.	0.07	0.08	0.14	0.37
12	a	6.98	8.20	8.28	8.99
	b	7.08	8.59	8.72	8.45
	c	7.04	8.10	8.47	8.23
	mean	7.03	8.30	8.49	8.56
	s.d.	0.05	0.26	0.22	0.39

Storage period (week)	Replicate	Initial moisture content (% wb)			
		7.5	10.0	12.5	15.0
13	a	7.17	8.06	8.56	8.92
	b	7.29	8.09	8.46	9.35
	c	7.25	7.96	8.48	8.72
	mean	7.24	8.04	8.50	9.00
	s.d.	0.06	0.07	0.06	0.32
14	a	7.24	8.33	9.08	8.90
	b	7.46	8.56	9.36	8.86
	c	7.30	8.22	9.20	9.15
	mean	7.33	8.37	9.21	8.97
	s.d.	0.12	0.18	0.14	0.16
15	a	5.86	7.03	6.89	8.34
	b	5.99	6.76	6.79	8.51
	c	6.12	6.70	6.33	8.50
	mean	5.99	6.83	6.67	8.45
	s.d.	0.13	0.18	0.30	0.10
16	a	6.41	7.40	7.41	7.81
	b	6.77	7.14	7.32	7.67
	c	6.33	7.15	7.24	7.92
	mean	6.50	7.23	7.33	7.80
	s.d.	0.24	0.15	0.08	0.13

* Standard deviation of the replicates from the mean.

Table B7. Moisture content of canola stored at 30°C.

Storage period (week)	Replicate	Initial moisture content (% wb) 7.5	10.0	12.5	15.0
1	a	6.60	9.15	12.01	14.63
	b	7.26	9.61	11.60	14.87
	c	7.18	9.33	11.56	14.62
	mean	7.14	9.52	11.92	14.78
	s.d.*	0.38	0.37	0.44	0.19
2	a	6.77	8.24	8.94	12.86
	b	6.65	8.19	8.61	12.69
	c	6.34	8.51	8.86	12.82
	mean	6.59	8.32	8.81	12.79
	s.d.	0.22	0.17	0.17	0.09
3	a	6.46	8.47	8.08	11.07
	b	6.67	8.00	8.40	11.11
	c	6.09	8.16	8.43	11.27
	mean	6.40	8.21	8.31	11.15
	s.d.	0.29	0.24	0.19	0.10
4	a	6.22	7.34	7.31	8.41
	b	6.36	6.89	7.42	8.70
	c	6.12	7.19	6.98	8.86
	mean	6.23	7.14	7.24	8.66
	s.d.	0.12	0.23	0.23	0.23

Storage period (week)	Replicate	Initial moisture content (% wb)			
		7.5	10.0	12.5	15.0
5	a	6.23	6.49	6.86	7.21
	b	6.19	6.78	6.79	7.31
	c	6.00	6.93	6.73	7.37
	mean	6.14	6.74	6.79	7.29
	s.d.	0.12	0.22	0.07	0.08
6	a	5.03	6.22	5.87	7.03
	b	4.87	6.62	6.38	7.81
	c	4.77	6.79	5.80	7.88
	mean	4.89	6.55	6.02	7.57
	s.d.	0.13	0.29	0.32	0.47
7	a	6.27	6.37	6.32	7.78
	b	6.27	6.98	6.30	7.34
	c	6.18	6.37	6.49	7.15
	mean	6.24	6.58	6.37	7.42
	s.d.	0.05	0.35	0.11	0.33
8	a	5.95	6.52	6.31	6.49
	b	6.17	6.23	6.06	6.82
	c	6.24	6.12	6.36	6.75
	mean	6.12	6.29	6.24	6.69
	s.d.	0.15	0.21	0.16	0.17

Storage period (week)	Replicate	Initial moisture content (% wb)			
		7.5	10.0	12.5	15.0
9	a	6.29	6.76	6.94	7.21
	b	6.46	6.63	6.30	7.34
	c	6.43	6.90	6.44	7.06
	mean	6.39	6.77	6.56	7.20
	s.d.	0.09	0.14	0.33	0.14
10	a	6.16	6.65	6.54	7.45
	b	6.26	6.33	7.08	7.70
	c	5.98	6.49	6.51	7.55
	mean	6.13	6.49	6.71	7.57
	s.d.	0.15	0.16	0.32	0.13
11	a	5.54	5.96	5.99	6.79
	b	5.75	5.98	5.82	6.80
	c	5.31	5.67	5.95	6.51
	mean	5.53	5.87	5.92	6.70
	s.d.	0.22	0.18	0.09	0.16
12	a	5.82	6.32	6.79	7.29
	b	5.98	6.33	6.99	7.05
	c	5.67	6.42	6.94	7.08
	mean	5.83	6.36	6.91	7.14
	s.d.	0.15	0.05	0.10	0.13

Storage period (week)	Replicate	Initial moisture content (% wb)			
		7.5	10.0	12.5	15.0
13	a	5.95	6.65	6.84	7.87
	b	6.21	6.31	6.84	7.32
	c	6.02	6.65	6.51	7.49
	mean	6.06	6.54	6.73	7.56
	s.d.	0.13	0.20	0.19	0.28
14	a	6.34	6.74	6.90	7.34
	b	6.60	6.52	6.42	7.36
	c	6.45	6.88	6.75	7.77
	mean	6.46	6.71	6.69	7.49
	s.d.	0.13	0.18	0.25	0.25
15	a	5.39	5.39	5.61	7.43
	b	5.73	5.41	5.65	7.67
	c	5.60	5.43	5.60	7.86
	mean	5.57	5.41	5.62	7.65
	s.d.	0.17	0.02	0.03	0.22
16	a	5.97	6.25	6.29	7.22
	b	5.74	5.92	6.28	7.31
	c	5.58	5.70	6.13	7.10
	mean	5.76	5.96	6.23	7.21
	s.d.	0.20	0.28	0.09	0.10

* Standard deviation of the replicates from the mean.

Table B8. Moisture content of canola stored at 40°C.

Storage period (week)	Replicate	Initial moisture content (% wb) 7.5	10.0	12.5	15.0
1	a	6.96	7.83	8.76	9.43
	b	6.75	7.62	8.31	9.20
	c	6.90	7.99	8.54	9.24
	mean	7.03	8.36	9.53	10.72
	s.d.*	0.33	1.10	1.99	2.86
2	a	5.63	6.73	7.24	8.74
	b	5.24	6.73	7.46	8.91
	c	5.26	6.94	7.46	8.94
	mean	5.38	6.80	7.39	8.86
	s.d.	0.22	0.12	0.12	0.11
3	a	4.84	5.21	5.44	7.68
	b	4.77	5.05	5.31	7.22
	c	4.72	5.34	5.44	7.21
	mean	4.78	5.20	5.40	7.37
	s.d.	0.06	0.15	0.08	0.27
4	a	4.56	4.55	3.79	4.33
	b	4.64	4.12	3.65	4.90
	c	4.51	4.16	3.36	4.33
	mean	4.57	4.28	3.60	4.52
	s.d.	0.06	0.24	0.22	0.33

Storage period (week)	Replicate	Initial moisture content (% wb)			
		7.5	10.0	12.5	15.0
5	a	4.51	3.62	3.74	3.85
	b	4.37	3.64	3.97	3.72
	c	4.34	3.90	3.63	3.71
	mean	4.41	3.72	3.78	3.76
	s.d.	0.09	0.16	0.17	0.08
6	a	2.52	3.32	3.54	
	b	2.60	3.27	3.69	
	c	2.63	3.14	3.21	
	mean	2.58	3.25	3.48	
	s.d.	0.06	0.10	0.24	
7	a	3.75	3.90		
	b	3.60	3.90		
	c	3.73	4.06		
	mean	3.69	3.96		
	s.d.	0.08	0.09		
8	a	3.70	4.21		
	b	3.42	4.08		
	c	3.75	3.85		
	mean	3.62	4.04		
	s.d.	0.17	0.18		

Storage period (week)	Replicate	Initial moisture content (% wb) 7.5	10.0	12.5	15.0
9	a	3.79	3.23		
	b	3.30	3.53		
	c	3.43	3.66		
	mean	3.51	3.48		
	s.d.	0.25	0.22		
10	a	3.82	3.74		
	b	3.59	3.43		
	c	3.52	3.21		
	mean	3.64	3.46		
	s.d.	0.16	0.27		
11	a	3.19	3.58		
	b	3.02	3.38		
	c	3.22	3.54		
	mean	3.14	3.50		
	s.d.	0.11	0.11		
12	a	3.76	3.50		
	b	3.74	3.59		
	c	3.93	3.54		
	mean	3.81	3.54		
	s.d.	0.10	0.04		

Storage period (week)	Replicate	Initial moisture content (% wb) 7.5	10.0	12.5	15.0
13	a	3.68	3.21		
	b	3.18	3.59		
	c	3.98	3.63		
	mean	3.61	3.48		
	s.d.	0.41	0.24		
14	a	3.91	3.73		
	b	3.60	3.56		
	c	3.84	3.71		
	mean	3.78	3.67		
	s.d.	0.16	0.09		
15	a	2.67	2.69		
	b	2.57	2.08		
	c	2.45	2.17		
	mean	2.56	2.31		
	s.d.	0.11	0.33		
16	a	3.36	2.42		
	b	3.15	2.59		
	c	3.09	2.71		
	mean	3.20	2.58		
	s.d.	0.14	0.15		

* Standard deviation of the replicates from the mean.
† No samples were analyzed after the germination reached 0%.

APPENDIX C: Invisible mould data

Table C1. Microflora of rye stored at 10°C.

Storage period (w)	Initial Moisture content (% wb)	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
4	10	a	16	20				100			
		b	24				4	100		8	
		c	4	4		4	8	92			
	12.5	a	4	4			12	96		4	
		b	12			4		88		4	4
		c	4	8	4		12	88		4	
	15	a	4			4	24	16			
		b	16				28	12			
		c	0	4			16	8			
	17.5	a	16	8	4		32	40	4		
		b	4	4	4		20	28	4		
		c	40	8			36	16		4	
8	10	a	92	8	4		8	64			
		b	36	4	4	4	4	68			
		c	44	4		4	4	88			
	12.5	a	24	16			28	60			4
		b	20	8		4	16	72			
		c	16					80			
	15	a	40	8			8	16		4	
		b	36	8	4	4	44	4		4	
		c	48	4	8		20	4		8	
	17.5	a	20	20	12	8	12	16			
		b	16		8	12	20	24		4	
		c	12	28	8			24			

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
12	10	a	4	4		4		80			4
		b	16	12		12	4	68			4
		c	12	4			12	64			
	12.5	a	8		4		4	48		4	4
		b	4	8		4	4	68		4	4
		c	8	4		4	8	60			4
	15	a	20		8		4				4
		b	28		12		8				
		c	40	4	16		12				
	17.5	a	32				24	32		8	
		b	20		8		8	20			
		c	16	4	8			44			
16	10	a	16	8		4	4	80			
		b	4	4		8		64			
		c	12				4	64			
	12.5	a	24		4	8	8	52			
		b	12	4	4	8	4	64			
		c	16	4		4	4	64			
	15	a	24	4	12		4	4			
		b	28	4	12		4	4			
		c	36	4	12		8				
	17.5	a	36		4		8	44			
		b	36	4	8		4	44			
		c	28	8	8		12	52			

Table C2. Microflora of rye stored at 20°C.

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
4	10	a	4	8	4			96		4	
		b	4	4	8			96			
		c	44	4				96	4		
	12.5	a	12	4		8	28	72	4		
		b	4	8	4		8	80			
		c		4	8		8	80			4
	15	a	8		8		48	8			
		b	8				28	20			
		c	8	4	8	8	28	32			
	17.5	a	8	8			8	52			
		b	16	4		4	8	60			
		c	12	8		12	8	64	4		
8	10	a	20	24		4	12	92		4	
		b	36	16	8		4	76			
		c	24	8	4	4	4	80			
	12.5	a	24	8	12	4	8	64			
		b	24	4	4	4	12	60			
		c	36	12	8	4	20	48		4	
	15	a	56	12			4				
		b	52	8		4	4				
		c	68	4	4		12				
	17.5	a	44	4			28	28		4	
		b	52	20	4	4	20	4		8	
		c	28	4	4	4	28	36		8	

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
12	10	a	20	4				80	4	4	4
		b	28	4	8		8	64	8		
		c	32	8			8	64			
	12.5	a	28	4				56	4		
		b	16	8	4		8	68	8		
		c	8	4			20	60	8		
	15	a	80	4	52		4				
		b	56	8	24		8				
		c	60	4	44		4			4	4
	17.5	a	40	12	12		20	20			
		b	16	12	4		20	40		8	
		c	24	8	8		20	28		8	
16	10	a	24	4	4		4	84	4		4
		b	24	8			12	60	4		4
		c	32					52			
	12.5	a	24	8			4	52	4		
		b	20	4			4	52	4		
		c	20	4			16	52	4		
	15	a	52	8	44		4				
		b	64	8	52		4				
		c	68	4	20		4				
	17.5	a	28	4	20		16	24		4	
		b	44	8	4		12	20		4	
		c	40	8	4		24	16			

Table C3. Microflora of rye stored at 30°C.

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
4	10	a	76	4	8			60			
		b	44		4		4	48			
		c	32		4		4	44		4	
	12.5	a	64		4		4	4		4	
		b	40		4	4		36		4	
		c	56		4		8	28			
	15	a	80	4	28		4	40		8	
		b	68		16		8	36			
		c	84	8	36	4		60			
	17.5	a	36	8	12	12	12	24			
		b	40	4	8	8	8	24			
		c	52	8	20			20			
8	10	a	88					8			
		b	84					4			
		c	84					4			
	12.5	a	84			4		4			
		b	80			4		8			
		c	84								
	15	a	92	4	4	8					
		b	84	4	4	12					
		c	84	8	8	4					
	17.5	a	52	12				12			
		b	60	8		4		4			
		c	60	8		4		4			

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
12	10	a	80		4		4				
		b	56				4				
		c	40				8			4	
	12.5	a	60		4	4	4	4		4	
		b	64		4	4					
		c	56		4		8				
	15	a	76		16		12			8	
		b	48	4	20		12				
		c	80	4	20	4					
	17.5	a	40	4	16		8	8			
		b	52	8	4	8	4	20			
		c	28	4	24			20			
16	10	a	80					8			
		b	88					4			
		c	76					4			
	12.5	a	80	4		4		4			
		b	88	4		4		8			
		c	68								
	15	a	88	4	8						
		b	96	4	4	8					
		c	76	8	16	16					
	17.5	a	48	4	12			12			
		b	76	4	4	8		20			
		c	68	8				28			

Table C4. Microflora of rye stored at 40°C.

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
4	10	a	16	8	4	4	12	88			
		b	20	4		8	4	96			
		c	12	12		8	4	96			
	12.5	a	4	4	4	8	4	32			
		b	12	4	8		24	32		4	
		c	20	8		4	20	36			
	15	a	28	4	4			44			
		b	60	4	4	8		36		4	
		c	20	4				28			
	17.5	a	52	48		4					
		b	52	60		4					
		c	36	52		12					
8	10	a	76		44			28			
		b	80		8			20			
		c	92		8			12			
	12.5	a	92		20		4	8			4
		b	96		12			8			
		c	100		20			4			
	15	a	100	4	4						
		b	92		16						
		c	92		8						
										8	
	17.5	a	100		12					12	
		b	96		8						
		c	2		8						

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
12*	10	a	80	20	28			20	4		
		b	84	16	20			16	8	8	
		c	80	12	16			20	4	8	
	12.5	a	80	36	8			4	4		
		b	84	40	12			4	8		
		c	76	40	8			4	8		
16*	10	a	92	24	16			16	4	8	
		b	84	24	12			24	4	4	
		c	80	16	28			24	4		
	12.5	a	76	28	32			4	8		
		b	96	44	16				4	12	
		c	88	44	28			4	4		

* No measurement was carried out once the germination reached 0%.

Table C5. Microflora of canola stored at 10°C.

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
4	7.5	a	52	4			24	28			
		b	36				32	40			
		c	8				20	80			
	10	a	28				44	48			
		b	28	4			40	52			
		c	24				52	40			
	12.5	a				16	28	64			
		b				24	64	32			
		c	8			28	52	44			
	15	a									
		b		4		4	12	88			
		c		4		4	16	84			
						4	32	92			
8	7.5	a	20				32	76			
		b	36				8	64		8	
		c	4				28	52			
	10	a	16			16	20	68			
		b	12			12	28	44		4	
		c	32	4		12	36	32			
	12.5	a				16	12	76			
		b					8	96			
		c		8			8	92			
	15	a					8	96			
		b		4			8	88			
		c					16	92			

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
12	7.5	a	8				28	76			4
		b	8				20	68			
		c	4				8	68			
	10	a	16			8	36	76			4
		b	12			12	40	80			4
		c	16			12	36	76			
	12.5	a					8	92			4
		b					12	92			8
		c					8	84			
	15	a					16	92			4
		b					12	88			4
		c					12	84			
16	7.5	a	16			4	32	80			
		b	12				44	72			
		c	8			4	16	52			
	10	a	20			12	36	88			8
		b	16			16	52	68			4
		c	16			20	48	68			
	12.5	a	4				16	88			4
		b	4				12	84			4
		c					12	96			4
	15	a					20	96			4
		b					28	60			
		c					24	76			

Table C6. Microflora of canola stored at 20°C.

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
4	7.5	a	8	20	4		20	96			
		b	12	4		4	16	92			
		c	4	4		8	24	92			
	10	a	36	16			4	80			
		b	48	20		4	8	76			
		c	44	20			8	76			
	12.5	a	12	8		24	4	72			4
		b	12	4		16	24	68		4	4
		c	12	4		8	16	84			4
	15	a	12	4	4	4	32	48			4
		b	14	4		8	28	44			4
		c	12	8	4	4	36	52			8
8	7.5	a	60	28			24	60			8
		b	28	28		4	20	64			4
		c	24	44			12	52	4		4
	10	a	40	8	4		16	52			12
		b	48	20			32	52	4		8
		c	28	16			24	32	4		8
	12.5	a	24	44	4		16	48			16
		b	36	48		4	8	48	4		20
		c	36	48	4		20	44			8
	15	a	4	32			8	68			16
		b	4	36	4		8	56			4
		c	4	32			12	60			16

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
12	7.5	a	16	12	4		12	64			
		b	20	8	4		16	76	4		
		c	16	8			12	72			
	10	a	24	12	8		12	88			
		b	20	16	4		12	84	4		
		c	20	12			16	84			
	12.5	a		36			36	64	4		
		b		36			32	60	8		
		c		20			36	72	4		
	15	a		8			36	56			
		b		4			28	52			
		c		16			40	48			
16	7.5	a	20	16	4		16	68	4		
		b	20	8			16	72	4		
		c	32	8			28	72			
	10	a	16	12			16	84			
		b	20	8	4		8	80			
		c	24	16			12	84			
	12.5	a	4	40	8		32	68			
		b		40	4		28	68			
		c		12			24	52			
	15	a		44			32	48			
		b		16			36	60			
		c		32			24	72			

Table C7. Microflora of canola stored at 30°C.

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
4	7.5	a	4	4		20	16	88			
		b	20	4		12	20	96			
		c	12	8		8	12	96			
	10	a	8	4	8	12	16	96			4
		b	4	4		8	20	96			
		c	4	4		16	24	92			4
	12.5	a	80	24			8	16			8
		b	56	20			4	32			4
		c	52	32			8	28			8
	15	a	48	8	4	12	16	32			12
		b	24	4	4	4	24	56			12
		c	16	4	4	4	12	36			4
8	7.5	a	12	20			4	96			
		b	8	4			4	84			
		c	4	16			16	84			
	10	a	36	12	4		4	64			8
		b	44	28			4	68			16
		c	16	20	4		8	80			16
	12.5	a	8	56			8	60			20
		b		16			16	52			16
		c	4	48				60			16
	15	a		44			12	56			12
		b		36			8	48			20
		c		32	4		20	48			24

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
12	7.5	a	12					96	4		
		b	16					92	8		
		c	8					92	4		
	10	a	60	16	8		12	40	4		4
		b	56	12	8		8	36	4		4
		c	60	20	12		16	36			
	12.5	a	8	36	4		12	76			8
		b	16	36			4	60			8
		c	12	28			8	36			4
	15	a	16	24	4		12	72			
		b	8	32	4		12	80			
		c	8	28			8	92			
16	7.5	a	24	8				92	4		
		b	16	4				92	4		
		c	12					84			
	10	a	48	16	4		8	80			
		b	52	24	12		16	52	4		
		c	48	16				44			
	12.5	a	36	32			16	60			
		b	40	32	8		20	56			
		c	24	44			12	24			
	15	a	28	28	4		20	80			
		b	16	24			16	64			
		c	32	12			24	56			

Table C8. Microflora of canola stored at 40°C.

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
4	7.5	a	12	12	8	8	20	92			24
		b	24	24	4	4	16	84			12
		c	16	20		12	36	76			8
	10	a	40	44	4	4	32	68			20
		b	64	36		8	36	76			16
		c	56	40		4	16	84			16
	12.5	a	20	44	8	12	12	64	8		4
		b	36	36			8	56	4		24
		c	56	52		4	32	48			28
	15	a	88	28	28	12	12	28	16		
		b	84	8	20	8	8	28	4		
		c	92	32	12		16	32	4		
8	7.5	a	20	44	4		4	80			
		b	4	36			8	76			
		c	24	32			4	52			
	10	a	72	64	8		4	16			
		b	56	76			4	28			
		c	80	56			4	32			
	12.5	a	20	36			8	80			
		b	28	40			4	76			
		c	40	40				76			

Storage period (w)	Moisture content	Replicate	Percent of seeds infected by								
			A.glaucus	*A.candidus*	*A.ochraceus*	*A.wentii*	*Hormodendrum*	*Penicillium*	*Rhizopus*	Bacteria	*Fusarium*
12*	7.5	a	48	28			4	80			
		b	40	28			8	72			
		c	40	32			4	76			
	10	a	84	32			4	84	8		
		b	60	16				84	4		
		c	72	20				68			
16*	7.5	a	60	16			8	72			
		b	52	28			4	64			
		c	12	12				56			
	10	a	48	32	4			60	4		
		b	60	32				48			
		c	44	16				48			

* No measurement was carried out once the germination reached 0%.

APPENDIX D: Fat acid value data

Table D1. FAV of rye stored at 10°C.

		Initial moisture content (% wb)			
Storage period (week)	Replicate	10.0	12.5	15.0	17.5
2	a	24.30	19.91	17.71	22.12
	b	15.50	17.70	19.90	15.49
	c	19.89	19.91	15.50	17.69
	mean	19.90	19.17	17.70	18.43
	s.d.*	4.40	1.28	2.20	3.37
4	a	17.70	15.48	17.70	17.70
	b	13.28	13.27	15.49	15.48
	c	15.49	17.70	15.49	15.48
	mean	15.49	15.48	16.23	16.22
	s.d.	2.21	2.21	1.28	1.28
6	a	17.70	15.48	13.27	15.48
	b	15.49	17.70	15.47	13.27
	c	17.69	17.70	17.68	13.27
	mean	16.96	16.96	15.47	14.01
	s.d.	1.27	1.28	2.21	1.28
8	a	15.48	13.28	15.48	15.48
	b	15.49	17.70	15.48	17.71
	c	13.26	15.48	15.49	15.49
	mean	14.74	15.48	15.48	16.23
	s.d.	1.28	2.21	0.01	1.29

Storage period (week)	Replicate	Initial moisture content (% wb)			
		10.0	12.5	15.0	17.5
10	a	11.06	15.50	15.49	19.90
	b	13.28	13.27	15.47	17.71
	c	15.48	11.07	15.48	17.69
	mean	13.27	13.28	15.48	18.43
	s.d.	2.21	2.21	0.01	1.27
12	a	17.68	17.68	17.69	17.69
	b	15.48	17.69	19.90	22.12
	c	17.69	17.70	19.92	17.69
	mean	16.95	17.69	19.17	19.17
	s.d.	1.28	0.01	1.28	2.56
14	a	15.48	17.71	15.48	28.78
	b	15.49	15.49	15.48	24.32
	c	17.71	15.47	17.70	24.32
	mean	16.23	16.23	16.22	25.81
	s.d.	1.28	2.57	3.85	6.43
16	a	17.69	17.70	11.06	26.55
	b	15.47	17.69	15.49	24.32
	c	13.27	17.69	17.69	26.55
	mean	15.48	17.69	14.75	25.81
	s.d.	2.21	0.01	3.38	1.28

* Standard deviation of the replicates from the mean.

Table D2. FAV of rye stored at 20°C.

Storage period (week)	Replicate	Initial moisture content (% wb) 10.0	12.5	15.0	17.5
2	a	19.91	19.90	22.13	24.34
	b	19.91	22.13	17.70	22.13
	c	19.89	17.68	22.11	22.12
	mean	19.90	19.90	20.65	22.86
	s.d.*	0.01	2.22	2.55	1.28
4	a	15.48	17.70	15.48	13.27
	b	17.69	17.70	15.49	15.48
	c	17.71	15.49	13.28	13.28
	mean	16.96	16.96	14.75	14.01
	s.d.	1.28	1.28	1.27	1.27
6	a	11.06	17.70	17.69	22.11
	b	15.47	13.28	17.70	26.54
	c	13.28	15.49	13.27	19.91
	mean	13.27	15.49	16.22	22.85
	s.d.	2.21	2.21	2.56	3.38
8	a	15.49	17.70	17.68	19.90
	b	15.48	17.69	19.92	26.54
	c	17.69	15.48	17.70	22.13
	mean	16.22	16.96	18.43	22.86
	s.d.	1.27	1.28	1.29	3.38

Storage period (week)	Replicate	Initial moisture content (% wb)			
		10.0	12.5	15.0	17.5
10	a	15.48	13.27	19.91	22.12
	b	15.50	13.28	17.68	22.11
	c	13.27	15.47	19.92	24.32
	mean	14.75	14.01	19.17	22.85
	s.d.	1.28	1.27	1.29	1.28
12	a	15.48	17.69	19.91	33.20
	b	17.69	19.89	19.91	33.20
	c	17.71	19.90	19.91	33.16
	mean	16.96	19.16	19.91	33.19
	s.d.	1.28	1.27	0.00	0.02
14	a	15.48	19.89	24.34	30.98
	b	15.47	22.10	24.32	31.00
	c	17.70	22.11	22.13	42.02
	mean	16.21	21.37	23.60	34.66
	s.d.	1.28	1.28	1.27	6.37
16	a	17.69	17.68	19.92	30.98
	b	13.27	15.48	17.68	35.40
	c	15.50	11.06	17.69	35.38
	mean	15.49	14.74	18.43	33.92
	s.d.	2.21	3.37	1.29	2.54

* Standard deviation of the replicates from the mean.

Table D3. FAV of rye stored at 30°C.

		Initial moisture content (% wb)			
Storage period (week)	Replicate	10.0	12.5	15.0	17.5
2	a	22.14	24.34	19.91	28.76
	b	19.92	24.34	19.92	30.95
	c	19.89	24.32	22.12	19.90
	mean	20.65	24.33	20.65	26.54
	s.d.*	1.29	0.02	1.27	5.85
4	a	19.90	19.93	17.68	22.13
	b	17.69	17.70	15.47	15.49
	c	17.69	2.21	17.70	17.69
	mean	18.43	13.28	16.95	18.44
	s.d.	1.28	9.65	1.28	3.38
6	a	22.14	22.10	19.93	26.54
	b	22.10	19.91	22.11	22.10
	c	17.69	22.10	22.11	22.13
	mean	20.64	21.37	21.38	23.59
	s.d.	2.56	1.27	1.26	2.55
8	a	17.71	19.92	19.91	30.99
	b	17.69	17.70	17.70	22.13
	c	17.70	17.68	17.69	24.34
	mean	17.70	18.43	18.44	25.82
	s.d.	0.01	1.29	1.28	4.61

Storage period (week)	Replicate	Initial moisture content (% wb) 10.0	12.5	15.0	17.5
10	a	19.89	22.11	22.12	24.35
	b	17.71	19.91	24.32	24.32
	c	19.90	22.12	22.12	19.91
	mean	19.17	21.38	22.85	22.86
	s.d.	1.26	1.27	1.27	2.56
12	a	24.33	13.26	19.90	26.54
	b	22.14	17.71	22.13	22.10
	c	19.92	22.12	22.11	26.56
	mean	22.13	17.70	21.38	25.07
	s.d.	2.20	4.43	1.28	2.57
14	a	22.10	24.32	26.54	30.96
	b	24.31	26.54	28.75	26.57
	c	22.11	24.34	28.78	24.35
	mean	22.84	25.07	28.02	27.29
	s.d.	1.27	1.28	1.28	3.36
16	a	17.70	22.11	19.91	22.13
	b	17.69	22.12	26.53	26.53
	c	19.91	19.90	19.92	26.55
	mean	18.44	21.38	22.12	25.07
	s.d.	1.28	1.28	3.82	2.55

* Standard deviation of the replicates from the mean.

Table D4. FAV of rye stored at 40°C.

		Initial moisture content (% wb)			
Storage period (week)	Replicate	10.0	12.5	15.0	17.5
2	a	22.11	22.10	19.91	22.13
	b	22.13	19.91	19.91	30.99
	c	17.68	15.48	22.13	30.99
	mean	20.64	19.16	20.65	28.04
	s.d.*	2.56	3.37	1.28	5.12
4	a	19.92	19.91	13.28	50.88
	b	15.47	17.69	19.89	28.75
	c	22.13	22.13	24.34	46.42
	mean	19.17	19.91	19.17	42.02
	s.d.	3.39	2.22	5.57	11.71
6	a	15.49	17.71	24.35	
	b	15.50	19.92	28.74	
	c	13.28	17.71	26.57	
	mean	14.76	18.44	26.55	
	s.d.	0.01	1.56	3.10	
8	a	19.91	15.47		
	b	13.26	17.70		
	c	13.27	17.68		
	mean	15.48	16.95		
	s.d.	3.84	1.28		

Storage period (week)	Replicate	Initial moisture content (% wb) 10.0	12.5	15.0	17.5
10	a	17.69	22.11		
	b	19.91	17.70		
	c	19.93	24.33		
	mean	19.18	21.38		
	s.d.	1.29	3.37		
12	a	15.48	19.90		
	b	17.71	19.90		
	c	17.68	24.34		
	mean	16.96	21.38		
	s.d.	1.28	2.56		
14	a	19.90	15.49		
	b	17.68	22.13		
	c	17.70	19.92		
	mean	18.43	19.18		
	s.d.	1.28	3.38		
16	a	17.69	19.90		
	b	17.68	15.47		
	c	15.48	17.70		
	mean	16.95	17.69		
	s.d.	1.27	2.21		

* Standard deviation of the replicates from the mean.
† No samples were analyzed after the germination reached 0%.

Table D5. FAV of canola stored at 10°C.

Storage period (week)	Replicate	Initial moisture content (% wb) 7.5	10.0	12.5	15.0
2	a	46.5	53.1	50.9	70.7
	b	50.9	66.4	57.5	119.4
	c	50.8	48.6	55.3	121.8
	mean	49.4	56.0	54.6	104.0
	s.d.*	2.5	9.2	3.3	28.8
4	a	59.8	64.2	66.3	278.9
	b	48.7	68.6	66.4	230.1
	c	53.1	75.2	66.4	210.2
	mean	53.8	69.3	66.4	239.7
	s.d.	5.6	5.5	0.1	35.3
6	a	43.2	35.6	48.4	249.5
	b	33.1	25.4	53.4	241.8
	c	25.5	33.1	48.3	162.9
	mean	33.9	31.4	50.0	218.1
	s.d.	8.9	5.3	2.9	47.9
8	a	28.0	38.1	40.7	257.2
	b	30.5	40.7	30.5	221.2
	c	35.6	38.1	53.5	302.7
	mean	31.4	39.0	41.6	260.4
	s.d.	3.9	1.5	11.5	40.8

Storage period (week)	Replicate	Initial moisture content (% wb) 7.5	10.0	12.5	15.0
10	a	25.46	45.82	66.17	223.95
	b	27.99	50.89	63.58	305.27
	c	27.97	45.82	58.58	282.49
	mean	27.14	47.51	62.78	270.57
	s.d.	1.45	2.93	3.86	41.95
12	a	35.66	45.79	63.62	175.56
	b	28.00	50.88	53.42	231.59
	c	30.54	25.43	45.81	208.64
	mean	31.40	40.70	54.28	205.26
	s.d.	3.90	13.46	8.94	28.16
14	a	33.07	50.91	71.26	290.24
	b	30.51	48.31	71.31	266.95
	c	33.05	53.42	78.85	277.23
	mean	32.21	50.88	73.81	278.14
	s.d.	1.47	2.55	4.36	11.67
16	a	33.05	63.67	88.98	325.62
	b	33.10	119.64	89.13	328.03
	c	38.16	58.54	91.67	269.82
	mean	34.77	80.62	89.93	307.82
	s.d.	2.93	33.89	1.51	32.94

* Standard deviation of the replicates from the mean.

Table D6. FAV of canola stored at 20°C.

Storage period (week)	Replicate	Initial moisture content (% wb) 7.5	10.0	12.5	15.0
2	a	48.69	59.67	64.09	243.35
	b	48.65	61.92	68.59	239.11
	c	50.88	59.73	66.39	227.81
	mean	49.41	60.44	66.36	236.76
	s.d.*	1.28	1.28	2.25	8.03
4	a	44.20	68.58	198.90	429.17
	b	42.07	57.50	119.41	427.13
	c	46.47	64.10	106.19	408.85
	mean	44.24	63.39	141.50	421.72
	s.d.	2.20	5.58	50.15	11.19
6	a	33.09	53.39	50.90	277.45
	b	38.14	56.00	68.67	198.54
	c	27.99	50.88	71.24	294.98
	mean	33.08	53.42	63.60	256.99
	s.d.	5.07	2.56	11.08	51.37
8	a	28.00	30.56	84.00	267.00
	b	30.51	63.67	61.02	313.21
	c	30.55	63.62	61.10	310.36
	mean	29.69	52.62	68.71	296.86
	s.d.	1.46	19.10	13.24	25.89

Storage period (week)	Replicate	Initial moisture content (% wb) 7.5	10.0	12.5	15.0
10	a	30.55	58.47	43.29	259.79
	b	30.54	73.85	76.30	312.84
	c	33.07	61.08	84.00	269.98
	mean	31.39	64.47	67.86	280.87
	s.d.	1.46	8.23	21.63	28.15
12	a				
	b	25.47	25.43	71.24	325.56
	c	28.02	68.77	78.94	341.09
	mean	27.97	50.88	61.05	335.86
	s.d.	27.15	48.36	70.41	334.17
		1.46	21.78	8.97	7.90
14	a				
	b	38.19	73.86	84.02	353.82
	c	35.60	91.65	91.58	338.68
	mean	35.61	71.31	94.12	335.73
	s.d.	36.47	78.94	89.91	342.74
		1.49	11.08	5.26	9.70
16	a				
	b	35.65	76.41	84.03	313.15
	c	30.56	84.02	66.21	300.06
	mean	38.17	78.81	99.23	300.30
	s.d.	34.79	79.75	83.16	304.50
		3.87	3.89	16.53	7.49

* Standard deviation of the replicates from the mean.

Table D7. FAV of canola stored at 30°C.

		Initial moisture content (% wb)			
Storage period (week)	Replicate	7.5	10.0	12.5	15.0
2	a	37.62	70.76	81.84	510.52
	b	48.69	73.06	84.00	493.72
	c	48.68	75.23	86.19	479.96
	mean	44.99	73.02	84.01	494.73
	s.d.*	6.39	2.23	2.18	15.30
4	a	53.07	104.04	70.72	605.79
	b	53.10	110.57	99.51	636.87
	c	59.73	99.57	108.44	530.62
	mean	55.30	104.72	92.89	591.09
	s.d.	3.83	5.53	19.71	54.63
6	a	33.07	68.70	99.23	409.65
	b	30.53	71.31	99.23	412.36
	c	33.05	96.73	101.82	315.44
	mean	32.22	78.91	100.09	379.15
	s.d.	1.46	15.48	1.49	55.19
8	a	27.99	66.22	137.45	373.81
	b	22.91	89.07	91.58	358.55
	c	25.43	68.66	68.73	274.74
	mean	25.44	74.65	99.25	335.70
	s.d.	2.54	12.55	35.00	53.34

Storage period (week)	Replicate	Initial moisture content (% wb) 7.5	10.0	12.5	15.0
10	a	30.52	81.39	140.00	435.36
	b	33.06	73.77	114.54	427.55
	c	33.06	104.24	112.04	376.80
	mean	32.21	86.47	122.20	413.23
	s.d.	1.46	15.85	15.47	31.79
12	a	35.63	124.63	86.54	425.17
	b	43.23	96.73	127.25	404.24
	c	45.82	106.78	122.23	414.99
	mean	41.56	109.38	112.01	414.80
	s.d.	5.30	14.13	22.19	10.47
14	a	33.11	94.07	101.80	470.62
	b	35.60	104.30	101.86	452.63
	c	35.65	96.78	106.91	488.14
	mean	34.79	98.38	103.52	470.47
	s.d.	1.76	7.24	0.04	12.72
16	a	43.30	104.38	104.30	254.24
	b	43.22	109.45	73.76	336.13
	c	45.85	71.24	68.70	272.31
	mean	44.12	95.03	82.25	287.56
	s.d.	1.49	20.75	19.26	43.02

* Standard deviation of the replicates from the mean.

Table D8. FAV of canola stored at 40°C.

Storage period (week)	Replicate	Initial moisture content (% wb) 7.5	10.0	12.5	15.0
2	a	53.09	77.41	88.49	172.55
	b	50.89	72.95	84.01	245.31
	c	53.11	70.76	84.12	128.33
	mean	52.37	73.71	85.54	182.07
	s.d.*	1.28	3.39	2.55	59.07
4	a	66.38	70.81	157.66	145.09
	b	88.40	99.55	53.42	150.27
	c	77.49	84.01	63.56	183.38
	mean	77.42	84.79	91.55	159.58
	s.d.	11.01	14.39	57.48	20.77
6	a	25.42	35.60	147.61	
	b	33.06	71.27	150.03	
	c	30.51	48.31	150.27	
	mean	29.67	51.73	149.30	
	s.d.	3.89	18.08	1.47	
8	a	43.26	63.67		
	b	45.82	53.39		
	c	40.73	48.33		
	mean	43.27	55.13		
	s.d.	2.08	6.38		

Storage period (week)	Replicate	Initial moisture content (% wb) 7.5	10.0	12.5	15.0
10	a	38.14	53.48		
	b	38.15	53.39		
	c	35.61	50.89		
	mean	37.30	52.58		
	s.d.	1.46	1.47		
12	a	48.31	58.51		
	b	45.78	58.49		
	c	40.74	53.39		
	mean	44.94	56.80		
	s.d.	3.86	2.95		
14	a	58.57	71.29		
	b	50.85	81.39		
	c	56.00	81.44		
	mean	55.14	78.04		
	s.d.	3.93	5.85		
16	a	35.60	43.22		
	b	43.26	43.25		
	c	33.05	45.85		
	mean	37.30	44.10		
	s.d.	5.31	1.51		

* Standard deviation of the replicates from the mean.
† No samples were analyzed after the germination reached 0%.

Table D9. Changes in FAV of rye stored at 10°C (n=3).

Moisture content (%)	Storage period (wk)								
	0	2	4	6	8	10	12	14	16
10.0	14.74^{bc*} ±1.3**	19.90^{a} ±4.40	15.49^{bc} ±2.21	16.96^{b} ±1.27	14.74^{bc} ±1.28	13.27^{c} ±2.21	16.95^{ab} ±1.28	16.23^{bc} ±1.28	15.48^{bc} ±2.21
12.5	14.74^{cd} ±1.3	19.17^{a} ±1.28	15.48^{bcd} ±2.21	16.96^{abc} ±1.28	15.48^{bcd} ±2.21	13.28^{d} ±2.21	17.69^{ab} ±0.01	16.23^{bc} ±2.57	17.69^{ab} ±0.01
15.0	14.74^{c} ±1.3	17.70^{ab} ±2.20	16.23^{bc} ±1.28	15.47^{bc} ±2.21	15.48^{bc} ±0.01	15.48^{bc} ±0.01	19.17^{a} ±1.28	16.22^{bc} ±3.85	14.75^{c} ±3.38
17.5	14.74^{c} ±1.3	18.43^{b} ±3.37	16.22^{bc} ±1.28	14.01^{c} ±1.28	16.23^{bc} ±1.29	18.43^{b} ±1.27	19.17^{b} ±2.56	25.81^{a} ±6.43	25.81^{a} ±1.28

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

Table D10. Changes in FAV of rye stored at 20°C (n=3).

Moisture content (%)	Storage period (wk)								
	0	2	4	6	8	10	12	14	16
10.0	14.74^{bc*} ±1.3**	19.90^{a} ±0.01	16.96^{b} ±1.28	13.27^{c} ±2.21	16.22^{b} ±1.27	14.75^{bc} ±1.28	16.96^{b} ±1.28	16.21^{b} ±1.28	15.49^{bc} ±2.21
12.5	14.74^{c} ±1.3	19.90^{ab} ±2.22	16.96^{bc} ±1.28	15.49^{c} ±2.21	16.96^{bc} ±1.28	14.01^{c} ±1.27	19.16^{ab} ±1.27	21.37^{a} ±1.28	14.74^{c} ±3.37
15.0	14.74^{d} ±1.3	20.65^{b} ±2.55	14.75^{d} ±1.27	16.22^{cd} ±2.56	18.43^{bc} ±1.29	19.17^{b} ±1.29	19.91^{b} ±0.00	23.60^{a} ±1.27	18.43^{bc} ±1.29
17.5	14.74^{c} ±1.3	22.86^{b} ±1.28	14.01^{c} ±1.27	22.85^{b} ±3.38	22.86^{b} ±3.38	22.85^{b} ±1.28	33.19^{a} ±0.02	34.66^{a} ±6.37	33.92^{a} ±2.54

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

Table D11. Changes in FAV of rye stored at 30°C (n=3).

Moisture content (%)	Storage period (wk)								
	0	2	4	6	8	10	12	14	16
10.0	14.74^{d*} ±1.3**	20.65^{ab} ±1.29	18.43^{bc} ±1.28	20.64^{ab} ±2.56	17.70^{c} ±0.01	19.17^{bc} ±1.26	22.13^{a} ±2.20	22.84^{a} ±1.27	18.44^{bc} ±1.28
12.5	14.74^{d} ±1.3	24.33^{ab} ±0.02	13.28^{d} ±9.65	21.37^{abc} ±1.27	18.43^{bcd} ±1.29	21.38^{abc} ±1.27	17.70^{cd} ±4.43	25.07^{a} ±1.28	21.38^{abc} ±1.28
15.0	14.74^{e} ±1.3	20.65^{bc} ±1.27	16.95^{de} ±1.28	21.38^{b} ±1.26	18.44^{cd} ±1.28	22.85^{b} ±1.27	21.38^{b} ±1.28	28.02^{a} ±1.28	22.12^{b} ±3.82
17.5	14.74^{c} ±1.3	26.54^{a} ±5.85	18.44^{bc} ±3.38	23.59^{ab} ±2.55	25.82^{a} ±4.61	22.86^{ab} ±2.56	25.07^{a} ±2.57	27.29^{a} ±3.36	25.07^{a} ±2.55

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

Table D12. Changes in FAV of rye stored at 40°C (n=3).

Moisture content (%)	Storage period (wk)								
	0	2	4	6	8	10	12	14	16
10.0	14.74^{d*} ±1.3**	20.64^{a} ±2.56	19.17^{ab} ±3.39	14.76^{d} ±0.01	15.48^{cd} ±3.84	19.18^{ab} ±1.29	16.96^{bcd} ±1.28	18.43^{abc} ±1.28	16.95^{bcd} ±1.27
12.5	14.74^{c} ±1.3	19.16^{ab} ±3.37	19.91^{ab} ±2.22	18.44^{abc} ±1.56	16.95^{bc} ±1.28	21.38^{a} ±3.37	21.38^{a} ±2.56	19.18^{ab} ±3.38	17.69^{abc} ±2.21
15.0	14.74^{c} ±1.3	20.65^{b} ±1.28	19.17^{bc} ±5.57	26.55^{a} ±3.10	-	-	-	-	-
17.5	14.74^{b} ±1.3	28.04^{ab} ±5.12	42.02^{a} ±11.71	-	-	-	-	-	-

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

Table D13. Changes in FAV of canola stored at 10°C (n=3).

Moisture content (%)	Storage period (wk)								
	0	2	4	6	8	10	12	14	16
7.5	22.02^{d*} ±1.5**	49.39^{a} ±2.52	53.85^{a} ±5.57	33.93^{bc} ±8.93	31.39^{bc} ±3.87	27.14^{cd} ±1.45	31.40^{bc} ±3.90	32.21^{bc} ±1.47	34.77^{b} ±2.93
10.0	22.02^{e} ±1.5	56.02^{bc} ±9.24	69.34^{ab} ±5.54	31.39^{de} ±5.32	38.99^{cde} ±1.47	47.51^{bcd} ±2.93	40.70^{cde} ±13.46	50.88^{bcd} ±2.55	80.62^{a} ±33.89
12.5	22.02^{g} ±1.5	54.57^{de} ±3.34	66.38^{bc} ±0.07	50.03^{ef} ±2.92	41.57^{f} ±11.49	62.78^{cd} ±3.86	54.28^{de} ±8.94	73.81^{b} ±4.36	89.93^{a} ±1.51
15.0	22.02^{f} ±1.5	103.96^{e} ±28.79	239.74^{bcd} ±35.34	218.06^{cd} ±47.95	260.38^{abcd} ±40.81	270.57^{abc} ±41.95	205.26^{d} ±28.16	278.14^{ab} ±11.67	307.82^{a} ±32.94

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

Table D14. Changes in FAV of canola stored at 20°C (n=3).

Moisture content (%)	Storage period (wk)								
	0	2	4	6	8	10	12	14	16
7.5	22.02^{g*} ±1.5**	49.41^{a} ±1.28	44.24^{b} ±2.20	33.08^{cde} ±5.07	29.69^{ef} ±1.46	31.39^{def} ±1.46	27.15^{f} ±1.46	36.47^{c} ±1.49	34.79^{cd} ±3.87
10.0	22.02^{d} ±1.5	60.44^{bc} ±1.28	63.39^{abc} ±5.58	53.42^{c} ±2.56	52.62^{c} ±19.10	64.47^{abc} ±8.23	48.36^{c} ±21.78	78.94^{ab} ±11.08	79.75^{a} ±3.89
12.5	22.02^{c} ±1.5	66.36^{b} ±2.25	141.50^{a} ±50.15	63.60^{b} ±11.08	68.71^{b} ±13.24	67.86^{b} ±21.63	70.41^{b} ±8.97	89.91^{b} ±5.26	83.16^{b} ±16.53
15.0	22.02^{g}±1.5	236.76^{f} ±8.03	421.72^{a} ±11.19	256.99^{ef} ±51.37	296.86^{cd} ±25.89	280.87^{de} ±28.15	334.17^{bc} ±7.90	342.74^{b} ±9.70	304.50^{bcd} ±7.49

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

Table D15. Changes in FAV of canola stored at 30°C (n=3).

Moisture content (%)	Storage period (wk)								
	0	2	4	6	8	10	12	14	16
7.5	22.02^{d*} ±1.5**	44.99^{b} ±6.39	55.30^{a} ±3.83	32.22^{c} ±1.46	25.44^{d} ±2.54	32.21^{c} ±1.46	41.56^{b} ±5.30	34.79^{c} ±1.76	44.12^{b} ±1.49
10.0	22.02^{f} ±1.5	73.02^{e} ±2.23	104.72^{ab} ±5.53	78.91^{cde} ±15.48	74.65^{de} ±12.55	86.47^{bcde} ±15.85	109.38^{a} ±14.13	98.38^{abc} ±7.24	95.03^{abcd} ±20.75
12.5	22.02^{c} ±1.5	84.01^{b} ±2.18	92.89^{ab} ±19.71	100.09^{ab} ±1.49	99.25^{ab} ±35.00	122.20^{a} ±15.47	112.01^{ab} ±22.19	103.52^{ab} ±0.04	82.25^{b} ±19.26
15.0	22.02^{g} ±1.5	494.73^{b} ±15.30	591.09^{a} ±54.63	379.15^{de} ±55.19	335.70^{ef} ±53.34	413.23^{cd} ±31.79	414.80^{cd} ±10.47	470.47^{bc} ±12.72	287.56^{f} ±43.02

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation

Table D16. Changes in FAV of canola stored at 40°C (n=3).

Moisture content (%)	Storage period (wk)								
	0	2	4	6	8	10	12	14	16
7.5	22.02^{f*} ±1.5**	52.37^{bc} ±1.28	77.42^{a} ±11.01	29.67^{ef} ±3.89	43.27^{d} ±2.08	37.30^{de} ±1.46	44.94^{cd} ±3.86	55.14^{b} ±3.93	37.30^{de} ±5.31
10.0	22.02^{c} ±1.5	73.71^{a} ±3.39	84.79^{a} ±14.39	51.73^{b} ±18.08	55.13^{b} ±6.38	52.58^{b} ±1.47	56.80^{b} ±2.95	78.04^{a} ±5.85	44.10^{b} ±1.51
12.5	22.02^{c} ±1.5	85.54^{b} ±2.55	91.55^{b} ±57.48	149.30^{a} ±1.47	-	-	-	-	-
15.0	22.02^{b} ±1.5	182.07^{a} ±59.07	159.58^{a} ±20.77	-	-	-	-	-	-

* Values with same letters in a row are not significantly different by least significant difference (LSD) comparison of means, ** Standard deviation