
INTRODUCTION

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Seed and its importance in agriculture

Seed is a basic input in agriculture which can be defined as a matured ovule consisting of an embryonic plant together with a store of food, all surrounded by a protective seed coat. Seed is also defined as any part or organ of the plant which has the capacity to regenerate into a new plant under congenial atmosphere. In seed, the importance is given to the biological existence whereas; in grain the importance is given to the supporting the economic produce.

Seed is the vital input in crop production because through seed only the investment made on the other inputs like pesticide, fertilizer, irrigation and crop maintenance can be realized. Modern agriculture demands that every seed should readily germinate and produce a vigorous seedling ensuring high yield. The seed required for raising the crop is quite small and it’s cost is also less compare to other inputs , but the greater income farmer gets depends upon the quality of the small quantity of seed he use. Further, with rise in population a sustainable increase in productivity is imperative. Very often poor field emergence or loss of standing crop due to untimely rain or flood or drought or severe pest infestation may require re sowing for which a buffer seed stock is necessary. In a word the seed is the master key to success with cultivation.

Classification and use of seed in agriculture

Agricultural crops seed are classified under two broad categories, the orthodox dry stored seeds in which viability of seed is extended by drying; within a range of seed moisture content, storability is inversely related to the seed moisture content and recalcitrant seeds of fleshy fruits and plantation crops in which seed longevity drastically falls when the seed moisture content fall below a certain critical moisture level for that particular kind of seed. Most of our annual commonly used agricultural and horticultural seeds including field pea seed belongs to the orthodox group. These orthodox seeds if dried properly and stored in the moisture impervious container at requisite seed moisture content can be maintained with a high level of germinability for a prolonged period. In India seed used for planting of majority of our field and horticultural crops are medium to low vigour in quality. According to Banerjee (1984), less than 15% of our fields are sown by quality seeds and the remaining areas are covered by the farmers own produced seed, bulk of which are stored without following any scientific parameter. Though scientific seed production has made a good beginning, it still falls short of target. Seed processing and quality control are still in rudimentary stage. Seed protection in storage, although a serious problem, has not yet received due attention of the farmers. But, for a seed of the ideal value, all these are of great importance.

Consciousness on seed quality

Seed quality is the possession of seed with required genetic and physical quality that is accompanied with physical soundness and health status. The importance of quality seed has been recognized from the time immemorial. Manu Smriti says "Subeejam Sukshetre Jayate Sampadyathe" i.e. Good seed in good soil yield abundantly. Seed quality has been treated as sacred, being an important factor in the improvement of agriculture and agrarian societies. Modern crop production and the science of agriculture also confirm that without seed quality we won't have a successful agricultural production. Seed which perform well at sowing are termed as quality seed and based on the degree of performance in production of elite seedlings it is classified as high, medium and low vigour seed. Seed with good vigour is preferable for raising a good plantation as the fruit, the economic come out are to be realized after several year. Hence, selection of seed based on seed vigour is important for raising finalized plantation.

Glimpse about pea crop

The pea is one of the earliest human foods. It thrives well in places with cool climate and hence is grown in almost all the temperate region of the world. In tropical countries it is grown during the cold months. There are two types of cultivated peas, the garden pea (*Pisum sativum* var. hortense) and field pea (*Pisum sativum* var arvense) . Garden peas are harvested in an immature condition to be cooked as green peas to provide a delicious dish, or to be canned or frozen for subsequent use. Field peas are grown as forage crop for cattle or as a forage crop for cattle or as a green manure crop for soil improvement or as a cover crop to reduce the soil erosion or as a mature seed as whole or split into “dal” and prepared in various ways for human consumption. Field pea is one of the important pulse crops of the world cultivated over an area of 25 million acre (2009). The important field pea growing countries are Russia, China, India, Ethiopia and USA. Uttar Pradesh is the major field pea growing state in India. Uttar Pradesh alone produces about 60% of the total pea produced in India. Beside Uttar Pradesh, Madhya Pradesh and Bihar is the major field pea producing states.

Importance of pulse crop in human nutrition and soil health

The nutritional importance of pulse crop is numerous. In this part of the world, pulse crop provide a large proportion of the protein required for adults and children. About 20% of the protein presently available to man come from pulses in the developing countries (Reddy *et al*., 1986). Pulses have a high protein content , the value is about twice that in cereal and several times that in root tuber (FAO, 1968), so they can help to improve the protein intake of meals in which cereals and root tubers in combination with pulses are eaten (Kushwah *et al.*, 2002). In man, protein helps in the repair of body tissue, synthesis of enzymes and hormones and also in the supply of energy. In children, the consumption of pulses should be encouraged, particularly where animal protein is scarce and expensive, as this would help to furnish the child with the necessary amino acids required for growth.

The cultivation of pea maintains soil fertility through biological nitrogen fixation in association with symbiotic rhizobium prevalent in its root nodules and thus plays a vital role in fostering sustainable agriculture (Negi et al., 2006). Therefore, apart from meeting its own requirement of nitrogen, pea are known to leave behind residual nitrogen in soil 50-60 kg/ha (Kanwar et al., 1990)

Genesis behind the present study

At present the per capita availability of pulse in India is 31.6 gm which was 65.5 gm in the year 1960. The prime reason behind this decline in the per capita availability is the lack of availability of good quality seed, price hike of the essential inputs, low market price, poor storage facility and less minimum support price . The first parameter i.e. non availability of good quality seed in sufficient quantity is of prime reason behind the less area coverage and productivity since replacement of existing poor quality seed with the certified high quality seed alone can increase the productivity by around 20%. Considering these two facts i.e. low per capita availability of 'dal' and less availability of good quality seed in India, present study was conducted on the field pea so that a suitable technique of seed invigoration as well as storage could be put forward to the farmer.

Importance of seed storage mechanism

Seed storage means the phase of the post-harvest system during which the seeds are kept in such as to guarantee the quality of seed till they are planted in the field. Degradation of seeds during storage depends principally on a combination of three factors viz. temperature, moisture and oxygen content. Temperature and moisture content are the determining factors in accelerating or delaying the complex phenomenon of the biological transformation that are at the origin of seed deterioration. Furthermore, they have a direct influence on the speed of development of insects and microorganism and on the premature and unseasonal germination of seed. Harrington and Douglas (1970) and subsequently Agrawal(1976) have identified specific locations in the country which are better for seed storage than other areas and have suggested safe moisture levels for storage of seeds of various crops. Farmers of this region store the seed either in gunny bag, cloth bag or in the earthen pot, seed bin made up with bamboo cane. As these storage structures /containers are not moisture proof, seeds absorb moisture readily from the external atmosphere especially during the period of high humidity and temperature resulting in deterioration of quality of seed depending on the type of storage.

Problem of seed storage in eastern region

As most of the farmers of this region are belong to small and marginal category, they may find it difficult to store their seeds in the cold storage or other safe storage structure. More over sealed storage structure at domestic level may not be feasible; firstly, metal containers or other moisture proof containers are not readily available and secondly, due to lack of knowledge regarding safe moisture content to which individual species of seed is to be brought down before storing them in the sealed containers. Unless the seed is properly dried, storage in sealed containers may do more harm than good. Field pea is generally harvested in the month of March-April and then stored under ambient conditions in the moisture pervasive containers would show a rapid fall in the germinability due to high relative humidity and temperature prevailed during entire monsoon season .In most of the cases it was noticed that due to faulty storage method by the time the field is ready for sowing in the next season there has been a major decline in the viability as well as the vigour of the stored seed lot.

Seed ageing

Ageing is a common phenomenon in seed storage which can be described as the loss of seed quality with time and is an irreversible change in seed quality after it reaches maximum quality level (Abdul-Baki and Anderson, 1972b). The rate at which ageing process depends upon the ability of the seed to resist degradation change and protection mechanism, which are specific for each plant species (Gupta and Aneja, 2004; Sisman and Delibas, 2004; Mohammadi et al., 2011).The most widely accepted single criteria of seed deterioration is reduced germinability. However , many test for measuring the loss of viability have been developed based on the physiological effect of ageing (ISTA,1993, Jatoi etal.,2004 ; Khan et al.,2007 ; Malik and Shamet, 2009). Among them the most important method is accelerated ageing which is done by subjecting the seeds to elevated temperature and high relative humidity. It provides a simple and good method for studying sequence and relationship process of deterioration over a short time. For seed viability testing numerous tests such as cold, accelerated ageing and hiltner can be applied (Milosevic and Malesevic 2004). Accelerated ageing test procedures have been standardized for several crop species such as soybean (Tekrony, 1993; Sung,1996; Krishnan et al.,2003), corn (Woltz and Tekrony, 2001) pea (jatoi et al.,2004), chick pea (Maeda and Wutke,1996; Kapoor et al.,2010), pigeon pea (Kalpana and Rao,1995),radish (Jain et al.,2006) and rice (Krishnaswamy and Sheshu,1990; Ray et al.,1990, Bam et a l.,2006). Thus in our present investigation process accelerated ageing was one of the mechanism to judge the treatment effect on seed ageing.

Factors affecting seed ageing

The rate of seed deterioration is highly influenced by environmental (temperature, humidity and seed moisture content) and biological factors such as fungi that create their own niche (Ghassemi-Golezani et al., 2010). Seed longevity is determined by seed moisture, temperature and seed attribute that are influenced by genetic and environmental interactions during seed maturation, harvesting and storage (Walters et al., 2010). Several other factors such as environmental conditions during seed producing stage, pests, diseases, seed oil content, storage longevity, mechanical damage of seed in processing, fluctuations in moisture (including drought), weathering, nutrient deficiencies, packaging, pesticides, improper handling, drying and biochemical injury of seed tissue can affect vigour of seeds (Krishnan et al., 2003, Marshal and levis, 2004; Astegar et al., 2011; Simic et al., 2007). Harrington (1963) proposes three rules of thumb which are useful as a guide as well as measure of effect of seed moisture content, temperature and relative humidity on seed ageing. According to him for every one percent decrease in moisture content and for every 10^0F decrease in temperature nearly double the storage potential of seed. He also suggested that good seed storage is achieved when percentage of relative humidity in storage environment and the storage temperature in degree Fahrenheit add up to one hundred. Estimation of storage life of a large number of agricultural seed may be made by viability nomograph made by Robert (1972) based on the viability equations with temperature and seed moisture content as extrinsic factor. Ellis and Roberts (1981) have presented a new improved viability equation of a number of agricultural crops.

Pathological deterioration of seed

Organisms associated with seeds in storage are bacteria, fungi, mites and rodents. The activity of these entire organisms can lead to damage resulting loss of vigour, viability or complete loss of seed. Mechanically damaged seed allow quick and easy access for microflora to enter the seed (Shelar et al., 2008). Insects are also very important agent initiating deterioration of seed. Not only they destroy enormous quantity of grains but also they are often responsible for the condition that facilitate fungi infestation. In the present study emphasis was given to standardize a suitable pesticide which either solely or in combination with different crude plant product, chemicals or pharmaceutical product could retain the viability and field performance of field pea seed.

Problem of rain-soaked seed

Incidentally, storage of field pea seeds in certain years has been problematic even in the traditionally field pea growing states of India as occasional rains during harvesting and threshing cause significant deterioration of the seeds. Further, an increase in seed moisture content either in the standing ready-to-harvest crop or in the threshing floor would advance the physiological and pathological deterioration of the seed. Drying to safe moisture content would reduce such deterioration. It, however, needs to be mentioned here that under ordinary conditions, the ageing process of the partially deteriorated rain-soaked seed cannot be completely halted. More specific alternative methods should be standardized for controlling further deterioration in storage.

Seed rate adjustment for compensating loss of viability

It has been observed that seed when stored under conventional system of storage face a drastic downfall in viability and vigour by the time it is ready for sowing. This fall in germination percentage could be compensated by corresponding adjustment in seed rate but the loss of vigour cannot be compensated by seed rate adjustment. Literature reveals that the vigour of the seedling is an important parameter for crop improvement. It has also been reported by several researchers that bold size seed showed vigorous seedling than small and medium size seed. In the present study, endeavor was made to investigate the effect of different seed size on germinability and subsequent field performance when stored as such or treated with different dry treatments.

Need for proper storage methodology

Basic objective of good storage is to create environmental conditions that protect the seed and maintain its quality and thus reducing product loss and financial loss. Seed deterioration is slowed down when seeds are stored under cool and dry conditions. Temperature and relative humidity should therefore be considered in planning for safe storage. Seed moisture is the most important factor affecting seed longevity. Seeds adjust their moisture content until they are in equilibrium with the surrounding storage environment. Temperature and relative humidity affect the amount of moisture in the air and will influence the equilibrium moisture content of seed. Generally farmer of this region do store their seed in the conventional storage structure which aggravate the deterioration process both in terms of vigour and viability culminating into poor seed yield. At this juncture if an easily practicable but effective storage technology could be made available to the farming community would be welcomed.

Post harvest treatment for better seed treatment

Seed invigoration is one of the techniques which enhance the seed performance. Seed invigoration can be defined as any treatment that speeds up germination and synchronizes emergence. The development of seed invigoration treatments really started with seed priming, as first described by heydecker et al.(1973).Basu,(1990) described seed invigoration as improvement in the seed performance by any post harvest treatment resulting in improved germinability , greater storability and field performance than corresponding untreated control.

Biochemical changes during seed deterioration

Physiological and biochemical studies on seed deterioration have shown changes in respiratory activity and activities of enzymes which participate in the break down and synthesis of carbohydrates, fats and proteins and peroxidative changes in cellular membranes and other vital bio-organelles (Matthews and Brandnock, 1967; Takayanagi and Murakami, 1968b, Abdul-Baki and Anderson ,1970;1972 ; Berjak and Villiers ,1972). Seed deterioration is a detrimental attribute in agriculture which is a separate event from seed development and germination. Seed deterioration is associated with various cellular, metabolic and chemical alterations including lipid peroxidation, membrane disruption, and DNA damage, impairment of RNA and protein synthesis ultimately causing several detrimental effects on seed.

Role of free radical in seed deterioration

A free radical is an atom or a group of atoms with an unpaired electron, which possess the ability of donating or accepting an atom. The hydroxyl (-OH) and superoxide (o_2^-) are the two most important radicals believed to cause most damaging biological action. The free radical damage is an important aspect of seed deterioration and has a close relationship between the loss of vigour and viability of seeds (Basu et.al., 1975)

Beneficial effect of seed priming

Extensive research has been carried out in this laboratory to develop a practically feasible but economical method of seed treatment for the maintenance of vigour and viability. It has been established that hydration-dehydration treatment of stored seed of a wide range of agriculturally important crop plants would greatly minimized their physiological deterioration during subsequent storage under uncontrolled warm conditions (Basu et al.,1974; Basu and Dasgupta, 1974). They have also reported that hydration-dehydration treatments are very much effective in improving grain yield and other attributes of several crop plants over respective untreated control (Kundu and Basu, 1981; Mitra and Basu 1979; Mandal and Basu, 1982;1986). Ella et al.,(2011) found that pre soaking and priming of paddy seed improved seedling establishment in the flooded soil, enhanced the capacity to scavenge reactive oxygen species in seed by increasing superoxide dismutase and catalase enzyme activity and also hasten the carbohydrate mobilization.

Soaking injury in leguminous seed

Hydration-dehydration treatments are effective when it is given to 4-5 months old seeds. But, if weather condition is not favorable during the period of drying it will do more harm than good. Besides, it will welcome the incidence of pest and disease infestation in seed. More over under pre storage condition, hydration-dehydration treatments are ineffective in most of the leguminous or non- leguminous seeds because of imbibitional injury (Saha and Basu, 1984; Bhattacharya and Basu, 1990). This investigation was also made to standardize a suitable wet treatment for leguminous crop, field pea in particular.

Dry seed invigoration treatment

The effectiveness of dry seed invigoration treatment on improvement of germinability , storability and field performance of seed have been studied by several research worker (Mandal and Basu, 2002; Adebisi et al, 2003 ;Adebisi and Oyekale, 2005) . Basu and coworkers (Rudrapal and Basu, 1980; Mandal and Basu, 1986) demonstrated that dry dressing of seed with halogenated compounds such as bleaching powder or iodinated calcium carbonate effectively slow down the deterioration of seed. More recently infusion of fungicides, growth regulators, pesticides, bio-products, bio-ingredients, agro-chemicals and herbicides into the seed prior to germination is reported to alleviate the impact of adverse factors on seed quality and performance (Janmohammadi et al., 2008).

Dry seed treatments with non-toxic pharmaceuticals and plants product

Mandal, Basu and other coworkers tested a wide range of plant preparations which are used traditionally as spices and house hold preservatives and have an antioxidant property. They have reported that acetylsalicylic acid (aspirin), a plant derivatives and widely used pharmaceutical formulations ‘aspro’(50-100 mg/kg of seed) and crude powdered plant materials (1-2 g/kg of seed) are effective in controlling seed deterioration (Pal and Basu, 1994; De, Mandal and Basu, 1998; Mandal, De and Basu, 1999 ; Mandal, De ,Saha and Basu,2000 , Guha et al., 2013; Saha et al., 2014).

Objective of the present Study

Keeping the above background in mind, the present investigation was taken up to

i) Standardize a suitable inexpensive eco-friendly and easily practicable dry seed invigoration treatments for the maintenance of vigour, viability and productivity of field pea seeds.

ii) Studies on the compatibility of dry physiological treatments with seed protectants to check physiological as well as pathological seed deterioration.

iii) Efficacy of seed invigoration treatments in different sizes of field pea seed for extended storability and improved field performance.

iv) Elucidation of possible mode of action of seed invigoration treatment in viability maintenance.