Available online at www.notulaebotanicae.ro

Print ISSN 0255-965X; Electronic 1842-4309

Not Bot Hort Agrobot Cluj, 2011, 39(1):178-182

Notulae Botanicae Horti Agrobotanici Cluj-Napoca

Seed Development and Quality in Maize Cultivars

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Abstract

In order to evaluate seed development and quality of maize *(Zea mays)* cultivars ('DC-370', 'SC-500', 'OSSK-602' and 'SC-604'), a split plot experiment (using R.C.B. design) with three replicates was conducted in 2009 at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran. Seeds were harvested at five day intervals in eight stages. Subsequently, the quality of seed samples was determined in the laboratory. Germination percentage and seedling dry weight were enhanced, but electrical conductivity of seed leachates was reduced with increasing seed weight on mother plant. Maximum seed quality of maize cultivars was attained at the end of seed filling phase. Seed quality at earlier harvests was low, because of immaturity. Differences in maximum seedling dry weight of maize cultivars were attributed to variation in genetic constitution. It was concluded that in maize cultivars, maximum seed quality could be achieved at physiological maturity.

Keywords: germination, maize, physiological maturity, seed development, seed quality

Introduction

Rapid and synchronized seed germination and seedling emergence are crucial for achieving an optimal crop stand and high productivity. By a good seedling establishment, plant life cycle would be guaranteed a strong plant, with a good plant density and uniformity (Harris *et al*., 1999; Ghassemi-Golezani, 1992; Ghassemi-Golezani *et al*., 2010a,b). This is particularly true for crops such as maize (*Zea mays* L.), which has not the capacity to adjust to incomplete stand by tillering (Ghiyasi *et al*., 2008).

High quality seeds may improve crop yield via high and rapid emergence of seedlings, leading to the production of vigorous plants and optimum stand establishment under a wide range of environmental conditions (Ghassemi-Golezani, 1992). Therefore, cultivation of high quality seeds is essential for satisfactory yield production. Several reports have shown poor stand establishment caused by low seed quality and consequently yield loss in corn (Cruz-Garcia *et al*., 1995), wheat (Ganguli and Sen-Mandi, 1990; Ram and Wiesner, 1988), barley (Abdalla and Roberts, 1969; Copeland and Mc Donald, 2001; Kim *et al.,* 1989; Matthews and Collins, 1975; Perry, 1980a; Samarah and Al-Kofahi, 2008) soybean (Vieira *et al*., 1999), cottonseed, (Iqbal *et al*., 2002) and oilseed rape (Ghassemi-Golezani *et al*., 2010a,b).

According to some researchers (Harington, 1972; Tekrony and Egli, 1997) mass maturity (end of seed filling phase) described as physiological maturity is a good sign of achieving maximum seed quality on the mother plant. In contrast, many reports on various crops suggest that maximum seed quality is attained after mass maturity (Pieta Filho and Ellis, 1991; Ellis and Pieta Filho, 1992; Demir and Ellis, 1992, 1993; Sanhewe and Ellis, 1996; Ghassemi-Golezani and Mazloomi-Oskooyi, 2008). These contradictory results may relate to differences in harvest time and species (Tekrony and Egli, 1997; Ghassemi-Golezani and Hosseinzadeh-Mahootchy, 2009).

Hanway (1963) described accumulation of reserves in corn seeds through regressive equations as a function of time. The maximum values of these regressive equations were considered as the end of seed filling phase. Rench and Shaw (1971) described the point of maximum physiological quality of corn seeds with moisture content and dry weight accumulation, and observed that those characteristics vary with genotype and seeding date. Thus, this research was conducted to investigate the changes in seed quality of maize cultivars at different stages of seed development and maturity.

Materials and methods

A split plot experiment (using RCB design) with three replications was conducted in 2009 at the Research Farm of the Faculty of Agriculture, University of Tabriz, Tabriz, Iran (Latitude 38° 05'N, Longitude 46° 17'E, Altitude 1360 m above sea level), in order to determine the best developmental stage for harvest and production of high quality seeds from four maize (*Zea mays*) cultivars. Harvest times were located in sub plots and cultivars ('DC-370', 'SC-500', 'OSSK-602' and 'SC-604') were allocated to main plots. The climate is characterized by mean annual precipitation of 245.75 mm per year and mean annual temperature of 10°C.

Each plot had 6 rows of 6 m length, spaced 25 cm apart. Seeds were treated with Benomyl at a rate of 1.5 g/

kg before sowing. The seeds were then sown at mid-May in 5 cm depth of a sandy loam soil. All Plots were irrigated after 70 mm evaporation from class A pan. Plots were fertilized with 100 kg/ha Ammonium phosphate. Weeds were controlled by hand during crop growth and development as required.

Seeds were harvested at five day intervals in eight stages. Seed moisture content was determined in accordance with ISTA rules (2010). Subsequently, seeds were air dried at 18-20°C and 100 seed weight of each sample was determined. Seed samples within separate sealed bags were then placed in a refrigerator at 3-5°C. Four replicates of 25 seeds from each sample were tested for germination in sterilized filter papers. These papers were incubated at 20±1°C for 14 days and germinated seeds (protrusion of radicle by 2 mm) were counted every day up to 14 days. Rate of seed germination was calculated according to Ellis and Roberts (1980). At the end of each test, numbers of normal and abnormal seedlings were counted (ISTA, 2010) and germination percentage was calculated. Seedlings were then dried in an oven at 80°C for 24 hours (Perry, 1977) and mean seedling dry weight for each treatment at each replicate was determined.

Two replicates of 50 seeds from each sample were weighed (SW1 and SW2) and then seeds of each replicate immersed in 250 ml deionized water in a container at 20°C for 24 hours. The seed-steep water was then gently decanted and EC was measured, using an EC meter. Following equation was applied to calculate conductivity per gram of seed weight for each sample (Powell *et al*., 1984).

$$EC\ (\mu s/cm/g) = [(EC1/SW1) + (EC2/SW2)]/2$$

All the data were analyzed on the basis of experimental design, using MSTATC software. The means of each trait were compared according to Duncan test at P≤0.05. Excel software was used to draw figures.

Results and discussion

Seed weight of all maize cultivars linearly increased with progressing seed development up to 55 days after flowering. The highest maximum seed weight (mass maturity) was obtained for 'DC-370', followed by 'OSSK-602', 'SC-500' and 'SC-604' cultivars. These variations in seed weight could be largely attributed to differences in seed filling rate (slopes of the linear regressions). Therefore, 'DC-370' with the highest seed filling rate produced the largest seeds (Fig. 1).

Percentages of seed germination of maize cultivars increased with enhancing seed weight up to mass maturity (end of seed filling phase). The highest and the lowest

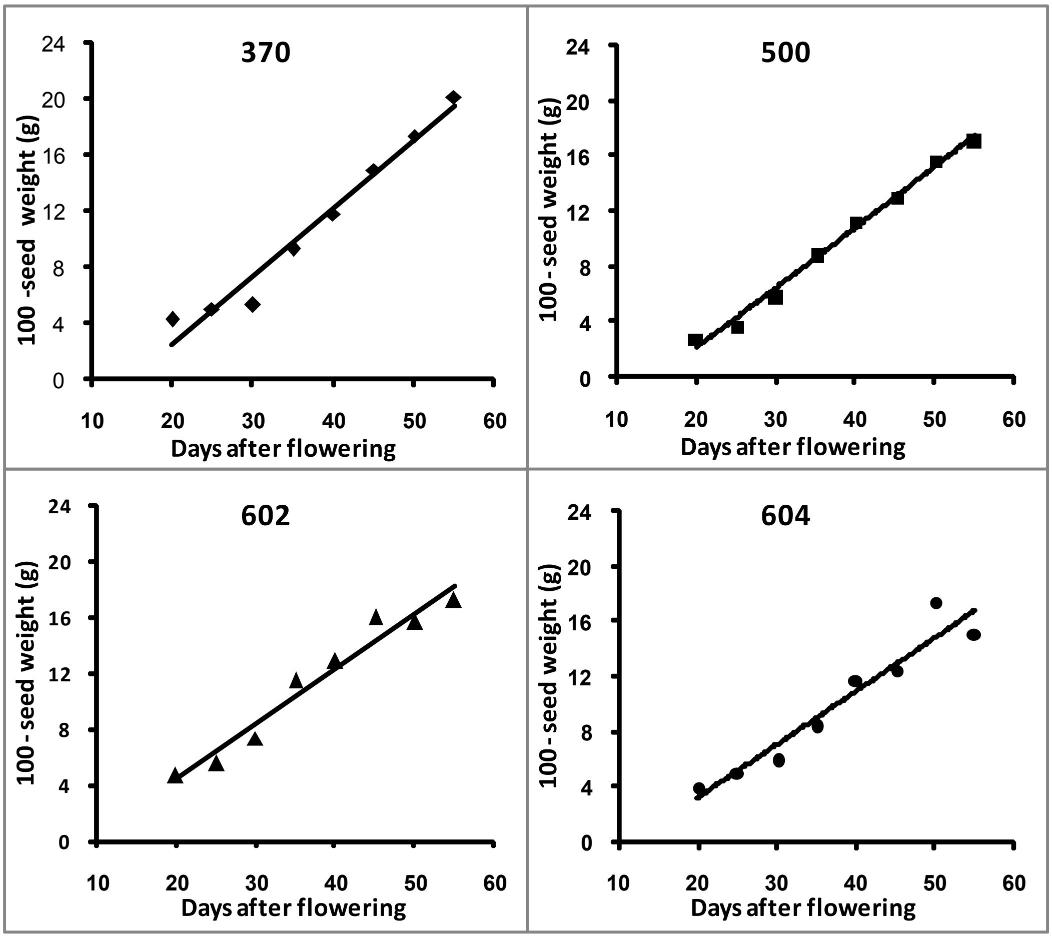

Fig. 1. Changes in seed weight of four maize cultivars at different stages of development

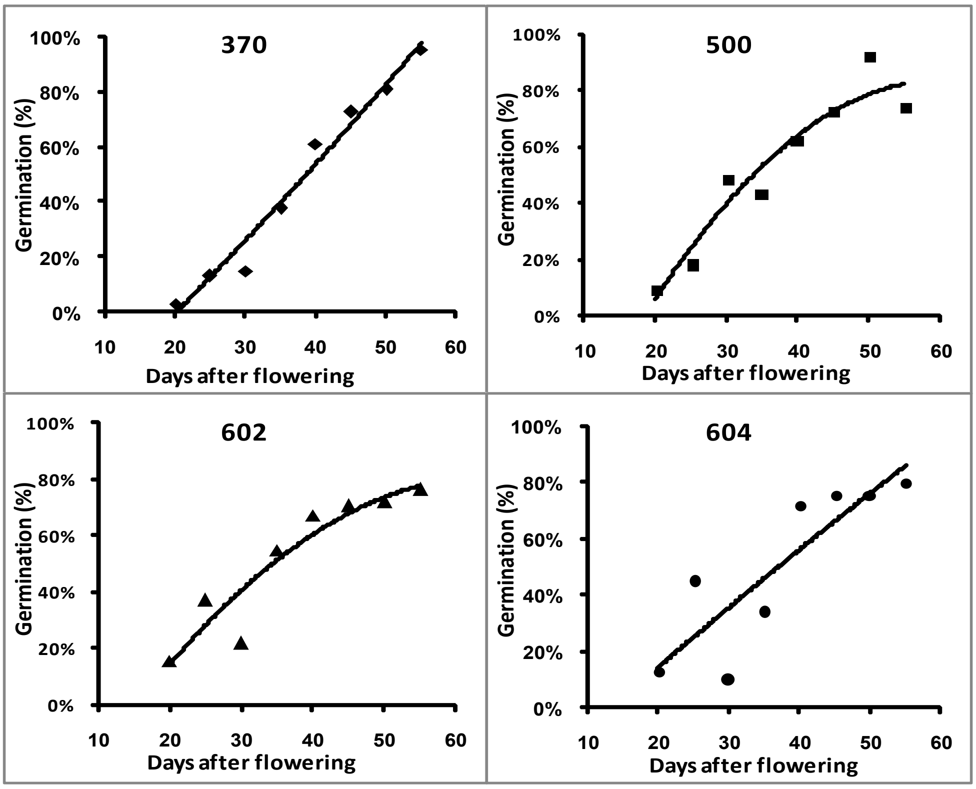

Fig. 2. Changes in seed germination of four maize cultivars at different stages of seed development

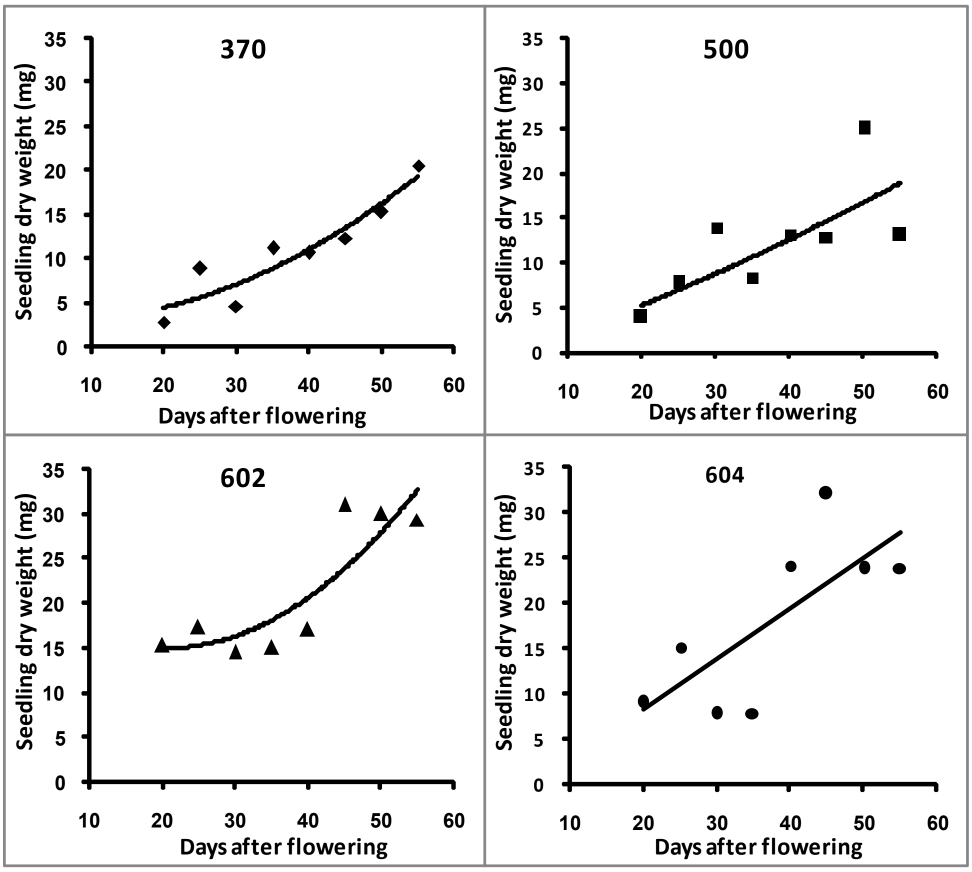

Fig. 3. Seedling dry weight of four maize cultivars at different stages of seed development

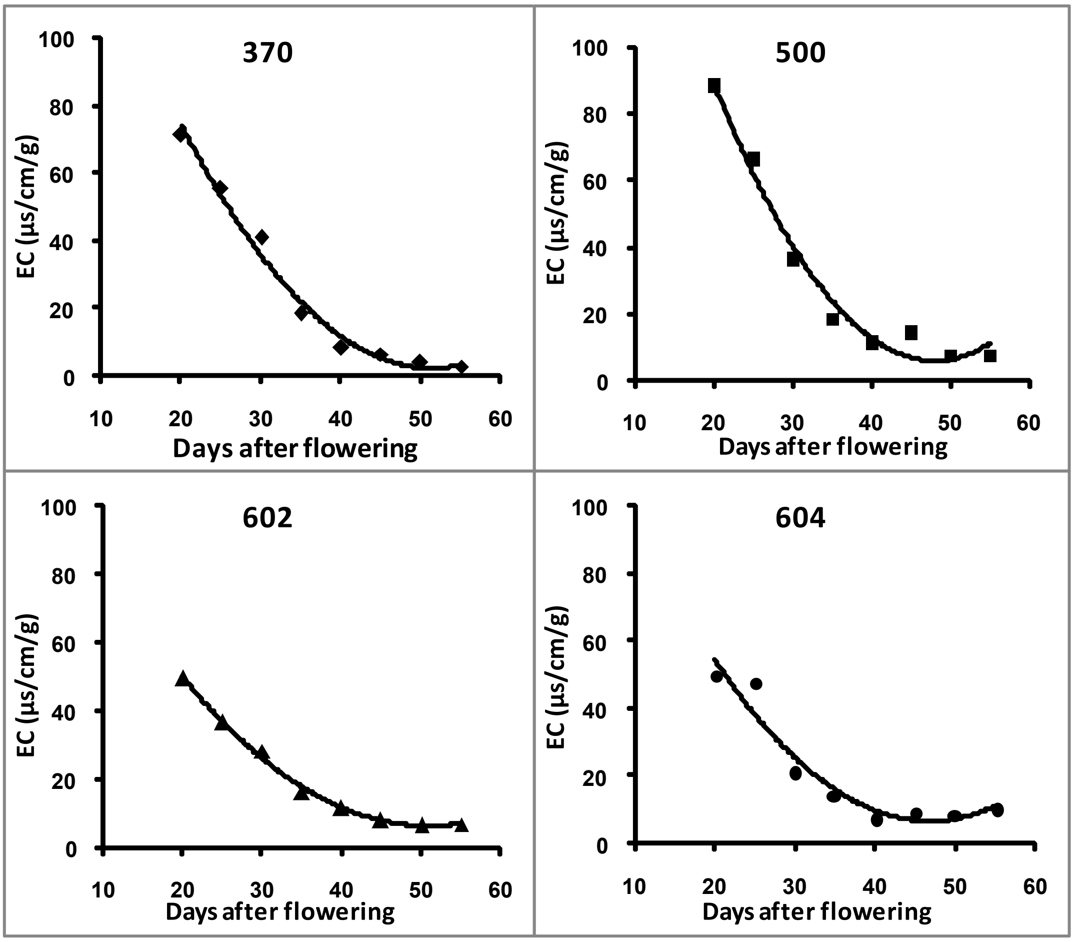

Fig. 4. Changes in electrical conductivity of seed leachates in four maize cultivars at different stages of seed development

germination percentages were recorded for 'DC-370' and 'OSSK-602' cultivars respectively (Fig. 2). Maximum seed germination of all maize cultivars was attained at mass maturity (Fig. 1 and 2). Similar results were reported for soybean (Miles *et al.,* 1988), mungbean (Hamid *et al.,* 1995) and barley (Samarah *et al.,* 2005).

Seedling dry weight of maize cultivars at the early stages of seed development was low, but it was improved with progressing towards mass maturity. Maximum seedling dry weight of 'DC-370' and 'SC-500' was lower than that of 'OSSK-602' and 'SC-604' (Fig. 3). Differences in maximum seedling dry weight among maize cultivars (Fig. 3) could be related with variation in genetic constitution, which can strongly influence seed quality and seedling vigor (Perry, 1980b; Ghassemi-Golezani *et al*., 2010).

Electrical conductivity (EC) of seed leachates for all maize cultivars decreased with improving seed development. Minimum electrical conductivity for 'DC-370', 'SC-500', 'OSSK-602' and 'SC-604' was obtained at 52, 48, 50, 47 days after flowering, respectively (Fig. 4). High electrical conductivity values of seed lots at the early harvests were due to immaturity, which had placed them as low quality seed lots (Hampton *et al.,* 1992; Vieira *et al.,* 2004; Ghassemi-Golezani and Mazloomi-Oskooyi, 2008; Ghassemi-Golezani and Hosseinzadeh-Mahootchy, 2009).

Conclusions

Maximum seed quality of maize cultivars as measured by seed germination percentage and seedling dry weight was achieved at mass maturity (Fig. 1-3), which is previously termed as physiological maturity (Harington, 1972; Tekrony and Egli, 1997). However, when seed quality was evaluated by electro- conductivity test (Fig. 4), maximum quality was obtained 3-8 days before the end of seed filling phase, depending on cultivar. Thereafter, no considerable changes in seed quality were observed, up to mass maturity. Thus, high quality seeds of maize cultivars could be produced, if seeds were harvested at mass maturity. High quality seeds can perform well in the field, ensuring optimum stand establishment and satisfactory yield under a wide range of environmental conditions (Ghassemi-Golezani *et al*., 2010b).

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