Mavi (2018).
Seed Science and Technology, **46**, 1, 131-137.
https://doi.org/10.15258/sst.2018.46.1.13

Research Note

Evaluation of organic priming to improve the emergence performance of domesticated *Capsicum* species

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(Submitted October 2017; Accepted February 2018; Published online February 2018)

Abstract

Domesticated pepper species are important for breeders in that they can provide higher yields, improved fruit quality, resistance to abiotic and biotic stress, and heartier rootstocks. The aim of this study was to determine the effects of organic priming on germination and seedling emergence of five domesticated *Capsicum* species. The seeds of all pepper species were sown in Petri dishes for germination testing and peat moss for emergence testing. Seeds were primed at 25°C for 24 hours before sowing for emergence testing. The *Capsicum* species had different germination and emergence percentages, while other traits did not vary. Primed seeds produced larger seedlings with greater fresh and dry weight for all species. It can be concluded that priming may be used to enhance pepper seedling performance, especially for *Capsicum chinense* (cv. Habanero) which showed lower emergence.

Keywords: germination, marigold, organic priming, pepper, seedling quality, seed treatment, vigour index

Experimental and discussion

The genus *Capsicum* consists of 36 species that are found in temperate regions throughout the world (Russo, 2012). There are five cultivated, summer vegetable species which are used as a spice and for flavour and nutrition, commonly known as “Chili” or “Aji” in South America and “pepper” in Europe and Asia.

In addition to the cultivated species, many wild *Capsicum* species have been described by plant breeders as useful material for the genetic improvement of cultivated peppers. These genetic materials present an opportunity to domesticate, breed and cultivate novel pepper varieties with high commercial potential. Depending on the objectives, *Capsicum* breeding involves selection for criteria such as high yield, degree of pungency, fruit types, colour, size, shape and pericarp thickness, as well as disease resistance (Pickersgill, 1997). Wild species of *Capsicum* also serve as an excellent source of useful genes. These genes have been transferred by interspecific hybridisation from species to species (Pickersgill, 1997), particularly from *C. baccatum* to *C. chinense* and *C. annuum* (Manzur *et al*., 2015).

These species, used in plant breeding (Pickersgill, 1997), are also very important for low temperature tolerance (Randle and Honma, 1980), disease resistance (Mahasuk *et al*., 2013), salt tolerance and graft compatibility (Penella *et al*., 2015). The most serious problem in these species is insufficient and uneven seedling emergence. High and uniform emergence percentage is required of both the parent species and related hybrids.

Some reports on domesticated and wild species of *Capsicum* have shown that the germination and emergence performance varies depending on seed development (Demir and Ellis, 1992; Eken and Mavi, 2016), dormancy (Randle and Honma, 1981), temperature (Randle and Honma, 1980), storage (Panayotov and Aladjadjiyan, 2014) and germination (Garcia *et al*., 2010; Lopez-Espena *et al*., 2017). Priming has been used to increase the seed quality for different pepper species and seed lots (Garruna-Hernandez *et al*., 2014; Andrade and Laurentin, 2015; Mavi, 2016). Organic priming, using various plant extracts which contain phytochemical(s) that inhibit the development of some diseases in growth medium, also resulted in higher seedling efficacy than hydropriming in eggplant (Mavi, 2014).

The objectives of this study were to (i) determine germination and emergence traits; and (ii) compare the effects of organic priming on emergence percentage and seedling performance for cultivars of five domesticated Capsicum species.

Five seed lots of domesticated pepper (*Capsicum annuum* cv. Sera demre, *C. baccatum* cv. MKU 19, *C. chinense* cv. Habanero, *C. frutescens* cv. MKU 52 and *C. pubescens* cv. Rocoto), were produced at Mustafa Kemal University. Fruits of these lots were harvested when they reached physiological maturity (red colour for 'Sera demre', 'MKU 19' and 'MKU 52', yellow for 'Rocoto', orange for 'Habanero'). Seeds are cream-coloured, apart from *C. pubescens* which has black seeds. Harvested seeds were stored at 5°C until the experiment was completed. An initial germination test was performed with four replicates of 25 seeds each. The seeds were placed on 200 × 200 mm moistened germination paper for 14 days at 25°C. Seeds were considered germinated when the radicle had emerged by 2 mm. The germination index (GI) and mean germination time (MGT) were calculated based on Maguire (1962), and Ellis and Roberts (1980), respectively. Germination vigour index (GVI) was calculated as MGT × GI. Dried petals (4 g) of marigold (*Tagetes patula* L.) were heated in 1000 ml of distilled water to boiling and then allowed to cool. This herbal tea was used as an organic priming solution. The seeds were primed on the filter paper moistened with 30 ml of the herbal tea in 150 mm-diameter Petri dishes, and kept at 25°C for 72 hours, in the dark (Mavi, 2016). After organic priming, they were washed with distilled water and used after surface drying.

For each species, four replicates of 50 primed and unprimed seeds were sown at a depth of 10 mm in peat moss packed into plastic boxes (300 × 190 × 60 mm, L × W × D). Emergence tests were performed inside a growing chamber at 23 ± 2°C for 24 days. Emergence was recorded daily. Seedlings were considered to be emerged when the hypocotyl hook was seen on the compost surface. The emergence index (EI) and mean emergence time (MET) were calculated according to Maguire (1962) and Ellis and Roberts (1980), respectively. Emergence vigour index (EVI) was also calculated as MET × EI. After seedling emergence had finished, destructive harvesting was performed on 21 randomly selected, normally grown seedlings of each treatment to determine seedling length (SL), fresh weight (SFW) and dry weight (SDW). Fresh and dry (under 80°C for 24 hours) seedling weights were recorded in units of mg per plant. *C. baccatum* seedlings could easily be distinguished from other species, since they have some undetermined phytochemicals in their leaves. In addition, the seedlings of *C. pubescens* differ from other species, such that they have hairy leaves while the other domesticated species have smooth leaves.

Data analysis was conducted using SPSS software. Percentages were arcsine transformed prior to analysis; the untransformed data is presented. Duncan's multiple range test was used to determine statistical significance with $P \leq 0.05$ for each domesticated species. Pearson correlation was used for MGT, GI, GVI and EP.

A higher germination percentage was obtained for *C. frutescens* ('MKU 52') and *C. baccatum* ('MKU 19') compared with *C. annuum* ('Sera Demre'), *C. chinense* ('Habanero') and *C. pubescens* ('Rocoto') seeds (figure 1). Mean germination time for three out of five species was quite similar and relatively quick (135-143 hours). In contrast, *C. chinense* and *C. pubescens* had a higher MGT, 214 and 252 hours, respectively. The highest germination index was recorded in *C. baccatum* and *C. frutescens*, reaching 4.09 and 4.03, respectively. However, the lowest GI was recorded in *C. pubescens*, reaching 0.50. The GVI was the highest in *C. frutescens* (372) and *C. baccatum* (350), similar to the other germination characters (GP, MGT and GI). *C. pubescens* seeds had the lowest GVI (8).

Unprimed seeds differed in emergence percentage. While EP of *C. frutescens* was the highest, EP of *C. pubescens* was the lowest (figure 2). There was no significant difference in EP between primed and unprimed seeds except for *C. chinense*. Unprimed seeds had 49% emergence, while primed *C. chinense* seeds had 71% emergence. In unprimed seeds, MET ranged from 242 hours in *C. baccatum* to 384 hours in *C. pubescens*. Organic priming shortened MET. MET was significantly lower for primed seeds in all species tested ($P < 0.05$).

Differences in EI, EVI, SL, SFW and SDW were significant (table 1). The EI, EVI, SL, SFW and SDW showed similar tendencies as SE. However, this similarity was not evident for *C. pubescens*, since *C. pubescens* had a very low EP. For EVI, both primed and unprimed seeds of *C. frutescens* showed superior results in comparison with the other genotypes, except for primed *C. baccatum* seeds. SL, SFW and SDW were significantly greater for primed seeds in all genotypes. Seeds of *C. chinense*, both unprimed and primed, performed the worst. Although primed seeds of *C. annuum*, *C. frutescens* and *C. baccatum* gave similar and high SFW and SDW, *C. chinense* had the lowest SFW and SDW. Organic-primed seeds of *C. chinense* were significantly better than unprimed seeds.

Mean germination time, GVI and GI were more strongly correlated with EP for unprimed seeds (r = -0.878, 0.934 and 0.938, respectively; $P < 0.05$) than for primed seeds (-0.765, 0.786 and 0.807, respectively; $P <$ not significant), when all of the species were analysed together (n-2 = 3). Priming improves seed lot quality. This improvement is due to the fact that irregular germination and emergence become more regular with the priming effect. This phenomenon was also shown in a previous study (Ermiş *et al.*, 2016).

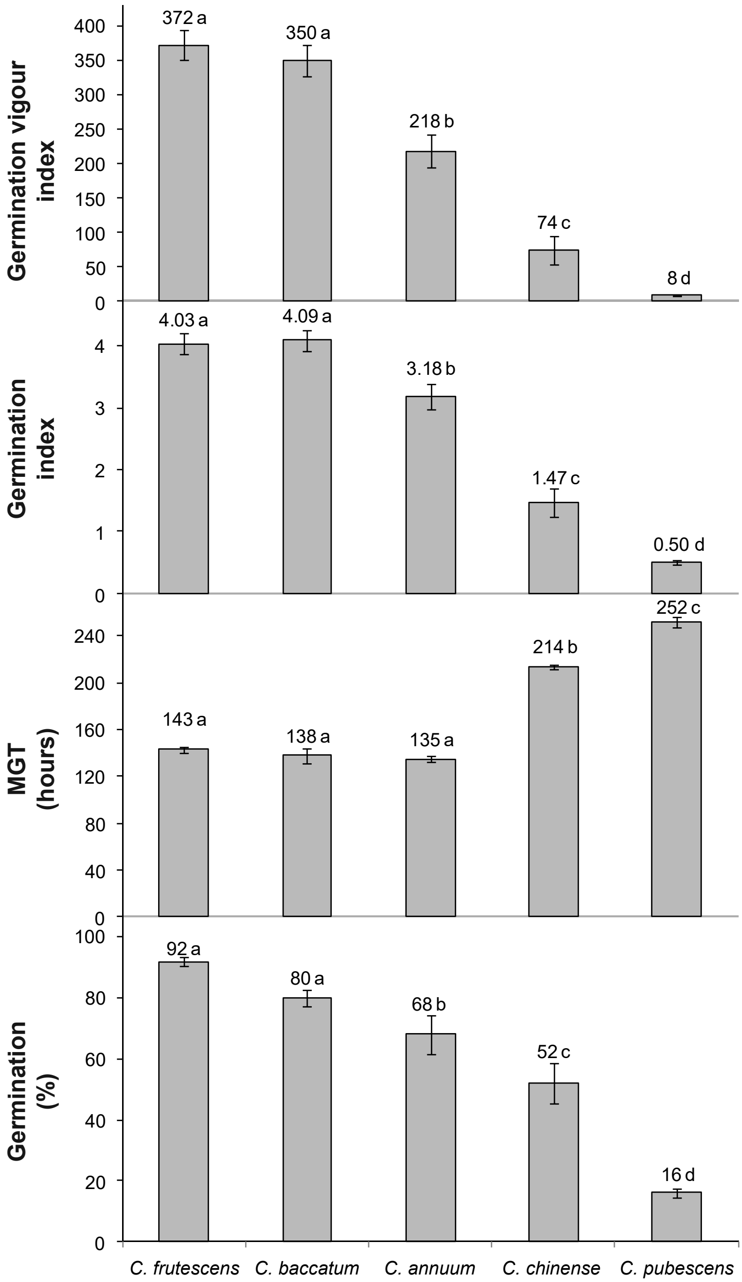

Figure 1. Seed germination (GP), mean germination time (MGT), germination index (GI) and vigour index (GVI) of seed lots of five pepper species. Within each graph, different letters indicate a statistically significant difference ($P < 0.05$).

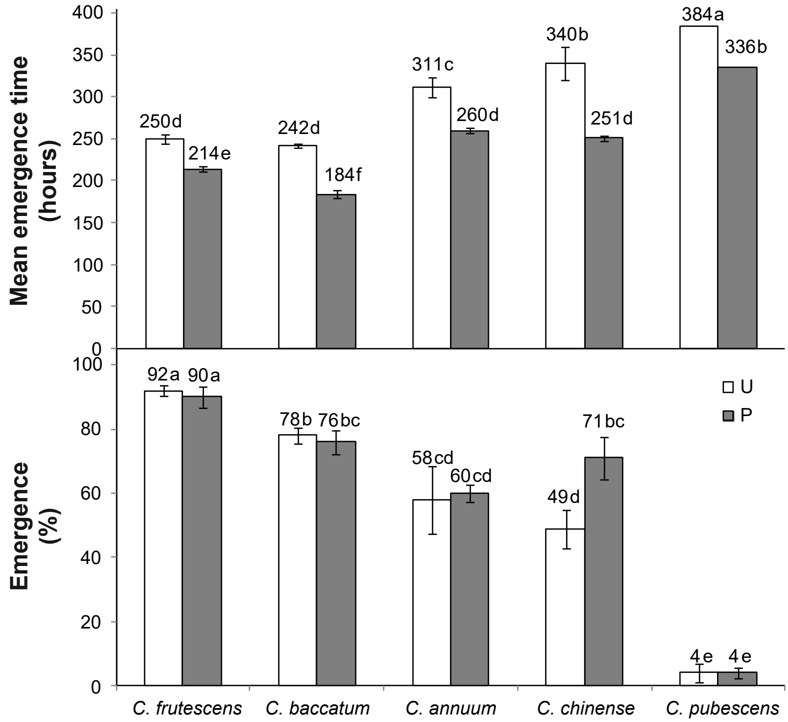

Figure 2. Emergence and mean emergence time (MET) of unprimed (□) and primed (■) seed lots of five pepper species. Within each graph, different letters indicate a statistically significant difference ($P < 0.05$).

Table 1. Characteristics of seedling emergence of primed and unprimed seeds in domesticated pepper species. Different letters in the same column show statistical significance ($P < 0.05$).

Species	Treatment	Emergence index	Emergence vigour index	Seedling length (mm)	SFW (mg)	SDW (mg)
C. annuum	U	1.16 ef	74 cd	20 c	61 b	5.1 b
C. annuum	P	1.40 de	84 cd	31 b	130 a	9.9 a
C. frutescens	U	2.28 bc	210 a	31 b	74 b	5.6 b
C. frutescens	P	2.54 ab	229 a	42 a	145 a	11.5 a
C. baccatum	U	1.98 c	155 b	29 b	70 b	5.1 b
C. baccatum	P	2.76 a	210 a	40 a	134 a	10.3 a
C. chinense	U	0.92 f	47 d	12 d	19 c	1.4 c
C. chinense	P	1.55 d	111 c	22 c	70 b	6.4 b

U = unprimed; P = primed.

Germination problems, especially poor and non-uniform emergence, are repeatedly observed in transplanted or direct-sown pepper seeds. Randle and Honma (1981) showed that germination varied between species, with some of them having good germination (*C. annuum* and *C. frutescens*) and some of them poor germination (*C. microcarpum* and

C. chacoense), similar to the present study. Others have also reported low germination for some pepper species (Federico *et al*., 2010). Germination varied among 16 accessions of *C. annuum* var. *glabriusculum* (0 to 66%) with an average of 15% (Cano-Vazquez *et al*., 2015).

If seed lots are high quality, with a high germination and emergence percentage, then priming is not likely to improve the emergence percentage very much, as seen for *C. baccatum* and *C. frutescens*. However, the advantage of organic priming was more prominent in *C. chinense* cv. Habanero seeds with low germination and emergence percentages. Andrade and Laurentin (2015) have shown the most positive effect of priming in the *C. chinense* cv. Pepon cultivar. They observed 48% cumulative germination in unprimed seeds and 68% cumulative germination in primed seeds. Ermiş *et al.* (2015) showed similar results in twelve seed lots of pepper (*C. annuum* cv. Sera Demre).

Our results concerning germination and emergence characteristics share similarities with previous studies for other species such as *C. annuum* (Demir and Ellis, 1992), *C. baccatum* (Eken and Mavi, 2016; Mavi 2016), *C. frutescens* (Sundstrom *et al*., 1987) and *C. chinense* (Garruna-Hernandez *et al*., 2014; Andrade and Laurentin, 2015). No previous data was found about the germination and emergence of *C. pubescens* seeds. Although seed germination percentage has been found to be relatively similar within some genera and families, there are previous reports of highly variable seedling emergence performance among related species.

Mean germination time is considered a predictor of seedling emergence and establishment in pepper (Demir *et al*., 2008), in that strong correlation has been observed between MGT and EP in pepper species.

The especially low emergence percentage of *C. pubescens* should be studied further. The pollen viability of *C. pubescens* is very low compared with other domesticated species (Monteiro *et al*., 2011). Pollen viability can affect the seed set and seed viability. Hence, comprehensive studies concerning *C. pubescens* should be performed.

Organic priming was found to be more influential on low emerged seed lots of *C. chinense*, but mean emergence times were equally influenced in all species. Organic priming is cheap, easy, simple and effective; it could become a standard practice used to enhance the emergence of pepper seeds (Mavi, 2016). The repair mechanism of priming was shown in previous works by Sunstrom *et al*., 1987; Garcia *et al*., 2010; Garruna-Hernandez *et al*., 2014; Andrade and Laurentin, 2015.

In conclusion, cultivars of domesticated Capsicum species have different germination and emergence percentages. Moreover, seedling emergence can be enhanced by organic priming in *C. chinense* cv. Habanero. The reason for low germination of *C. pubescens* cv. Rocoto is still unclear. Therefore, this point should be investigated with additional techniques such as dormancy breaking treatments.

Acknowledgements

This research was funded by the Scientific Research Project Directorate of the University of Mustafa Kemal (BAP project number 248).

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