



AGRONOMIC PRACTICES FOR OPTIMIZING MAIZE (*ZEA MAYS* L.) YIELD AND QUALITY SEED: A REVIEW

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ABSTRACT

Maize has been a subsistence crop and its uses as staple food in different local dishes and demand in markets make it very popular everywhere in the country. However, maize yield and quality seed production constraints revealed many common problems encountered such as diseases, insect pests, poor on-farm crop management, lack of technology and information dissemination, and poor seed quality. Therefore, to halt these persistent problems of maize seed and quality production, some research activities in areas of cultural practices were carried out with the objectives of generating improved crop management methods for various maize seeds and quality. The source of yield and seed quality improvements and the causes of those yield and seed quality are not well understood. To explain the drivers of seed yield and quality seed and current sources of yield improvements in maize. The maize yield and seed quality increases were primarily attributed to agronomic improvements (from site selection up to storage). Therefore, this review analyzes the Agronomic management factors contributing to the yield and quality of seed of maize and recommends enabling conditions to improve agronomic practices.

Keywords: Maize, Agronomic, Quality, Seed yield, Grain yield

INTRODUCTION

Maize (*Zea mays* L.) is a monocotyledonous arable crop belonging to the family *Graminaceae* and tribe *Maydeae* (Raemaekers, 2001). It is one of the principal food crop. The crop ranks first in terms of productivity and second in area coverage after tef. Maize is cultivated in all of the major agro-ecological zones in Ethiopia up to 2400 m.a.s.l (Assefa *et al.*, 1993). It is used to produce a large variety of food and non-food products (Raemaekers, 2001). The grain contains calories and protein and is used to formulate food for babies (Mashingaidze, 2004). Cantarero *et al.* (2000) reported that seed yield of maize consists of different proportional contributions of the effective factor in all growth stages from emergence to maturity corn. According to Shunway *et al.* (1992) high quality seed is necessary to establish crops, therefore cultivated seed should have vigour and related physiological characters (Farshadfar *et al.*, 2012). Maximum seed vigour is attained at harvest maturity and not at physiological maturity (Wambagu *et al.*, 2012).

The agronomic practices used maize seed productions are similar followed in producing commodity grain maize. The major difference between seed and grain production is the need to follow management practices 1) preserve the purity and identity of the seed from planting through storage, and 2) reduce crop risk from environmental stress and pest problems (Smith and

Weissinger, 1984). The best management practices recommended for use in normal crop production become especially important in seed production. According to Peter (2012) reported that commodity grain production, not following recommended practices may result in lower grain yield, but in seed production it can jeopardize grain quality, in addition to yield. Care shown in the selection and preparation of the seed fields to obtain the most uniform growing environment possible will greatly facilitate identification of off-type plants in future rouging operations (Dodd, 1998). Some researchers pointed out that especially, the effect on sowing date and plant density on corn expressed that delay in sowing reduces the number of kernels in corn (Cantarero *et al.*, 2000). Shunway *et al.* (1992) reported that delay sowing reduces quality performance and performance components of maize while early and intermediate sowings tend to best utilize solar radiation for seed production (Otegui *et al.*, 1995).

Maize seed production constraints was revealed many common problems encountered such as diseases, insect pests, poor on-farm crop management, lack of technology and information dissemination, and poor seed quality (Fajamision,1985). Agronomic management can play a major role in determining the seed yield, quality, seed germination and understanding whole phenological stages in many regions. Seed crop warrants greater care and more inputs than a grain crop to obtaining the maximum number of high quality genetically pure seeds while at the same time minimizing the risk (Tyron, 1993). Therefore, this review analyzes the Agronomic management factors contributing to yield and quality seed of maize in Ethiopia and recommends enabling conditions to improve agronomic practices.

OBJECTIVE

To review key agronomic practices required for optimal maize seed yield and quality

LITERATURE REVIEW

The Major Agronomic Practices for Maize Seed Production

Site Selection

Site selection is crucial in seed production. Abad choices reduce the potential yield of seed. It is very important to consider rainfall, soil type, and topography (slope) of the area (IITA, 2014). Establish seed production fields on the most fertile, well drained soils to reduce stress and maximize yield potential and grain quality. Avoid droughty soils as well as poorly drained soil conditions (Wych, 1988). The areas with steep slopes, sandy and clay soils, filed previously planted to the same family, large shadow trees, ant hills and termite colonies should be avoided. Seed production should be undertaken where soils and climatic conditions are favorable for good crop production. Each variety should be produced in areas of its best adaptation in order to harvest quality seeds (Dodd, 1998). The accessibility of the seed production field to transport and proximity to seed processing plants is also equally important in site selection for seed production so that the seeds of the varieties can be economically produced (IITA,2014).

Land Preparation

Land preparation methods greatly influence growth and seed yield parameters of maize and soil properties. It may be advantageous to prepare seed fields several weeks prior to planting to help in the pre-germination of weed seeds (Wych, 1988; Craig, 1977). Avoid droughty soils as well as poorly drained soil conditions. Good soil structure and tilth are important in order to avoid the

adverse effects of poor drainage and crusting (Wych, 1988). Among the maize seed production factors, tillage contributes up to 20% (Khurshid *et al.*, 2006). Conservation tillage involves the use of machete, hoe, pickaxe, mulch tillage. Mulch tillage leaves crop residue on the soil surface for quick germination and satisfactory yield (Iqbal *et al.*, 2005). Land preparation methods can affect seed weight and total seed yield. Ploughing followed by harrowing land produced higher seed weight and higher total seed yield than no tillage (Samuel, 2012). To optimize maize seed yield, there is the need to plough and harrow the land before planting (Rashidi *et al.*, 2010).

Sowing Date

Planting dates should be chosen to avoid risky environmental conditions such as excessively cool or hot temperatures and isolation problems. Various studies have demonstrated the advantage of early plantings to achieve better yields (Wych, 1988; Craig, 1977). (Yakup and Oner, 2014) reported that sowing date had statistically affected thousand seed weight, the seed number in corn cob, corn cob length, seed yield, ash, oil, protein, starch contents of corn seed. In respect to yield attributes such as cob length, weight of cobs per plant were found significantly higher between 26 May and 30 April sowing date. It could be due to the better growth and development of crop as Kolawole *et al.* (2009) reported that due to the fact that good photosynthetic accumulated in leaves and its transfer to economic part like seeds, cobs etc. It showed that early sowing produced greater yields compared to late sowing, and also the lowest pod yield was obtained for the latest sowing date, since seed filling and harvest time were affected by cold weather, rain, and frost after the late sowing date (Naab *et al.*, 2004). In addition, the late sowing date has a higher probability of experiencing water stress during the critical seed-filling phase, resulting in lower yields (Nigam *et al.*, 1998). It might be suggested that the late planted crop had a shorter period for the production of seed and a slightly lower rate of seed production due to reduced growth, and exposure of plants to warmer and longer photoperiod (long day) after the late sowing date. These differences were also largely related to the number of developing seed on cob. Percent of protein content in grain significantly affected by dates of sowing, the early sowing the highest protein value was recorded (Yakup and Canavar, 2014).

Planting Depth

Planting depth recommendation for maize 1.5 to 3 inches deep to ensure adequate moisture uptake and seed soil contact. Deep planting may be recommended as the season progresses and soil becomes warmer and drier planting shallower than 1.5 inches generally not recommended at any planting date or any soil type. Excessively shallow planting can cause slow, uneven emergence due to soil moisture variation and less developed roots, small stalk diameters, small ears and reduce seed yield and quality (Peter, 2012). Plant between 1 ½ to 2 inches deep to provide for frost protection and adequate root development when the soil is usually moist and evaporation rate is low, seed should be planted shallower - no deeper than 1 ½ inches. One risk associated with shallow planting depths is the possibility of poor development of the permanent (or secondary) root system - if the crown is at or near the soil surface, some of the permanent roots may not grow under hot, dry conditions (resulting in the rootless and floppy maize syndromes). Another potential risk from planting less than 1 ½ inches is shoot uptake of soil-applied herbicides. Maize seed yield were about 14% and 40% greater for the 1.5 inch and 3 inch planting depth than the 0.5 inch planting depth, respectively (Osue, 1995). Planting depth affected plant height and seedling emergence. The tallest and shortest plants were recorded from

6 cm and 12 sowing depth, respectively. Time of seedling emergence decrease with increasing planting depth (Seid *et al.*, 2013).

Planting Density

Planting density in the seed field should be chosen to produce maximum yields of high quality seed of saleable kernel size. Optimum population is principally a function of soil moisture and fertility, and the parental material being used. For maize, these densities can vary considerably from 44,444 to 66,667 plants ha⁻¹ (Muhidin Biya *et al.*, 2022). In general, slightly lower population densities are recommended for female rows. This will help ensure good seed set and development while avoiding problems of plant stress which can increase silk delay and result in more disease and lodging problems. However, too low female populations can result in sub-optimal seed yields, poor grade-out including excessive production of large round kernels. Male rows are frequently sown at higher densities as male gamete production is less sensitive to density and environmental stress, and hopefully greater pollen production can be achieved per unit area. Excessive population densities should be avoided to facilitate full expression of the plant type to aid in identification of true-to-type and to eliminate off-type plants (David, 2002). Plant populations are direct limiting variables for maize seed yield determination. The relationship between seed yield per unit area and plant population is usually parabolic. At low plant densities, seed yield is limited by the small number of plants; as plant densities increase, yield declines primarily due to more aborted kernels and/or barren stalks (Hashemi *et al.*, 2005). Factors limiting corn populations to current levels are primarily based on competition for resources –sunlight energy, nutrients, and water. Ultimately, maize breeding efforts should focus on combining high population-tolerance with improved per-plant yield potential. Periodic reassessment of plant population and row widths are needed as a result of continued genetic improvement in the ability of maize to withstand high plant populations (Lauer and Rankin, 2004).

Fertilizer

Maize requires adequate supply of nutrients particularly nitrogen, phosphorus, and potassium for good growth and high yield. (Muhidin Biya *et al.*, 2022) reported that nitrogen and phosphorus are very essential for good vegetative growth and grain development in maize production. The response of maize plant to application of nitrogen and phosphorus fertilizers varies from variety to variety, location to location, pre-clearing vegetation, organic matter content, tillage method , light intensity and also depends on the availability of the nutrients. Research results have shown that various maize cultivars differ markedly in seed yield response to nitrogen fertilization (Bundy and Carter 1988). (Onasanya *et al.*, 2009) reported that application rate of 120kgN/ha +40kgP/ha may be recommended for increasing maize seed yield particularly. This review is in disagreement with the finding that reported N and P should be applied at the rate of 240 kg ha-1 and 100 kg ha-1 for quality protein maize to realize good yields (Nadita *et al.*, 2013).

Several recent studies looking at optimal N fertilizer rates in maize seed fields have shown that best seed yields and grade-outs can be achieved with lower N rates (55 – 110 kg ha-1) than that recommended by many companies and commonly used by seed producers (Peterson and Corak, 1993; Wilhelm and Johnson, 1997). In addition to N-P-K, several micronutrients are of special importance for seed development processes including magnesium (essential for germination),

boron (flower development and pollen germination), zinc (seed formation), and molibdenum (endosperm development) (David, 2002).

Irrigation

Irrigation scheduling involves making a decision on how much and when to apply it. Three factors influence the decision: water needs by the crop (evapo transpiration), water availability, and water holding capacity of the soil (Mohamed and Makki, 2005). Irrigation should be applied based on soil texture and depth, climactic conditions, and the needs of the crop. Irrigation early in the season may be beneficial to help establish a uniform stand. Water availability during flowering in maize is especially critical to help achieve good seed set. Scheduling irrigations just ahead of flowering is important to both meet the crop needs but also to avoid complications with machines and/or personal involved in the detasseling operation (Taylor, 1979). According to Asim (2011) reported that maximum plant population and field water use efficiency were obtained at irrigation water amount of 50% ET and 10 days irrigation interval gave the highest values of plant height, cob length, 100-seed weight, and seed yield. The mean maximum temperature of about 42 °C and a minimum of 25 °C, high bright sunshine duration of more than 10 hours, and low relative humidity less than 20%. The soil of the experimental site was classified as loamy.

Isolation

Proper isolation is basically accomplished in three ways including: a) distance b) time, and c) good synchronization. Seed producers often say that the best isolation is a perfect nick, that is, when the pollen parent starts shedding just before silk emergence in the female parent. An additional option may be used when it is difficult to get suitable distance or time isolation. This includes planting a barrier of foundation or certified seed of the same variety on all sides about 50 m from the production block (Cordova *et al.*, 1999). Minimum standards for isolation of seed maize fields have been established by the Association of Official Seed Certifying Agencies (1971). When zero or one male pollinator border row is present, minimum distances ranging from 125 to 201 m are typically required between the female parent of the hybrid being produced and any other maize of the same seed color, maturity, or endosperm type. Where the possible contaminant maize may have different kernel color or endosperm type, a 201m minimal distance is specified. Additional distance is needed in situations where the contaminant maize may have different pollen shedding capacity and where wind velocities may be high (Wych, 1987). Minimum isolation distance requirements can be modified (i.e. reduced) by using additional border rows and the size of the field and production block (Jones and Brooks, 1950). In some states, effective natural barriers and differential flowering dates are allowed to “substitute” for some isolation distance. However, natural barriers may not as effective as border rows of maize in providing isolation (Jones and Brooks, 1952). Differential flowering times between seed maize production and neighboring hybrid maize can also be effective if silks of the of female seed parents are not receptive when pollen other than the male pollinator is present (Wych, 1988).

Pest Control

Controlling weeds, insect pests, and diseases has become an integral part of maize seed production (Jugenheimer, 1985). Broad leaf weeds seed growers rely heavily on herbicide applications to minimize weed pressure. Above and belowground insecticide applications (seed,

pre- and post-application) are regarded as a necessity by many producers. To address environmental concerns regarding excess pesticide application as well as cut unnecessary expenditures, some companies are using integrated pest management principles and use scouting to determine if and when pesticide treatment of seed fields is needed (David, 2002).

Weed control

Weeds are plants which are not cultivated and grow out of place among cultivated crops (Akobundu and Agyakwa, 1998). Proper control of weeds are an integral and necessary part of maize seed production.. Weed control with Inbreds is especially critical as they often have low vigor thus are not well suited to compete with aggressive broad-leaf weeds and grasses. Harvesting an excessive amount of weeds in a seed crop can complicate the cleaning and conditioning process. Additionally, weeds can be hosts of undesirable diseases and insects which can reduce seed quality. Numerous pre- and post-emergence herbicides are available for weed control in maize seed production fields but caution should be applied in their selection as inbred toxicity to certain compounds has been observed (Wych and Schoper, 1987). Additional precautions for herbicide and other chemical applications include ensuring that spray tanks are clean before use and properly calibrated to apply proper rates while limiting human contact (Swanton *et al.*, 1996).

Insect control

Control of both above and below ground insects is essential in maize seed production. Most below ground insects are controlled with either seed treatments or granular insecticides applied at planting. Chemical applications may be necessary to control insects particularly which feed on the silks, ears and tassels. Heavy populations of borers, rootworm beetles, or aphids can result in poor seed set and development and thus a reduction in both the quality and the quantity of maize seed (Culy *et al.*, 1992). An integrated pest management program (IPM) is recommended including proper scouting to determine if and when insecticides are needed. Selection of the proper insecticide will depend on the specific insect to be controlled, the level of infestation, the development stage of the seed crop, safety considerations, and the reentry period (Stefanovic *et al.*, 2000).

Disease control

Proper disease control is important to obtain good seed quality and avoid spreading seed born pathogens. Genetic resistance in parental lines is preferred but sometimes otherwise outstanding lines are susceptible to particular pathogens present in production fields. As with insect control, an IPM program is desirable to monitor disease development and to determine if and when chemical application is necessary (David, 2002). Diseases such as smut, rust, bacterial blight, and streak affect maize. These diseases can be controlled by the use of chemicals, seed selection and the removal of alternative host. To minimize yield reduction due to diseases, it is important to cultivate disease tolerant maize or practice crop rotation to control diseases (Brust and King, 1994).

Harvesting

Harvesting may begin as early as when developing kernels approach physiological maturity which is often in the 30 to 38% moisture range with maize (Knittle and Burris, 1976). At physiological maturity seeds develop to complete functional maturity and express maximum

quality potential. If possible, a prompt harvest of the maize seed crop after it reaches physiological maturity is recommended, as delays will unduly expose the seed to possible undesirable elements in the field including temperature extremes, rainfall, diseases and insects, bird damage, and theft. Harvesting fully mature seed will result in maximum yield, improved appearance of seed, better seedling vigor in the subsequent crop, greater resistance to mechanical injury while handling in the conditioning plant, and reduced susceptibility to injury from high drying temperatures (David, 2002).

Husking

Conditioning maize seed following harvest may take place in a mechanized processing facility, in a farmer's backyard, or somewhere in between. Regardless of the scale and sophistication of the processing facility, the objective of conditioning is basically identical: to ensure the timely production of uniform, clean seed lots of healthy, viable, and genetically pure seed (Agrawal et al., 1998). Ears harvested either using the sweet corn equipment or with the older "two-step" husking system will arrive to processing facility with husks. It is important that the husking equipment is able to remove as much husks as possible without damaging the seed. Most husking units need to be adjusted for different seed parents and for hourly changes in moisture content of the seed (Jugenheimer, 1985).

Drying

Maize seed must be dried in order to prepare it for storage and distribution including protecting seed from disease organisms. Unfortunately, the drying process has been a frequent cause of seed injury and significant economic loss (Burris, 1995). The basic methods used for drying maize seed include: a) natural drying of seed on the cob prior to harvest while plants are still standing in the field, b) sun drying of seed on the cob following harvest, and c) artificial drying (Agrawal et al., 1998). Natural drying in the field is commonly used in regions characterized by subtropical and tropical climates and is particularly popular among small-scale seed producers who lack the resources to establish an artificial drying facility. The main advantage of natural field drying is the low cost. However, the method is risky as the seed may be exposed to numerous undesirable elements including temperature extremes, rainfall, pests, etc. Sun drying involves spreading cobs on a drying floor and exposing them to the sun for certain periods (Agrawal et al., 1998).

Shelling

Following the drying of maize ears, seeds must be removed from the cob by a process called shelling. Although this may be done by hand, mechanical means are often used to speed up the process. However, mechanical shelling presents a great risk particularly for physical damage to the seed. The two most widely used types of maize shellers are the cylinder and the cone. Both types rely on compression, rubbing, and twisting to remove seed from the cob (Johnston, 1996). The specific design of the sheller including the base material and presence of smoothed parts and rubber coatings can have a big influence on the success of the operation (Jugenheimer, 1985; Stanfield, 1996).

Cleaning

Seed maize leaving the sheller often contains varying amounts of foreign material including bits of cob, husk, broken kernels, stones, dirt, weed seeds, insect larvae, etc. This debris must be removed to improve seed appearance, and to promote good storability and plant ability. This may

be done manually through a laborious separation operation or more efficiently though the use of hand-held screens. Air screen machines convey shelled maize to series of sloping shaker screens. Large debris including oversized kernels, broken pieces of cob, stones, etc. are removed as they pass over the first screen while the good seed passes through (Harrington,1959).

SUMMARY AND CONCLUSION

Production of maize seed is a unique and dynamic industry worldwide. Good field management of maize seed production requires giving attention to adequate site selection including isolation, use of the best agronomic management practices, using appropriate isolation, proper manage pest, effectively removing off-type plants, and harvesting the crop in a timely fashion. Once the seed crop has been harvested it must be transported to the processing facility where it is de-husked, dried and cleaned. This long chain of activities requires intensive management, meticulous planning, and impeccable timing, a high level of technical expertise, and the cooperation of weather and other factors. An effective quality control program should monitor and help coordinate all aspects of the maize seed program. Generally management should include: A well-designed and properly-operated agronomic practice with trimly checking during growing season from planting throughout growing season up to storage for good seed yield and quality.

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