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INFLUENCE OF SEED PRIMING ON PHYSIOLOGICAL PERFORMANCE OF FRESH AND AGED SEEDS OF MAIZE HYBRID [COH(M) 5] AND IT'S PARENTAL LINES

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ABSTRACT

Laboratory and field studies were conducted to evaluate the influence of seed priming on physiological parameters of fresh and aged seeds of maize hybrid (COH(M) 5) and its parental lines UMI 285 (female) and UMI 61 (male). Seeds were soaked in water, 1% KH_2PO_4, 3% KNO_3 and 2% $CaCl_2$ solution for 6 hrs. The result revealed that seed priming with 1% KH_2PO_4 for 6 hrs showed an increased physiological performance in fresh and aged seeds of UMI 285, UMI 61 and COH(M) 5. The increased physiological performance was observed in terms of increased germination percentage, shoot length, root length, dry matter production and vigour index; accompanied with earlier germination in terms of days to 50% germination and days to maximum germination. Increased field emergence potential was also observed in the seeds primed with 1% KH_2PO_4 for 6 hrs. However, more pronounced effect of seed priming with 1% KH_2PO_4 for 6 hrs was observed in aged seeds than in fresh seeds.

Keywords: seed priming, maize, physiological performance, KH_2PO_4, germination, vigour.

INTRODUCTION

Maize (*Zea mays* L.) is the third important cereal next to rice and wheat, in the world as well as in India. In India, it is grown in an area of 7.59 million ha^{-1} with a production of 15.1 million tonnes (Anon., 2008) and the average productivity is 1938 kg ha^{-1} (Anon., 2007). In Tamil Nadu, maize is cultivated in an area of 0.20 million ha with a production of 0.24 million tonnes recording an average productivity of 1189 kg ha^{-1} (Anon., 2007). By 2020 AD, the requirement of maize in various sectors will be around 100 million tonnes, of which the poultry sector demand alone will be 31 million tonnes. It is a challenging task for the agriculturists to increase the maize production from the present level of 34 to 100 million tonnes (Seshaiah, 2000). The only option is to increase the maize productivity per unit area of land and time, which can be achieved through selection of genotype and application of proper production management techniques.

In any variety or hybrid, higher production and productivity is possible only through use of good quality seeds and proper management practices. Good quality seeds imply vigour, uniformity and structural soundness besides its genetic and physical purity. Seed priming, identified as an effective seed invigouration method has become a common seed treatment to increase the rate and uniformity of emergence and crop establishments. Seed priming is a controlled hydration process that involves exposing seeds to low water potentials that restrict germination, but permits pregerminative physiological and biochemical changes to occur (Heydecker and Coolbear, 1977; Bradford, 1986 and Khan, 1992). Upon rehydration, primed seeds may exhibit faster rates of germination, more uniform emergence, greater tolerance to environmental stress, and reduced dormancy in many species (Khan, 1992; Ashraf and Foolad, 2005).

Several literatures revealed that seed priming could advance germination, improve the initial quality characters, improve field emergence, better establishment and crop stand and thus increase yields in many diverse environments. Amarjit *et al*., (1988) found that priming maize seed with 2.5% K_2HPO_4 and 2.5% K_2HPO_4+KNO_3 accelerated germination even at a chilling temperature and the effect of priming was largely retained after seeds had been dried back. Harris *et al*., (1999) soaked the maize seeds for 8 hrs in distilled water and in 200ppm of NaCl, KCl, and $CaCl_2$ to alleviate the adverse effects of salt stress on maize at germination stage and found that $CaCl_2$ proved to be more effective, showing higher germination per cent, rate of germination and fresh and dry weights of plumules and radicles than those primed with other salts and distilled water. Murungu *et al*., (2004) revealed that priming of maize seeds (seed soaking in water for overnight) decreased the mean time to 50% emergence by 12 hrs, but there was a little effect of priming on growth, time to flowering and maturity and yield of plants.

Although, several studies have clearly indicated that some benefits are associated with pre-sowing treatments for seed vigour enhancement, the major problem encountered with the commercial application of seed priming is the variability among species, varieties and even seed lots, especially when treating large quantities of seeds (Bradford, 1986). Since different batches of seeds are intrinsically heterogeneous with respect to germination rate, the specific treatment conditions must be optimized for each seed lot. The present study was carried out with the objective to evaluate the effects of different priming treatments on physiological parameters of seed germination in seed lots having different germination percentage in order to find out the most promising priming technique for maize hybrid and its parental line seeds.

MATERIALS AND METHODS

To assess the effect of priming on two seed lots having different germination percentage laboratory and field studies were carried out at the Department of Seed Science and Technology, Tamil Nadu Agricultural University, Tamil Nadu, India. Genetically pure fresh seeds of hybrid maize COH(M) 5 and its parental lines (Female - UMI 285, Male - UMI 61) were obtained from Millet Breeding Station, Tamil Nadu Agricultural University, Coimbatore and used for this study. Half the quantity of fresh seeds of all the genotypes having 90% germination was subjected to accelerated ageing. Seeds were packed in perforated butter paper bags and placed in a desiccation glass jar containing water instead of silica gel to maintain relative humidity at 98 ± 2%. Then the glass jar was kept inside an incubator maintaining 40 ± 1°C. The seed samples were drawn at every day and subjected to germination test until the germination reduced to 80 per cent. Then the aged seeds were shade dried to its original moisture content. Both fresh and aged seeds of maize hybrid COH(M) 5 and its parental lines UMI 285 and UMI 61 were subjected to the priming treatments *viz*., (i) Soaking in water for 6 hrs; (ii) Soaking in 1% KH_2PO_4 for 6 hrs; (iii) Soaking in 3% KNO_3 for 6 hrs and (iv) Soaking in 2% $CaCl_2$ for 6 hrs. After priming, the seeds were removed from the solutions, rinsed in distilled water, redried to original moisture content under shade at room temperature and assessed for the following physiological seed quality parameters. The unprimed seeds were used as control. The experiment was carried out with four replications in factorial completely randomized block design.

The germination test was conducted by following the procedure outlined by ISTA (1999) using sand medium. Four replicates of 50 seeds each were germinated in a germination room maintained at 25 ± 2ºC temperature and 95 ± 3% RH using sand medium. Germination was counted in 24 hrs intervals and continued until no further germination occurred. At the end of seventh day, the number of normal seedlings in each replication were counted and expressed in percentage. Days to 50% germination and Days to maximum germination were calculated according to the methods prescribed by Heydecker and Coolbear (1977) and Mauromicale and Cavallaro (1995), respectively and the mean values were expressed in days.

Speed of germination was calculated based on the following formula of Maguire (1962)

$$\text{Speed of germination} = \frac{X_1}{Y_1} + \frac{X_2 - X_1}{Y_2} + \ldots\ldots\ldots\ldots + \frac{X_n - X_{n-1}}{Y_n}$$

Where; X_1, X_2 and X_n are number of seeds germinated on first, second and n^{th} day, respectively and Y_1, Y_2 and Y_n are number of days from sowing to first, second and n^{th} count, respectively.

Root length and shoot length were measured at the time of germination count from ten normal seedlings selected at random from each replication and expressed in centimeter and those seedlings used for growth measurement were placed in a paper cover and dried in shade for 24 hrs and then they were kept in an oven maintained at 85±2°C for 48 hrs. The dried seedlings were weighed to estimate the dry matter production and the mean values were expressed in g per 10 seedlings.

The vigour index value was computed as described by Abdul-Baki and Anderson (1973) by multiplying germination of seeds in percentage and total seedling length in centimeter and expressed in whole number.

To assess the field emergence potential, four replication of 100 seeds from each treatment were line sown in the field on the raised beds separately. The normal seedlings emerged were counted on 14 days after sowing and the mean values were expressed in percentage.

The data obtained from different experiments were analysed by the 'F' test of significance following the methods described by Panse and Sukhatme (1985). The values expressed in percentage were transformed to angular (Arc-sine) values before analysis. The critical differences (CD) were calculated at 5 per cent probability level. If the F test is not significant it was indicated by letters NS.

RESULT AND DISCUSSIONS

Studies on the effect of seed priming with water, 1% KH_2PO_4, 3% KNO_3 and 2% $CaCl_2$ solution for 6 hrs in fresh and aged seeds of maize hybrid COH(M) 5 and its parental lines revealed that the priming treatments significantly influenced the physiological seed quality parameters of both fresh and aged seeds of maize hybrid COH(M) 5 and its parental lines UMI 285 and UMI 61. The influence of seed priming on physiological characters among the genotypes was also significant. However, the effect of interaction between priming treatments and genotypes were not significant for all the seed quality parameters studied.

Both fresh and aged seeds of all the genotypes primed with 1% KH_2PO_4 for 6hrs attained 50% germination in shortest duration when compared to other treatments while the unprimed seeds took the longest duration. In case of genotypes performance, seeds of maize hybrid COH(M) 5 took the shortest period to attain 50% germination followed by its female parent UMI 285 which was on par with each other (A of Figure-1). Fresh seeds primed with 1% KH_2PO_4 for 6 hrs attained 50% germination in 1.3 days earlier than unprimed seeds, whereas aged seeds primed with 1% KH_2PO_4 for 6hr attained 50% germination in 1.4 days earlier than unprimed seeds. In case of days to attain maximum germination, also both fresh and aged seeds of all the genotypes primed with 1% KH_2PO_4 for 6 hrs attained maximum germination in shortest duration with highest speed of germination when compared to other treatments while the unprimed seeds took the longest duration and has lowest speed of germination. Among the genotypes, fresh and aged seeds of maize hybrid COH(M) 5 attained maximum germination in shortest duration with highest speed of germination followed by UMI 285 and then UMI 61 (B and C of Figure-1).However, as in the case of days for 50% germination, fresh seeds primed with 1% KH_2PO_4 for 6hrs attained the maximum germination 1.3 days earlier than unprimed seeds, whereas aged seeds primed with 1% KH_2PO_4 for 6hr attained maximum germination 1.5 days earlier than unprimed seeds.

Seeds primed with 1% KH_2PO_4 for 6 hrs produced higher germination both in fresh and aged seeds of all genotypes when compared with other treatments. Among the genotypes, fresh seeds of COH(M) 5 produced the highest germination of 95% followed by UMI 285 (94 %) and UMI 61 (93%), whereas aged seeds of COH(M) 5 recorded the highest germination of 86% followed by UMI 285 (85%) which were on par with each other. However, in fresh seeds of UMI 285, UMI 61 and COH(M) 5, the increase in germination was 6, 5 and 6 per cent, respectively due to priming over unprimed seeds; whereas in aged seeds, the increase in germination was 9, 8 and 9 per cent, respectively due to priming over unprimed seeds (D of Figure-1). Many studies have related the priming induced germination enhancement to the improvement in membrane integrity as well as the increases in protein and nucleic acid syntheses (Khan *et al*., 1978; Dell'Aquila and Taranto, 1986; Fu *et al*., 1988; Smith and Cobb, 1991).

Both fresh and aged seeds of UMI 285, UMI 61 and COH(M) 5, primed with 1% KH_2PO_4 for 6 hrs produced the longer seedlings in terms of shoot and root length, increased dry matter production and vigour index. Among the genotypes, COH(M) 5 recorded the highest shoot and root length (E and F of Figure-1), increased dry matter production (A of Figure-2) and vigour index than the other genotypes. The increase in vigour index of fresh seeds of UMI 285, UMI 61 and COH(M) 5 primed with 1% KH_2PO_4 for 6 hrs were 35, 36 and 36%, respectively over unprimed seeds; whereas the increase in vigour index of aged seeds of UMI 285, UMI 61 and COH(M) 5 primed with 1% KH_2PO_4 for 6 hrs were 54, 56 and 53%, respectively over unprimed seeds (B of Figure-2). These variations in the effect of seed priming in fresh and aged seeds revealed that the seed priming was more effective in increasing the performance of deteriorated or marginal seed lots than the seed lot containing fresh seeds. Bray *et al*., (1989) reported that the priming treatment abolishes the difference in germination performance of fresh and aged seeds. Similar results were also reported by Nagarajan and Pandita (2001).

From this study it is plausible to presume that the enhanced germination due to potassium dihydrogen phosphate might be due to ions absorption during priming as reported by Alvarado *et al*., (1987) and Frett *et al*., (1991). Moreover, the potassium salts had been reported to raise the ambient oxygen level by making less oxygen available for the citric acid cycle (Bewley and Black, 1982). In the present study, the increase in shoot length, root length and dry matter production due to priming might be due to earlier start of emergence as evidenced by lesser days to 50% germination and minimum days to maximum germination. This was in agree with the earlier studies on maize by Murray (1990) and Afzal *et al*., (2008).

The enhanced performance of seedling emergence due to seed priming in laboratory conditions was also reproducible under field condition which was evidenced by the increased field emergence in fresh and aged seeds of maize hybrid and its parental lines primed with 1% KH_2PO_4 for 6 hrs. The increase in field emergence of fresh and aged seeds of UMI 285 primed with 1% KH_2PO_4 for 6 hrs were 9 and 11%, respectively and in the seeds of UMI 61 it was 7 and 12% and in COH(M) 5 hybrid, the increase was 8 and 11%, respectively over the unprimed seeds. Among the genotypes, higher field emergence was observed in maize hybrid COH(M) 5 and its female parent UMI 285 which were on par with each other (C of Figure-2). Barlow and Haigh (1987) reported that the improvement in rate of germination due to priming with potassium salts under laboratory conditions appear to be sustained in the field and leads to improvements in seedling emergence from cold soils. Similar results were also reported by Ananthi (2008) who indicated that there was 5% increase in field emergence in maize hybrid seeds primed with 1% KH_2PO_4 for 10 hrs.

CONCLUSIONS

From the present study, it was clearly concluded that the priming of COH(M) 5 maize and its parental line seeds with 1% KH_2PO_4 for 6 hrs was found to improve all the physiological seed quality parameters significantly and also the seed priming effect was more pronounced in aged seeds than in fresh seeds. Hence marginal seed lots having low vigour and germination percentage can be primed with 1% KH_2PO_4 for 6 hrs for enhanced germination, vigour and uniform field establishment.

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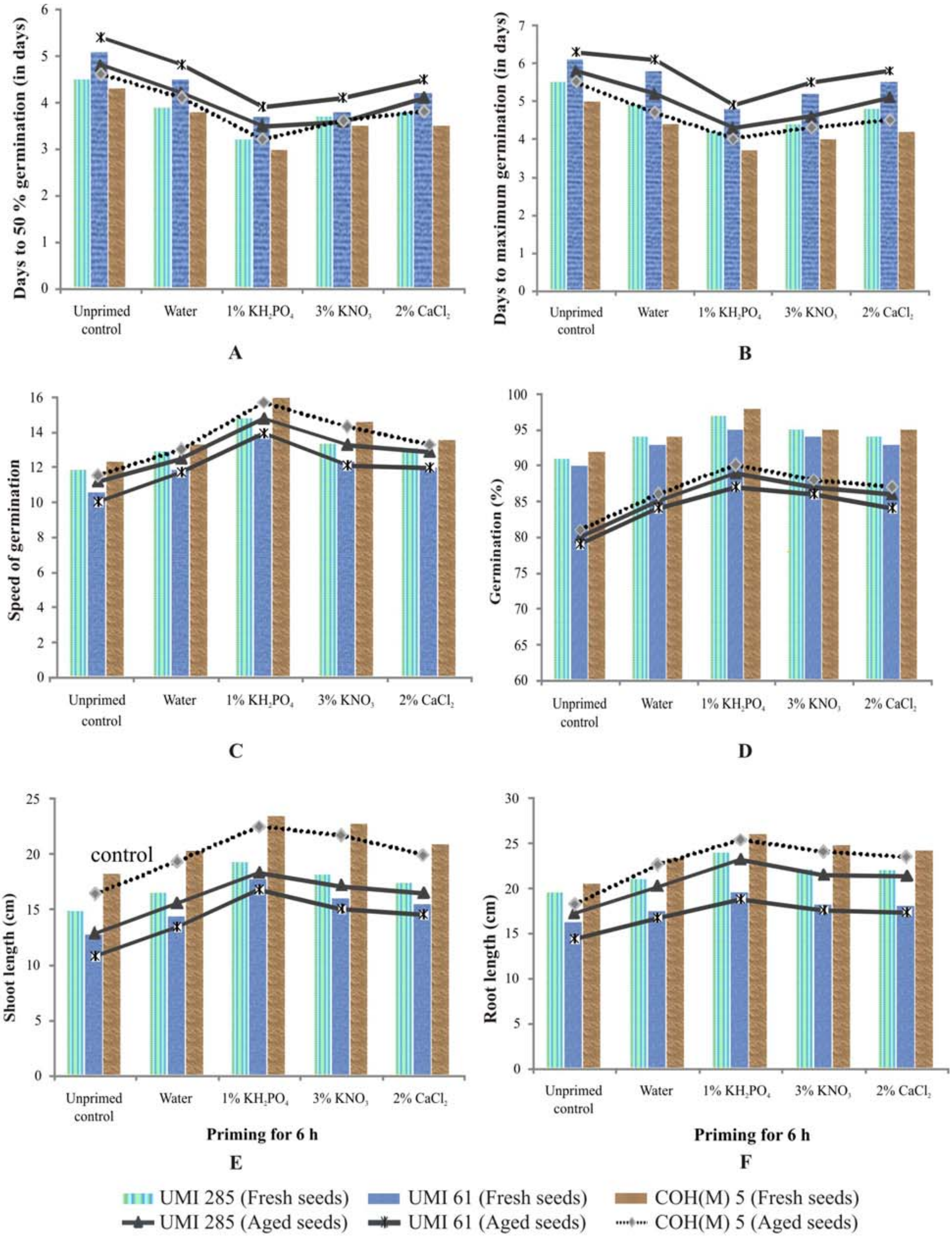

Fig. 1. Effect of seed priming treatments on days to 50 % germination (A), days to maximum germination (B), speed of germination (C), Germination (D), shoot length (E) and root length (F) of fresh and aged seeds of maize hybrid COH (M) 5 and its parental lines UMI 285 and UMI 61.

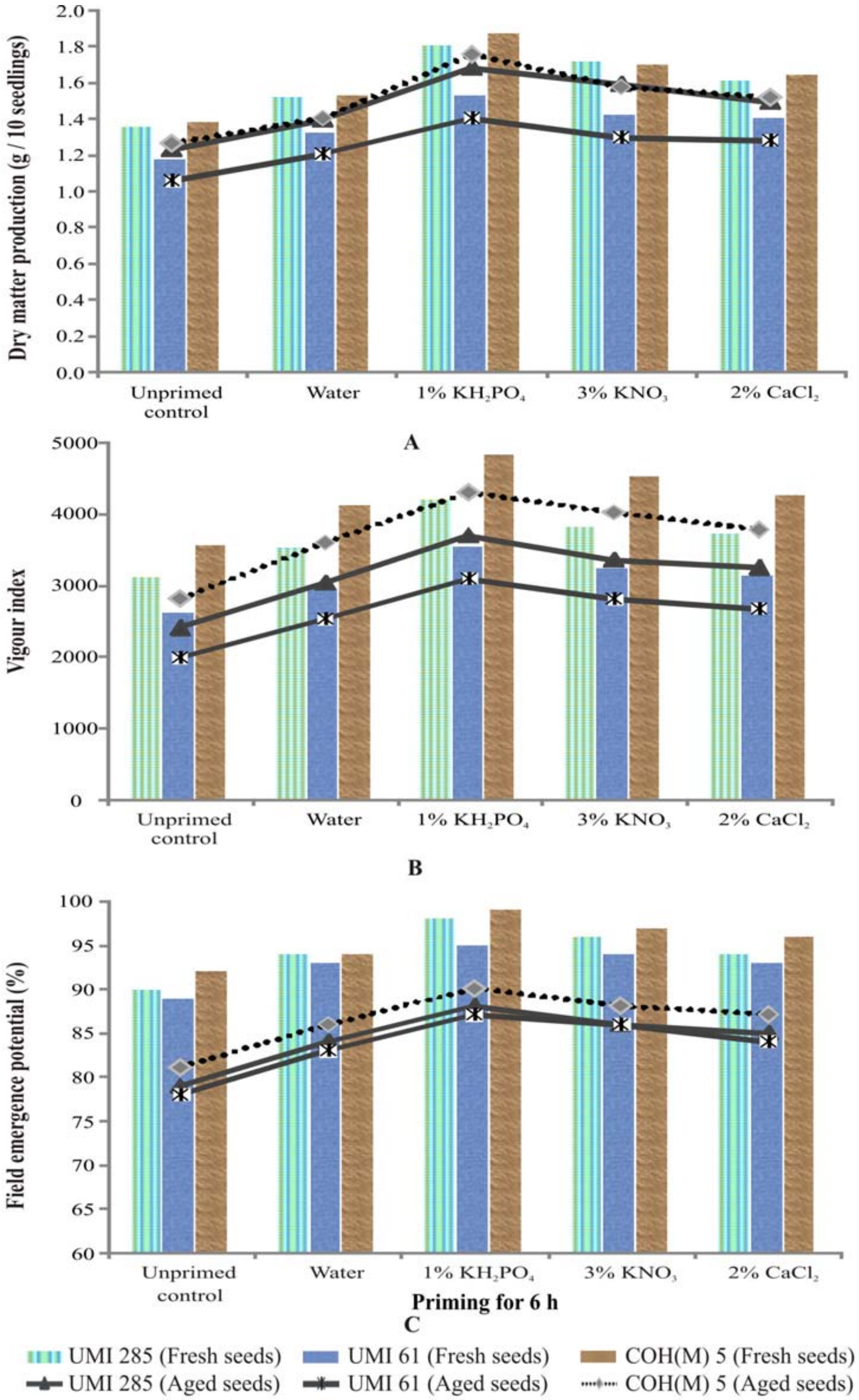

Fig. 2. Effect of seed priming treatments on dry matter production (A), vigour index (B) and field emergence potential (C) of fresh and aged seeds of maize hybrid COH (M) 5 and its parental lines UMI 285 and UMI 61.