Factors affecting seed and seedling vigour essay sample

Technology

Seed vigour is a term encompassing the sum total of those properties of the seed that determine the potential performance of the seed or seed lot during germination and seedling emergence (Perry, 1978). Rapid and uniform germination are among the properties of vigorous seeds (Argerish & Bradford, 1989). Low vigour adversely affects such factors as optimal emergence, stress resistance and uniform growth of emergent seedlings (Patrick et al, 2000) and is thus of great economic importance. Seeds, which grow well under the ideal conditions of the germination test, often do not perform so well when planted under the more stressful conditions of the field. Some seedlots perform particularly badly under stress, and are said to be of low vigour. A considerable amount of research has been carried out to discover the causes of low vigour, since if it could be prevented, fewer low-vigour seedlots would need to be wasted (pers. comm. Dr. A. Goldsworthy, 2003). Unfortunately, there does not seems to be a single underlying cause.

Seeds which are either smaller or larger than normal, are often of low vigour. Sawan et al (1999) found that both seed size and seed density are correlated with seedling vigour in cotton. Small seeds may lack food reserves, and large seeds may be more easily damaged by harvesting or have metabolic abnormality. These can be removed from an otherwise healthy seedlot by seiving. The seedling characteristics most closely associated with lower seedling vigour are a small embryo, small primary leaves on the main shoot, a low leaf area to leaf weight ratio, and a low frequency of coleoptile tillers (Richards & Lukacs, 2002).

Sometimes low vigour seeds have a low protein content. This may be due to inadequate nitrogen fertilisation. Application of more nitrogen will remedy this problem (Sawan et al, 1999).

Most cases of low vigour are due to seed damage (pers. comm. Dr. A. Goldsworthy, 2003). Seeds can be damaged in a multitude of ways and the actual cause of the trouble is often difficult to ascertain. Damage from harvest can often be diagnosed by visual inspection. Such damage can be caused if the harvesting and threshing machinery is run too fast, especially if the seeds are at the wrong moisture content. If the seeds were too dry and brittle, there may be a large number of split or broken seeds in the sample. Conversely, if the seeds were too wet and soft, the embryos are more likely to be partially pulled-out or missing. Grass and Tourkmani (1999) looked at rejected durum wheat seed lots in Morocco. All the samples had a low moisture content, with an average moisture content of 9. 3%.

The most prevalent form of damage was mechanical damage from harvesting and threshing machines. The types of mechanical damage comprised damaged embryos, damaged scutellum and damaged integuments covering the embryos. They suggested that main reason behind mechanical damage was the threshing machine being run at too high a cylinder speed. Seedlings from mechanically damaged seeds showed a high proportion of abnormalities; however, this was related to the type of seed damage, with embryo damage resulting in the highest proportion of abnormalities.

In regions characterised by periods of air temperature and relative humidity higher than 25OC and 65-70%, respectively, as in the humid tropics, a storage of more than 3-4 months may be harmful to maize seed viability and vigour unless seed is stored in suitably dry, preferably air-conditioned conditions. In these tropical environmental conditions the seed is highly susceptible to fungal attack resulting in low seed viability and vigour. Fungicide treatment has been shown to lower seed equilibrium moisture in stored maize and thus improve germination and vigour (Abba & Lovato, 1999). Insect attack on stored seed and subsequent insecticide treatment generally have a deleterious effects on seed vigour. When infestations of Green Gram seed are attacked by Pulse beetles, the phosphine fumigation that is used to eradicate such infestations has been shown to reduce seed vigour, as well as reducing future shoot and root length (Gupta & Kashy, 1995).

The damaging effect of phenyl murcury acetae (PMA) on the field emergence of the wheat cultivar, Summit, which exhibited reduced vigour after long storage in contact with PMA at the normal rate of treatment has been demonstrated by Tuohey et al (1972). The types of abnormal growth germination observed included lack of plumule development, stubby roots and coleoptiles, loss of tropism and the breaking out of the first leaf from the coleoptile before emergence. Laboratory tests showed a reduction in germination but did not fully detect the lack of vigour apparent in field emergence. Eid et al (1971 showed that seedling vigour in cotton was reduced by pretreatment of the seeds with the insecticides, Dieldrin, Dipterex and Sevin. However, the same insecticides had a stimulating effect on rice seedlings, and increased their vigour.

Heat damage due to drying of seed lots in air that is too hot can cause reduced vigour. The symptoms of heat damage are similar to those where seeds are losing their viability due to old age. Heat and moisture accelerate the ageing process of seeds, so over-enthusiatic drying can cause accelerated aging. This results in membrane damage, making them leak during imbibition. The most serious form of membrane damage is to the vacuoles, which contain hydrolytic digestive enzymes, such as proteases, DNA-ase, RNA-ase amongst others. If sufficient quantities of these enzymes leak into the rest of the cell they can kill it. During imbibition there is therefore a race between the membrane repair and the rate at which these catabolic enzymes leak into the cytosol. The more cells that are killed, the lower the vigour of the seed, and if a certain proportion of the cells die the seed will fail to germinate.

Under the ideal conditions of the official germination test low vigour seeds may germinate because the seeds are able to repair themselves relatively quickly when they imbibe. However, if the same seed were planted in the field, in cold soil, repairs would be slower, more harmful enzymes would be released into the cytosol, and more cells would be killed. This effect can be seen using vital stains such as tetrazolium. Tetrazolium is a redox stain for mitochondrial enzymes. It stains only living cells, or cells which have recently been killed. In wheat, the most likely cells to be killed are those of the scutellum.

This is the main digestive organ of the endosperm. The scutellum thus contains more digestive enzymes, and is more likely to be damaged by heat than the rest of the seed. When low vigour seeds are germinated and then stained with tetrazolium, the intensity of the staining in the scutellum is often inversely correlated with the speed of growth of the embryo (pers. comm. Dr. A. Goldsworthy, 2003). This is probably due to the fact that it is the scutellum which absorbs food for the embryo. If the scutellum is damaged or non-functional, the embryo may be starved or only grow very poorly.

Seed deterioration involves many biochemical and biophysical changes, including the loss of enzymatic activities, the loss of membrane integrity and genetic alterations, although the exact cause of seed viability loss and low vigour is still not well defined, as has already been mentioned (Bradbeer, 1988). Lipid peroxidation and associated free radical oxidative stresses are widely considered to be major contributors to seed deterioration. They affect the structure and function of membranes, including the inactivation of membrane bound proteins and the alteration of membrane permeability (Bradbeer, 1988). However, different mechanisms of seed deterioration may exist under different storage conditions. While at lower temperatures free radical damage may be the primary form of seed deterioration, the loss of seed vigour at high temperatures is closely related to thermal inactivation of proteins (Kozlowski, 1972). Water content is another important factor affecting the rate of seed deterioration and potentially resulting in low vigour seed lots. In dry seeds, enzymatic reactions may play little role in seed ageing, because dry seeds lack enzymatic metabolism. However, certain non-enzymatic reactions, such as Amadori and Maillard reactions, could occur even at very low moisture content.

Amadori and Maillard reactions refer to a series of complex reactions that occur following an initial carbonyl-amine reaction. These reactions generally follow four steps:

1)The non-enzymatic condensation of a reducing sugar, aldehyde or ketose with a free amino group of proteins or nucleic acids to form a glycosylamine. This step is reversible.

2)The rearrangement of the glycosylamine to Amadori product, 1-amino-alpha-deoxyketose.

3)The degradation and dehydration of Amadori products into amino or carbonyl intermediates.

4)The reaction of carbonyl intermediates with other amino groups as well as the subsequent rearrangement to form advanced glycosylation end-products (AGE products).

The formation of Amadorii and Maillard products are believed to play significant roles in the ageing process. The non-enzymatic glycation (Step 1) reduces the activity of enzymes like Cu-Zn-superoxide dismutase, ribonuclease and lysozyme. It has been reported that non-enzymatic glycosylation of DNA plays an important role in the incidence of DNA strand breaks and intra and inter-strand cross-linking (Bradbeer, 1988). The loss of activity of DNA repair enzymes such as DNA ligase, is an important factor contributing to the alteration of genetic material and seed mortality during seed ageing. DNA degradation impairs transcription, causing incomplete protein synthesis that is essential for seed germination (Argerish & Bradford, 1989).

The relevance of Amadori and Maillard reactions to seed deterioration and low seedling vigour has been studied in soybeans. The accumulation of Maillard products was observed in soybeans under accelerated ageing conditions. A correlation was established between accumulation of Maillard products and the loss of seed viability and vigour, under long term storage conditions. Amadori and Maillard reactions may contribute to seed ageing through chemical alteration of proteins, thus depressing metabolic capability and reducing the ability of the metabolic system to limit free radical damages and to repair the damages during germination.

Vigour measurements may be used for predicting potential performance in the field. There is a need to identify for each species and geographical area the environmental factors which are likely to influence field performance. This is essential to make it possible to determine whether poor performance should be attributed to the seed or to the environment. Feddes (1972) reported on the effects of water and heat on seedling emergence using as test species radish, spinach, broad bean and garden beat. He found that the level of the groundwater table influenced temperature, so tht the mean daily temperatures of the plots with higher ground water were 1 to 2 OC lower than those of plots with lower ground water. At the same ground water level, clay was warmer than sandy loam.

The minimum temperatures and the minimum soil moisture content necessary for emergence was calculated. It was found that the ideal combination is a high temperature and adequate soil moisture. It should be noted though that normally higher soil temperatures occur in soils where the soil moisture is low. A similar difficulty in obtaining optimum conditions was reported by Stubbendieck and McCully (1972) for sand bluestem. Germination and seeling survival are usually poor in sandy soils because of low moisture availability. When moisture levels are raised, pathogen development increases leading to seed mortality. In moister soils it is necessary to pretreat the seed with insecticide and fungicide.

As has been shown the reasons for loss seedling vigour are often varied and complex. Improved pretreatment to protect seeds from pathogens and priming of seeds in osmotic conditions etc all reduce the probability of low vigour occurring. However, probably the most important factor preventing/causing low vigour is the harvesting and processing of the seed. Care and improvements in this area are likely to pay dividends.

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