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# Studies on correlation of the seed speherecity and seedling characteristics of maize (*Zea mays* L.) inbred lines

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## Abstract
Seedling characteristics such as germination per cent and seedling vigour index becomes a major factor in influencing performance and grain yield of the low phytic acid (LPA) maize genotypes. In this study, seventeen maize inbreds, varying in their phytic acid content which ranges from 2.74 mg/g to 13.89 mg/g were evaluated for finding the relationship among nine characters such as seed germination per cent, seedling shoot length, seedling root length, seedling vigour index, seed length, seed breadth, seed thickness, phytic acid content and yield. Germination per cent was positively correlated with seedling root length, shoot length and seedling vigour index as well as with phytic acid content in the seeds. This illustrates the necessity of phytic acid in seed health. Seedling vigour index was also found to be positively correlated with that of seedling shoot length and root length. While seed length and seed breadth were correlated with each other, seed breadth was correlated with phytic acid content in the seeds. Most importantly, it was found out in the experiment that the phytic acid content in the seeds had a highly significant and positive correlation with that of single plant yield. Thus, from this study, it can be inferred that the screening of low phytic acid maize inbreds without compromising the seed spherecity, germination and yield have to be undertaken in the future in order to produce maize hybrids with altered phytic acid content.

**Keywords:** Seed speherecity, seedling characteristics, maize (*Zea mays* L.) inbred lines

## Introduction
As the world population level is increasing, food security is a major problem that accompanies it. In 2017, about 821 million people in the world were poor and malnutritioned while, about 40,6000 people worldwide die due to the same problem (Wang *et al*. 2016) [16]. An important prevention measure for this is through various plant breeding programs that ensure biofortification of food crops along with an increase in yield.

Being an indispensable food for over 900 million people in the developing countries, maize is mainly utilized as food and feed by the people. One of the major constraints in the maize is its high content of phytic acid, which acts as an antinutrient that chelates mineral ions such as $Cu^{2+}$, $Zn^{2+}$, $Mg^{2+}$ etc. This causes poor absorption of these minerals by the animals when maize is provided as feed to them. It is also the major form of phosphorous storage in plants, which is not digested by monogastric animals. This causes for high phosphorous content in their feces, resulting in environmental pollution by eutrophication Various low phytic acid mutants have been identified in maize by several authors wherein the decrement in the phytic acid content was attained by upto 66% without reducing the total phosphorous content (Raboy *et al;* 2000, Pilu *et al;* 2003) [13, 12]. But, the role of phytic acid in ATP formation, germination and in signaling was also proposed by Morton and Raison in 1963 and Safrany *et al*., in 1999 [14] respectively. This suggests that the perturbations in phytate pathway in producing low phytate lines yields poor agronomic charatcteristics in maize. A reduction in seed emergence of low phytic acid mutants was reported in soyabean (Hulke *et al;* 2004) [7] while, a reduced grain weight and seed viability were reported in low phytate mutants in barley (Bregitzer *et al;* 2006) [3] and rice (Zhao *et al*. 2008) [17]. An association was also found out between reduced seed dry weight and reduced seed phytic acid content (Raboy *et al;* 2000) [13].

Hence, the current work was conducted to find the relationship among seedling characteristics, yield and phytic acid content in seventeen inbred lines including some phytic acid lines.

## Materials and methods
The present work was carried out at the Department of Millets, Tamil nadu Agricultural University, Coimbatore during Kharif 2018.

Seventeen maize inbred lines were studied for their eight quantitative characters such as seed germination per cent, root length, shoot length, seedling vigour index, seed sphericity, seed yield per plant and for the quality trait, seed phytic acid content. Among the 17 inbreds studied, four genotypes were low phytate lines with phytic acid content below 5 mg $g^{-1}$, four genotypes were of moderate phytate content (5-10 mg $g^{-1}$) while the remaining nine lines were of high phytic acid content (more than 10 mg $g^{-1}$). The Phytic acid content was estimated using Davies and Reid method (1979) [4].
The inbreds were tested for their germination per cent and seedling vigour index following roll towel method. The root length, shoot length and number of seeds germinated were estimated after one week (Abdul Baki and Anderson, 1973) [1].

1. Germination per cent = $\frac{\text{Number of seeds germinated}}{\text{Total Number of seeds}}$ x100

2. Seedling vigour Index (SVI) = Germination per cent × (Root Length + Shoot Length).

The results obtained out of seed and seedling analysis along with phytic acid content and single plant yield were subjected to correlation analysis using the statistical software, SPSS 16.0.

**Results and discussions**
The mean performances of the inbreds for the traits studied are depicted in Table 1. The mean single plant yield was found to be the highest for the inbred UMI-1205 with a yield of 546.9 g per plant. This inbred also showed the highest germination per cent (100 %) and a higher phytate content of 13.64 mg $g^{-1}$. The lowest mean single plant yield was found in case of the inbred UMI-447 (77.5 g/plant) with a low phytic acid content of 3.31 mg $g^{-1}$. The shortest roots (12.7 cm) and shoots (5.5 cm) were found for the inbred K-155 with the lowest seedling vigour index of 1456 but had a moderate content of phytic acid (7.39 mg $g^{-1}$). The longest roots and shoots were recorded for DMR-QPM-06-12 with an average root length of 18.5 cm and shoot length of 8.1 cm. DMR-QPM-06-12 also recorded the highest seedling vigour index (2660.0) among the 17 inbreds studied. LPA-2-395 had the highest seed length of 0.93 cm, the inbred DMR-QPM-06-12 had the highest seed breadth (0.77 cm) and seed thickness was found to be the highest for the entry DMR-QPM-9-13-1. Among the 17 inbreds studied, the entry LPA-2-285 had the lowest content of phytic acid (2.74 mg $g^{-1}$) but yielded 218.2 g per plant, which was around the overall mean of the genotypes. The entry DMR-QPM-01-06-02 had the highest phytic acid content in it (13.89 mg/g) with an above average single plant yield of 465.5 g.
The simple correlations were estimated for the nine characters (Table 2). Seed phytic acid content and seed length showed positive and significant correlation with that of single plant yield with a correlation coefficiant of 0.386 and 0.401 respectively. This indicates that these traits had a positive contribution in the grain yield. Thus, decrease in the phytic acid content in seeds may result in reduction in seed size and in turn in yield. This result showed an agreement with the reports of Landoni *et al.* (2013) [8]. Germination per cent of the inbreds was positively correlated with seedling root length, shoot length, seedling vigour index as well as with its phytic acid content, i.e., lower seed phytic acid content might be the cause for reduction in seed germination per cent. Similar results were obtained from the studies done by Pilu *et al. posse* (2005) and Bregitzer *et al.* (2006) [3]. Seedling root length showed positive correlation with single plant yield and seedling shoot length had negative and non-significant association with grain yield. The correlation of seedling shoot and root length with phytic acid was positive and negative respectively. Similar results ie., positive correlation of seedling shoot length with grain yield per plant was reported by Ali *et al.* (2011) [2]. Even though, seedling root length and shoot length had no significant correlation with grain yield as well as with phytic acid content, a direct and highly significant association (correlation coefficient of 0.490) was found between seed phytic acid content and seedling vigour index. There are several studies which discussed the importance of phytic acid in the establishment of plants in their early growth stages by influencing the seedling vigour index (Meis *et al.*, 2003, Naidoo *et al.* 2012) [9, 11]. In this study also it is clear that, a higher content of phytic acid is having an important role in maintaining better seedling vigour. But for the inbred lines UMI-2-395 and UMI-2-285, which had a low phytic acid content in its seed, had comparable seedling vigour indices (1992.4 and 1748 respectively). Thus, selection has to be made by making a balance between seedling vigour index, yield and phytic acid content.
Seed length was positively correlated with that of seed breadth and yield. i.e., selection for longer seeds can help in improving the single plant yield in maize genotypes. A similar result of positive correlation of seed length with yield was also reported by Haddadi *et al.* (2012) [6]. Comparative studies of low phytic acid and other elite lines revealed a small shriveled or obovate seeds for low phytate lines, which was comparable to the earlier reports by Raboy *et al.* (2000) [13]. Seed breadth had positive and significant correlation with seed length and seed thickness but was non-significantly correlated to phytic acid and yield. This indicates that selection for seed breadth is not useful for improving the yield. Seed thickness showed a positive and highly significant relationship with phytic acid content in the seeds indicating thicker seed possesses higher content of phytic acid. Some of the low phytic acid inbread lines such as LPA-2-285 and LPA-2-395 showed a moderate performance in yield (218 g per plant and 204.4 g per plant respectively). These inbreds could be used as donors in the process of developing LPA hybrids with better yield. Understanding seed parameters, seedling vigour and phytic acid content, which has direct relation to seed yield and seed health is essential in formulating effective LPA maize breeding programmes. Hence, the knowledge on seed phytic acid with seed and seedling characters are to be explored further to fix the parental materials in LPA breeding programmes.

**Table 1:** Mean performance of the seventeen inbreds studied.

| Inbreds | GP (%) | RL (cm) | SL (cm) | SVI | SEED-L (cm) | SB (cm) | ST (cm) | PA (mg $g^{-1}$) | Yield (g $plant^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| UMI-113 | 82.5 | 16.15 | 7.55 | 1984.1 | 0.63 | 0.47 | 0.33 | 8.13 | 174.3 |
| UMI-467 | 70 | 17.35 | 6.75 | 1687 | 0.68 | 0.67 | 0.39 | 2.86 | 88.70 |
| UMI-447 | 77.5 | 14.55 | 7.3 | 1693.4 | 0.63 | 0.43 | 0.30 | 3.31 | 55.60 |
| UMI-158 | 77.5 | 15.65 | 5.7 | 1654.6 | 0.50 | 0.47 | 0.33 | 6.13 | 98.64 |
| LPA-2-285 | 80 | 16.2 | 5.65 | 1748 | 0.89 | 0.64 | 0.35 | 2.74 | 218.2 |
| LPA-2-395 | 87.5 | 16.85 | 7.3 | 2113.1 | 0.93 | 0.69 | 0.24 | 2.83 | 204.4 |
| UMI-1099 | 85 | 15.7 | 6.5 | 1887 | 0.87 | 0.57 | 0.37 | 9.01 | 138.4 |
| K-155 | 80 | 12.7 | 5.5 | 1456 | 0.71 | 0.67 | 0.28 | 7.39 | 119.12 |
| UMI-1200 | 97.5 | 17.4 | 7.6 | 2437.5 | 0.84 | 0.69 | 0.35 | 13.78 | 436.8 |
| UMI-1201 | 82.5 | 14.4 | 6.7 | 1740.75 | 0.89 | 0.61 | 0.36 | 12.60 | 487.4 |
| UMI-1205 | 100 | 17.3 | 6.3 | 2355 | 0.86 | 0.64 | 0.33 | 13.64 | 546.9 |
| DMR-QPM-9-13-1 | 87.5 | 15.1 | 6.2 | 1988.75 | 0.80 | 0.70 | 0.48 | 11.68 | 367.1 |
| DMR-QPM-3-72 | 82.5 | 17.5 | 7.25 | 2568.9 | 0.80 | 0.65 | 0.38 | 13.29 | 291.6 |
| DMR-QPM-11-17 | 97.5 | 16.6 | 7.5 | 2345.0 | 0.77 | 0.75 | 0.42 | 13.45 | 197.8 |
| DMR-QPM-6-12 | 100 | 18.5 | 8.1 | 2660.0 | 0.90 | 0.77 | 0.37 | 13.38 | 113.6 |
| DMR-QPM-1-6-2 | 97.5 | 15.8 | 6.7 | 2193.7 | 0.74 | 0.52 | 0.33 | 13.89 | 465.5 |
| DMR-QPM-4-5 | 92.5 | 14.4 | 7.2 | 1995.2 | 0.87 | 0.59 | 0.35 | 12.22 | 339.6 |

**Significance at 5% level.
*****Significance at 1% level.

**Table 2:** Genotypic correlations of the nine characters studied.

| | GP (%) | RL (cm) | SL (cm) | SVI | SEED-L (cm) | SB (cm) | ST (cm) | PA (mg $g^{-1}$) | Yield (g $plant^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| GP | 1 | | | | | | | | |
| RL | .351* | 1 | | | | | | | |
| SL | .433* | .325 | 1 | | | | | | |
| SVI | .880** | .691** | .665** | 1 | | | | | |
| SEED-L | .268 | .145 | -.057 | .207 | 1 | | | | |
| SB | .193 | .190 | -.149 | .159 | .579** | 1 | | | |
| ST | .100 | -.067 | -.231 | -.030 | .093 | .433* | 1 | | |
| PA | .732** | -.010 | .094 | .490** | .148 | .214 | .388* | 1 | |
| Yield | .245 | .013 | -.317 | .083 | .401* | .187 | .217 | .386* | 1 |

**Significance at 5% level.
*Significance at 1% level.
GP= Germination Per cent, RL= Root Length, SL= Shoot Length, SVI= Seedling Vigour Index, SEED-L= Seed Length, SB= Seed Bredth, ST= Seed Thickness, PA= Phytic Acid.

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