

Review on the Effects of Seed Priming on Performance of Maize Seedlings

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Abstract

Maize (*Zea mays* L.) is members of the grass family, Poaceae (Gramineae). It is believed that the crop was originated in Mexico. Maize is an important food crop in southeastern Ethiopian produced in a number of agro ecologies in region. The main objective of this senior seminar is to review the effect of seed priming on performance of maize seedling. The effect of Priming and ambient temperature due to different sowing dates on emergence of maize seedlings. Seed priming also called is osmo conditioning is one of the most promising treatments for reducing the time needed between sowing and seedling emergence. Seeds planted in early spring frequently experience low temperatures stress in soil during Germination and early plant growth. All part of the crop can be used for food and non-food products. In industrialized countries, maize is largely used as livestock feed and as a raw material for industrial products. .Different factors, such as soil moisture stress, temperature extremities, and soil salinity, poor seed bed preparation, weed competition, low seed quality, and extreme disease pressure adversely affect the emergence of maize seed. Seed priming could be used as a viable technology to improve seedling establishment. Rapid and uniform emergence has been achieved by seed priming in some field. Seed priming is an effective technology to enhance rapid and uniform emergence and to achieve high vigour, leading to better stand establishment and yield .There are several priming techniques, such as hydro priming osmo priming, halo priming, matrix priming and bio priming.

Keywords: Seed physiological quality, Seed priming, Sowing date, Seedling emergence

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1. INTRODUCTION

Maize ($2n=2x=20$) is monoecious allogamous and highly cross pollinated crop and grass family Poaceae (Gramineae) (Ali et al., 2014).It is genetically accepted its center of origin is Mexico and Central America with domesticated starting 6,000 to 7,500 years ago in the Mexican highlands (Doebley .2004).Francisco Hernandez Boncalo was the first to report the existence of this crop in 1570 and carried out the study of Mexico's flora with several evidences about maize by(Serratos-Hernandez .2009). Now maize is the second most grown cereal crop for human consumption after wheat globally critically in Sub Sharan Africa (SSA) including Ethiopia (Muli et al., 2016).Maize is extensively consumed in Central and West Africa used as raw materials in the food industry starting from 16th to 17th it has been highly and widely produced in Ethiopia in the mid and lowland sub humid areas of the country (Gemechu et al., 2016).

Ten to twelve thousand years ago, in independent locations around the world, cereal grains began to be consumed in larger quantities (Larson et al.,2014).Global maize agriculture was significantly enabled through adaptation to temperate environments that initially occurred during a 2000-year period following introduction into the North American continent a 4000 years before present (Swarts et al.,2017).Maize occupies approximately equal areas of production in the tropics and temperate environments, yet the majority (70%) of maize production occurs under temperate conditions (Edmeades et al., 2017). Maize is the most popular and palatable feed for all kinds of livestock and poultry birds all over the world (Hossain and Shahjahan, 2007). It is one of the oldest human-domesticated plants (Abdolreza Abbassian, 2006). Maize is high yielding, easy to process, readily digested and cheaper than other cereals. It is also a versatile crop, growing across a wide range of agro ecological zones (Akinbode, 2010).

Maize is the most important staple in terms of calorie intake in rural Ethiopia. The 2004/5 national survey of consumption expenditure indicated that maize accounted for 16.7 % of the national calorie intake followed by sorghum (14.1 %) and wheat (12.6 %) among the major cereals (Berhane et al., 2011). Compared to the 1960s the share of maize consumption among cereals more than doubled to nearly 30% in the 2000s, whereas the share of teff, a cereal that occupies the largest area of all crops in Ethiopia, declined from more than 30% to about 18% during the same period (Demeke, 2012). Ethiopian farmers grow maize, primarily for subsistence with 75% of all maize output consumed by farming households, making. It a key crop for overall food security and for economic development in the country (CSA, 2018).

Conventional maize is used directly for human consumption as well as infant nutrition in the form of porridge during weaning period without any protein supplement such as egg, meat or beans, which are comparatively expensive especially for poor-resource in the rural area (Yusuf, 2010). Normal maize has 10% protein which is of poor nutritional quality due to limiting concentration of essential amino acids (lysine and tryptophan) which the

human body cannot synthesize and has to be supplemented (Krivanek et al., 2007). Therefore adoption and cultivation of QPM with high concentration of lysine and tryptophan contents therefore could drastically reduce malnutrition, diseases and death among low income maize consumers in the developing countries (Mbuya et al., 2011).

Seed priming, a promising technique have been successfully employed to overcome the problem associated with poor germination and subsequent terratic crop stand under normal and stressful conditions (Jafar et al.,2012;). (Basra et al., 2011; Afzal et al., 2012) have e been tested to improve the maize performance under lown temperature stress. Kernel weight and composition can influence tolerance to cold stress, particularly in sweet corn, with heavier, kernels, containing higher starch, showing better germination(Trimble et al , 2016).In the field, small kernels may have lower emergence under cold conditions (Frascaroli et al.,2013). . Seed priming can increase emergence rate, early seedling growth and stand establishment in many plant species (Khan. et al., 2010)

Pre-sowing seed invigoration treatments have beneficial effect on field emergence, crop stand and seedling growth of Maize under low and sub-optimal temperatures (Rashid et al., 2002). Emergence performance of maize seeds varies with sowing dates due to variation in ambient temperature(Farooq et al., 2008) .According to Basu et al. (2005) found that primed seed sown at higher temperature showed higher emergence performance and dry matter compared to low temperature. Medany et al., (2007) stated that optimum temperature for maize growing is between 25 and 30°C. The objective of this paper is to review the effect of maize seed priming on seedling performance of maize

2. LITERATUR EREVIEW

2.1. Origin and Botanical Description of the Maize

Origins and taxonomic organization of maize was hotly debated until the late 1970s after which genetic studies, including the use of molecular markers and comparative DNA sequence data allowed breakthroughs in the taxonomy and phylogeny of maize and its wild relatives, including the identification of specific loci involved in the domestication process (van Heerwaarden *et al.*, 2011). Maize was domesticated in the tropical lowlands of southwest Mexico with subsequent introgression from teosinte (Piperno *et al.*, 2009; Huford *et al.*, 2013).

Maize diversified under genetic drift and selection as it was carried through a diverse habitats during its spread by humans both south and north from its origin, including its arrival in the southwestern region of North America by 2260 BC (Merrill *et al.*, 2009). The initial selection for adaptation to a temperate environment then occurred during the subsequent 2000 yrs. in North America (Bouchet *et al.*, 2013). Maize has become adapted to the broadest range of climatic conditions of all crops, from 40S in Chile to 50N in Canada and Russia, from sea level in the West Indies to elevations above 3400 m in the Andes (Bouchet *et al.*, 2013). Maize is propagated by seed. Maize seed needs a soil that is warm moist well aerated and fine to give enough contact between the seed and the soil (Kassie *et al.*, 2012).

2.2. Agro-Ecologies and Production of Maize in Ethiopia

The maize productivity gap between stressed and high potential areas is not only an issue of technology but also differences in climatic factors. Non- availability of suitable maize varieties is also responsible for such significant yield reduction (Mosisa *et al.*, 2001).Unavailability of improved infrastructure and grain marketing represents major limiting factors for maize production. Wise utilization and conservation of natural resources will also have a significant impact on maize grain production (Mosisa *et al.*, 2001).

Table 1. Major agro-ecological zones for maize in Ethiopia (MOA 2005)

Agro-Ecological zone	Elevation(m)	Rainfall (mm)	Estimate Area (%)	Administrative regions
Moist and semi-moist mid-altitudes	1700–2000	1000–1200	30	Parts of South Netin National Part of region (SNNPR), south west (SW) and west(W) Oromia ;W and north west(NW) Amhara;Ben Shangul- Gumuz (BSG)
Moist upper mid-altitudes	2000–2400	>1200	25	Central highlands; High lands of SNNPR,
Dry mid-altitudes	1000–1600	650–900	20	Parts of SNNPR,south west(SW) and W Oromia; W and NW Amhara;
Moist lower mid-altitudes	900–1500	900–1200	15	Pockets of Amhara, Oromia, SNNPR and BSG
Moist lowlands	<900	900–1200	5	Gambella and parts of BSG
Dry lowlands	<1000	<700	5	Afar and parts of Oromia and lowlands of Somali

2.3. Structure, Physiology and Breeding of Maize

The maize plant is often 2.5 m (meters) (8ft) in height, though some natural strains can grow 12 m (40 ft). The stem has the appearance of a bamboo cane and is commonly composed of 20 internodes of 18 cm (7 in) length. (Aorta, 2012) A leaf grows from each node, which is generally 9 cm (3.5 in) in width and 120 cm (4ft) in length (Arora .2012) Ears develop above a few of the leaves in the midsection of 18 cm. They are female inflorescences, tightly enveloped by several layers of ear leaves commonly called husks. Certain varieties of maize have been bred to produce many additional developed ears. These are the source of the baby corn used as a vegetable in Asian cuisine (Arora T. 2012). Most global production is provided by hybrid maize (Manuka et al., 2017a, b). Hybrids developed by CIMMYT yield >20% more than OPVs under optimal conditions, and the disparity is magnified to 30–>60% under a biotic and biotic stress conditions (Masuka et al., 2017a). However, open-pollinated varieties (OPVs) provide the majority of seed supply in some regions provided by the formal breeding sector (e.g., West Africa), albeit with much regional variation (Kassie et al., 2012) and due to many cited issues including seed supply (Gafney et al., 2016). More resources in terms of breeding support over a longer period of time have been directed toward maize improvement in temperate climates than have been applied, to date, to the improvement in maize production in the tropics (Edmeades et al., 2017) and heterotic patterns are not firmly established in tropical maize populations (Wen et al., 2011).

2.4. Seed Ageing and Salinity Induces Membrane Damage through Oxidative Stress

Biochemical and physiological deterioration during seed aging has been studied mostly under accelerated aging conditions using high temperatures and high seed water content.(Oliveira et al., 2011a;)Some studies indicate that membrane lipid per oxidation is one of the major causes of seed aging under accelerated aging conditions (Oliveira et al., 2011a). However, plants contain numerous antioxidant compounds, both enzymatic and non-enzymatic, which act to prevent oxidative damage by scavenging free radicals before they attack membranes or other seed components (Bhaskaran and Panneerselvam, 2013). Some protective mechanisms involving free radical and peroxide scavenging enzymes, such as (CAT), (POX), (APX) and (SOD), have been evaluated within the mechanism of seed aging (Espanany et al., 2016).

Soil salinity may affect the germination of seeds and seedling establishment either by creating an osmotic potential external to the seed and roots, preventing water uptake, or through the toxic effects of sodium ion and Chlorine–ions on the germinating of the seed and plant growth (Iqbal and Ashraf, 2013). In addition to ionic and osmotic components, salt stress, e.g. accelerated aging of seeds, also leads to oxidative stress through an increase in reactive oxygen species (ROS), such as, hydrogen peroxide (H₂O₂) and hydroxyl radicals (OH) (Bhaskaran and Panneerselvam, 2013).

2.5. Priming Effect on the Physiological Potential of Maize Seeds under Abiotic Stress

Seed priming may be an alternative for improving seed vigor. Priming may be performed with the use of substances

that contribute to the expression of the seed physiological potential (Batista, 2016). Seed priming may promote more balanced germination rates and higher germination speed, in addition to faster seedling growth under adverse conditions, for instance, under a biotic stress (Arif *et al.*, 2014). However, few studies have been conducted on seed priming using the amino acid phenylalanine, which is a precursor of phenolic compounds that increase in response to different types of stress, e.g., related to the plant defense systems and adaptation to adverse situations (Stangarlin, 2011). According to Batista (2016), priming with chemical enhances physiological seed quality, producing seeds with high tolerance to stress under high temperature.

2.6. Effect of Seed Priming on Seed Vigor and Early Growth in Maize

2.6.1. Under suboptimal temperature condition

Low temperature is one of the major environmental factor that has a significant influence on the growth and development of plants (Farooq *et al.*, 2008a). The negative impact of low temperatures on plant metabolism can be detected from the cellular level to the level of the whole plant (Gay *et al.*, 2008). The potential visual symptoms of chilling injuries in chilling-sensitive plants are leaf and hypocotyls wilting, the appearance of surface pits and large cavities, leaf necrosis, accelerated aging and the rupture of injured tissues, delayed, partial, or uneven ripening and growth decreasing, low temperature stress disturbs cells ultra-structure, enzyme activity, mitochondrial respiratory activity and electron transport (Gay *et al.*, 2008). Accord mining to Saeidnejad *et al.*, (2012) review that low temperature decreased maize seed germination parameters, seedling emergence and growth. Low temperature had deleterious effect on membrane stability, relative water content, starch metabolism and antioxidant activities (Farooq *et al.*, 2008a).

2.6.2. Under optimum temperature conditions

The optimum temperature for the germination of maize seed ranges from 25 to 28 °C. A stressful condition in germination lowers the plant population, which leads to reduction of grain yield (Radić *et al.*, 2009).

2.7. Different Effects of Seed Priming Techniques can Improve Seed Vigor and Early Seedlings Growth.

There are several priming techniques, such as hydro priming (Kaya *et al.*, 2006), osmo priming (Foti *et al.*, 2008), halo priming (Patade *et al.*, 2012), matrix priming (Zhang *et al.*, 2007) and bio priming (Begum *et al.*, 2010). The two most commonly used seed priming methods are hydro priming and osmo priming.

➤ Hydro priming

Hydro priming is the simplest method of seed priming, which relies on seed soaking in pure water and re-drying to original moisture content prior to sowing. (Goswami *et al.*, 2013). It is easily available and uncostly pre-sowing treatment, where seed hydration is achieved by soaking seeds in water (Casenave and Toselli, 2007). Kaya *et al.* (2006) According to this review hydro priming increased germination and seedling growth under salt and drought stress during germination in sunflower. Hydro-priming plays an important role in the seed germination, radical and plumule emergence in different crop species under saline and non-saline conditions and also have beneficial effect on enzyme activity required for rapid germination. (Rahman *et al.*, 2011).

Beneficial effect of hydro priming on seed germination and seedling growth under both optimal and stress conditions, in various crop plants such as chickpea, maize, rice mung bean and capsicum has been observed (Posmyk and Janas, 2007 and Patade *et al.*, 2012). Harris (2006) has reported improvement in seed yield in various crops at farmer's field by seed priming with water. Caseiro *et al.*, (2004) found that hydro-priming was the most effective method for improving seed germination of onion, especially when the seeds were hydrated for 96 hr compared to 48 hr. The main disadvantages of hydro priming is uncontrolled water uptake by seeds (Caseiro *et al.*, 2004). This is a consequence of free water availability to seeds during hydro priming, so that the rate of water uptake depends only on seed tissue affinity to water (Caseiro *et al.*, 2004).

➤ Bio priming

Bio priming involves seed imbibition together with bacterial inoculation of seed (Gulick *et al.*, 2012). As other priming method, this treatment increases rate and uniformity of germination, but additionally protects seeds against the soil and seed-borne pathogens. (Gulick *et al.*, 2012). It was found that bio priming is a much more effective approach to disease management than other techniques such as pelleting and film coating (Muller and Berg, 2008). Nowadays, the use of bio priming with plant growth-promoting bacteria as an integral component of agricultural practice (Timmusk *et al.*, 2014). In pearl millet, bio priming with *Pseudomonas* fluorescent isolates enhanced plant growth and resistance against downy mildew disease (Raj *et al.*, 2004). Bio priming with rhizo bacteria improved germination parameters of radish seeds under saline conditions (Kaymak *et al.*, 2009).

➤ Osmo priming

It is standard priming method that involves the use of adverse osmotic solution like mannitol, polyethylene glycol or salts such as chlorides, sulphates, nitrates to control water potential (Chen *et al.*, 2010; Papastilianou and Karamanos, 2012). The usefulness of osmo priming with Potassium Nitrite (KNO₃) was shown in different plant species (Kaya *et al.*, 2006; Eskandari and Kazemi, 2011). Osmo priming is the most widely used type of seed priming in which seeds are soaked in aerated low water potential solution. Priming of seeds in osmoticums has

been reported to be an economical, simple and a safe technique for seedling establishment and crop production under stressed conditions (Guzman and Olave, 2006).

➤ **Solid matrix priming**

Solid matrix priming (SMP), matrix conditioning in which water uptake by seeds is controlled (McDonald, 2000). The use of solid medium allows seeds to hydrate slowly and simulates natural imbibition process occurring in the soil (McDonald, 2000).

➤ **Halo priming**

Halo-priming refers to soaking of seeds in solution of inorganic salts i.e., sodium chloride (NaCl), Potassium Nitrite (KNO₃) and Calcium dichloride (CaCl₂) e.t.c. A number of studies have shown a significant improvement in seed germination, seedling emergence and establishment and final crop yield in salt affected soil in response to halo-priming (Iqbal *et al.*; 2006). Priming with sodium chloride (NaCl) and Potassium chloride (KCl) was helpful in removing the deleterious effects of salts (Iqbal *et al.*, 2006). It is a pre-sowing soaking of seeds in salt solutions, which enhances germination and seedling emergence uniformly under adverse environmental conditions and normal condition. Inorganic salts are used. Review the effects of sodium chloride (NaCl) priming with potassium Nitrite (KNO₃) on the germination traits and seedling growth of four *Helianthus annuus* Cultivars under salinity conditions and review that germination percentage of primed seeds was greater than that of un-primed seeds (Bajehbaj, 2010).

➤ **Hormonal priming**

It is soaking of seed in hormone solution is referred as hormonal priming. GA₃, Salicylic acid, Ascorbic acid, Cytokine's etc. can be used for this investigated the primed seeds of carrot, onion and tomato showing that priming these seeds with GA₃ increased the germination percentage and rate (fzal *et al.*, 2006). Review that the effect of hormonal priming with ABA, salicylic acid, or ascorbic acid on Wheat germination and seedling growth under normal and saline conditions (Bahrani and Pourreza, 2012).

2.8. Effect of Seed Priming on Maize Seedling Emergence

Different factors, such as soil moisture stress, temperature extremities, and soil salinity, poor seed bed preparation, weed competition, low seed quality, and extreme disease pressure adversely affect the emergence of maize seed. Seed priming could be used as a viable technology to improve seedling establishment. Rapid and uniform emergence has been achieved by seed priming in some field crops (Murungu *et al.*, 2004).

2.9. Importance of Seed Priming in Plant G

❖ **Germination**

Primed seeds enhanced uniform seedling emergence which may contribute to regular crop establishment, it often exhibit an increased germination rate and greater germination uniformity (Galhaut *et al.*, 2014). Priming may also induce structural and ultra-structural modifications that could facilitate subsequent water uptake and attenuate initial differences between the seeds in terms of imbibition, thus resulting in a more uniform germination (Galhaut *et al.*, 2014). In mung bean plants, faster seedling establishment resulting from priming may contribute to a total increase in yield up to 45% (Rashid *et al.*, 2004). Priming-induced increase in germination may be associated to a change in plant hormone biosynthesis and signaling. Priming has been reported to increase gibberellins (GA)/abscisic acid (ABA) ratio (El-Arab *et al.*, 2006) and this may be a direct consequence of a priming impact in gene expression pattern (Schwember *et al.*, 2010). Ethylene also directly influences germination speed and percentage. Increase in ethylene production during priming may promote endo-β-mannase activity facilitating endosperm weakening and post-priming germination (Chen and Arora, 2013).

❖ **Plant growth and development**

Plants produced from primed seeds often exhibit a faster growth than unprimed ones (Chen and Arora, 2013). The beneficial impact of priming on plant growth may be due to an improved nutrient use efficiency allowing a higher relative growth rate (Muhammad *et al.*, 2015). A higher growth of seedlings issued from primed seeds may also be analyzed in relation to a direct impact of pretreatment on cell cycle regulation and cell elongation processes (Chen and Arora, 2013). The growth parameters of chickpea were significantly affected by seed priming (Gupta and Singh, 2012).

❖ **Yield**

Yield increase may also result from a higher plant density observed as a -consequence of priming-induced increase in germination percentage (Murungu *et al.*, 2004 and Harris *et al.*, 2004). Seed priming treatment resulted in increased crop growth rate in treated sets which encouraged deposition of more photo assimilates in key plant parts, greatly affecting the final yield (Srivastava and Bose, 2012). Highest grain yield of Pusa Basmati 1121 was obtained with hydro-priming at 60 kg/ha of N application applied in 3 splits (Mahajan *et al.*, 2011). Binang *et al.* (2012) also demonstrated that priming had a significant effect on the number of tillers number of fertile panicles, and consequently grain yield of new rice varieties.

4. CONCLUSION

This review summered that suboptimal temperatures had negative effects on seed vigor and early seedlings growth. Seed priming treatments had more improving effects on review seed and seedlings traits under suboptimal (low and mixed temperature) than at optimal conditions. The beneficial effects of priming have also been proven in germination and the emergence of seeds and seedlings in many crops, particularly under a biotic stress. The improvements in the physiological quality of seeds and seedling vigor by seed priming under a biotic stress conditions has been related to the repair and build-up of nucleic acids, the increased synthesis of proteins, osmotic adjustment mechanisms. Seed priming is an effective technology to enhance rapid and uniform emergence and to achieve high vigour, leading to better stand establishment and yield .There are several priming techniques, such as hydro priming osmo priming, halo priming, matrix priming and bio priming. The two most commonly used seed priming methods are hydro priming and osmo priming. Seed priming is an old empirical strategy used since centuries by farmers, and since decades by seed companies, to improve germination processes in cultivated plant species. The underlying mechanisms involved in this positive impact of pre- sowing treatments remained obscure for a long time. The present review aimed to summarize recent information provided by various tools allowing the identification of molecular cues conditioning priming efficiency.

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