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Short Communication

Field performance of cultivars of okra (*Abelmoschus esculentus*) under cultivar-specific seed priming

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Okra [*Abelmoschus esculentus* (L.) Moench] also known as lady's finger, belonging to the family Malvaceae, is grown for its tender fruits throughout the regions of Asia, Africa and America. Wider adaptability (tropical to temperate), round the year availability, good economic return and rich nutritional quality (fibre, folate, xanthophylls, calcium and magnesium) have rendered the choicest vegetable to the growers as well as consumers world wide (Ndaeyo *et al*. 2007). India occupies first rank in acreage (5 00 000 ha), production (6 000 000 tonnes) and the productivity (12 tonnes/ha) in the world (FAO 2014). Sub-optimal plant population caused by poor and erratic seed germination is one of the major factors responsible for its low productivity in India. One of the serious problems in okra, is delayed and erratic seedling emergence which in turn poses problems in synchronized germination, fertilizer utilization, post-emergence weed control and uniform harvesting.

Seed priming has been proved to be an important strategy to improve germination rate and seedling uniformity, thereby, facilitating maintenance of optimal plant population (Nascimento and Pereira 2007). We have earlier reported the comparison of various seed priming methods on okra cv. Hisar Unnat (Sharma *et al*. 2014). On the basis of the encouraging results in previous report, for present study, we choose three most popular cultivars of okra, i.e. A-4, Phule Utkarsha and VRO-6, popularly grown in northern, southern and eastern part of India, respectively, to standardize the effective priming treatments for improving their yield performance in the field.

The study was conducted in Laboratory and at Research Farm of National Bureau of Plant Genetic Resources (NBPGR), New Delhi, for two consecutive years. Freshly harvested seeds of okra cv. A-4, Phule Utkarsha and VRO-6 were procured from Indian Agricultural Research Institute, Research Station, Karnal, Haryana; Mahatma Phule Krishi Vidyapeeth, Rahuri; Maharashtra and Indian Institute of Vegetable Research, Varanasi; Uttar Pradesh, India, respectively. The seeds of each cultivar were divided into nearly equally 19 lots; each lot comprised of 900-1 000 seeds and subjected to various priming treatments (Table 1). The treated seeds were air-dried to achieve about 8% moisture content and packed in laminated three layered aluminium foil pouches (20 × 16 cm with a 12 μm outer layer of polyester, 12 μm middle layer of aluminium and 70 μm inner layer of polyethylene) and stored in medium-term storage module at 4^0C and 30 ± 2% relative humidity, until further used. Fifty seeds of each cultivar were sown between two germination papers (AXIVA, India) and incubated in a seed germinator (SANCO, India) in dark at constant temperature (25^0C). All the germination experiments were replicated 4 times and each replicate comprised of 50 seeds. Thus, the observations are based on a total of 200 seeds for each cultivar and each treatment (Table 1). Seeds were considered germinated if radicle protruded (at least 2 mm) through the seed coat. The final germination percentage was calculated on the 7^{th} day of seed sowing in laboratory conditions (ISTA 1985). For seedling vigour, 10 seeds/replicate of each cultivar were sown in 5 replicates between germination papers and maintained in a germinator (SANCO, India) for 7 days at a constant temperature (25 ± 2^0C). The root and shoot vigour were calculated as the sum of total root length (cm) and shoot length (cm) of all the seedlings of a replicate divided by 10. The seedling vigour was calculated as the average sum of root length and shoot length (Srinivasan and Saxena 2007) while seedling vigour index was calculated as the product of seedling vigour (root length and shoot length) and germination percentage (Abdul-Baki and Anderson 1973).

For field evaluation of all three cultivars, we used seeds treated with selected priming agents on the basis of highest vigour index; seeds with five priming treatments of each

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Table 1 Priming treatments applied to seeds of okra cv. A-4, Phule Utkarsha and VRO-6

Seed priming code	Duration (hr)	Treatment substrate	Concentration
Control			
Hydro-6	6	Distilled water	
Hydro-12	12	Distilled water	
Hydro-18	18	Distilled water	
Osmo-24-1	24	Polyethylene glycol (PEG-6000)	13.5% (-0.25 MPa)
Osmo-48-1	48	Polyethylene glycol (PEG-6000)	13.5% (-0.25 MPa)
Osmo-24-2	24	Polyethylene glycol (PEG-6000)	20.2% (-0.50 MPa)
Osmo-48-2	48	Polyethylene glycol (PEG-6000)	20.2% (-0.50 MPa)
Osmo-24-3	24	Polyethylene glycol (PEG-6000)	25.2% (-0.75 MPa)
Osmo-48-3	48	Polyethylene glycol (PEG-6000)	25.2% (-0.75 MPa)
Halo-6-1	6	Calcium chloride	1.00%
Halo-12-1	12	Calcium chloride	1.00%
Halo-18-1	18	Calcium chloride	1.00%
Halo-6-2	6	Potassium nitrate	2.00%
Halo-12-2	12	Potassium nitrate	2.00%
Halo-18-2	18	Potassium nitrate	2.00%
SM-24	24	Calcium aluminium silicate	1 : 0.4 : 1 (Seed : SM: Water)
SM-48	48	Calcium aluminium silicate	1 : 0.4 : 1 (Seed : SM: Water)
SM-72	72	Calcium aluminium silicate	1 : 0.4 : 1 (Seed : SM: Water)

Method for Hydropriming (Harris *et al*. 2001), Osmopriming (Michael and Kaufman 1973), Halopriming with calcium chloride (Kulkarni and Eshanna 1988) and potassium nitrate (Afzal *et al*. 2002) and Solid matrix priming (Khan 1992) were used.

cultivar (bold faced values of vigour index) were selected along with control (Table 2). The experimental field was divided into 54 plots; each measuring 2.25 m × 2.10 m. Soil was intermixed with farmyard manure (FYM) @ 8 tonnes/ha before sowing of seeds. A total of 100 seeds were sown in each plot for seedling emergence count (until seedling established became stable). By thinning after 15 days of sowing, 35 plants/plot were maintained at spacing of 45 cm × 30 cm for further recording of data. Soil was enriched with 100 kg nitrogen, 60 kg phosphorus and 60 kg potassium per hectare. Full dose of phosphorus and potassium and one-third dose of nitrogen were applied as basal dose before sowing. Remaining two-third nitrogen was applied in two split doses as top dressing at 30 and 60 days after sowing. The experiment was conducted for two consecutive years in randomized block design; each treatment was replicated 3 times in each year. Seedling emergence (%) was recorded before thinning on the basis of 300 seeds in each year, after 15 days of sowing. Data on days to flower (first flower appearance), days to marketable fruits, Number of fruits/plant and fruit length (cm) and fruit yield/plot (kg) were recorded after 7-8 days of flowering in each year.

All data were analysed statistically using SPSS software (version 16.0). Two years data recorded on physiological and field evaluation, were pooled together for statistical analyses. The data recorded as percentage were transformed to the respective angular (arcsine) values before subjecting them to statistical analyses. Differences in mean values due to treatments were compared by applying Duncan's multiple range test (DMRT) at 5% probability.

Priming influenced seed germination and plant growth which contributed directly or indirectly in better yield performance in field. Another important factor which effects the performance in the field is interaction of genotype and environment. To find out best response of three most popularly grown cultivars in different okra growing areas in India, three cultivars, viz. A-4, Phule Utkarsha and VRO-6 were subjected to various priming treatments to assess their field performance. The details of data on seed germination, seedling vigour and vigour index are presented in Table 2. The priming treatments influenced the seed germination in okra cultivars. No single treatment was found effective to increase the seed germination in all three cultivars tested. Highest seed germination was recorded in cv. Phule Utkarsha (97.3%) in osmoprimed seeds with 20.2% PEG 6000 for 24 hr (osmo-24-2), whereas seeds of cv. VRO-6 hydroprimed for 18 hr (hydro-18) showed maximum germination (95.3%) (Table 2). In comparison to the control, significantly higher seedling vigour was observed in osmoprimed (osmo-24-1) and haloprimed (halo-6-1) seeds of cv. A-4 and VRO-6, respectively. Regarding the vigour index, it was registered highest in hydroprimed (hydro-18) seeds of cv. A-4, osmoprimed (osmo-24-2) or haloprimed (halo-6-1) seeds of cv. VRO-6.

Priming improved uniform seed germination and seedling establishment in various crops (Jisha *et al*. 2013). In the present study, the initial seed germination and seedling vigour were significantly improved by priming treatments in comparison to control seeds. Seed germination increased significantly in osmoprimed seeds of cv. Phule Utkarsha and hydroprimed seeds of cv. VRO-6 over the initial germination of control seeds. Seedling vigour increased significantly in hydroprimed seeds and haloprimed seeds of cv. A-4 and VRO-6, respectively. For higher vigour index, hydropriming for cv. A-4 and osmopriming for cv. VRO-6 were found best among all the treatments. Not only in vegetable crops, e.g. for eggplant and radish (Rudrapal and Nakamura 1998), okra (Sharma *et al*. 2014) but also in several other field crops, e.g. wheat (Kahlon *et al*. 1992), rice (Farooq *et al*. 2006), maize (Ajirloo *et al*. 2013) hydropriming was found beneficial for increasing seed germination and vigour index. Osmopriming (PEG 10%) was reported to increase the seed germination and seedling vigour in wheat (Lemrasky *et al*. 2012). Similarly, halopriming ($CaCl_2$) was also effective for wheat (Afzal *et al*. 2008). It was also noted that besides the priming agent

Table 2 Effects of seed priming treatments on germination, seedling vigour and vigour index in seeds of okra cultivars

Seed priming code	A-4			Phule Utkarsha			VRO-6		
	G (%)	SV	VI	G (%)	SV	VI	G (%)	SV	VI
Control	88.0^{a}	23.1^{gh}	**2031.0^{de}**	93.3^{abcd}	36.5^{a}	**3407^{abc}**	86.0^{cd}	27.3^{i}	**2348.0^{fg}**
Hydro-6	82.7^{bc}	32.5^{b}	2686.0^{b}	85.3^{fg}	30.5^{e}	2603^{e}	88.0^{bc}	33.7^{bc}	**2968.0^{b}**
Hydro-12	84.0^{abc}	29.4^{c}	2469.0^{c}	93.3^{abcd}	35.6^{ab}	**3327^{abc}**	89.3^{bc}	30.8^{ef}	2755.0^{c}
Hydro-18	84.7^{abc}	38.0^{a}	**3212.0^{a}**	88.0^{efg}	33.7^{bcd}	2964^{d}	95.3^{a}	21.6^{k}	2058.0^{hi}
Osmo-24-1	77.3^{de}	27.5^{cd}	2126.0^{d}	95.3^{abc}	35.9^{a}	**3472^{ab}**	90.7^{b}	27.5^{hi}	2495.0^{ef}
Osmo-48-1	85.3^{abc}	29.1^{c}	**2485.0^{c}**	86.0^{fg}	30.4^{e}	2619^{e}	78.7^{b}	27.2^{i}	2141.0^{hi}
Osmo-24-2	72.0^{f}	26.4^{def}	1897.0^{ef}	97.3^{a}	32.9^{d}	3206^{bcd}	82.0^{ef}	35.1^{b}	**3190.0^{a}**
Osmo-48-2	54.0^{h}	22.6^{gh}	1223.0^{hi}	76.0^{h}	32.9^{d}	2502^{ef}	70.0^{g}	20.0^{l}	1398.0^{j}
Osmo-24-3	80.7^{cd}	21.9^{h}	1765.0^{fg}	94.7^{abc}	35.2^{abc}	3330^{abc}	90.7^{b}	11.5^{m}	1039.0^{k}
Osmo-48-3	75.3^{ef}	27.0^{cde}	2034.0^{de}	92.0^{bcde}	28.8^{e}	2646^{e}	82.7^{de}	32.5^{cde}	2686.0^{cd}
Halo-6-1	64.7^{g}	24.9^{efg}	1608.0^{g}	94.7^{abc}	33.4^{cd}	**3166^{cd}**	91.3^{b}	38.9^{a}	**3202.0^{a}**
Halo-12-1	84.7^{abc}	32.1^{b}	**2719.0^{b}**	88.7^{def}	33.8^{bcd}	2993^{d}	91.3^{b}	32.8^{cd}	2994.0^{b}
Halo-18-1	67.3^{g}	24.3^{fgh}	1634.0^{g}	84.7^{fg}	30.4^{e}	2577^{e}	72.0^{g}	31.1^{def}	2237.0^{gh}
Halo-6-2	76.0^{def}	18.3^{i}	**1392.0^{h}**	88.0^{efg}	33.4^{cd}	**2941^{d}**	88.7$_{bc}$	24.3^{j}	**2154.0^{hi}**
Halo-12-2	56.0^{h}	15.9^{j}	892.8^{k}	84.0^{fg}	28.7^{e}	2411^{ef}	87.3$_{bc}$	23.3^{j}	2031.0^{i}
Halo-18-2	76.7^{def}	13.1^{k}	1003.0^{jk}	88.0^{efg}	25.6^{f}	2250^{fg}	61.3$_{h}$	18.5^{l}	1133.0^{k}
SM-24	86.0^{ab}	14.3^{jk}	1228.0^{hi}	91.3^{cde}	36.9^{a}	3367^{abc}	91.3$_{b}$	29.6^{fg}	**2698.0^{cd}**
SM-48	83.3^{abc}	28.2^{cd}	**2345.0^{c}**	96.7^{ab}	37.1^{a}	**3535^{a}**	86.0$_{cd}$	29.0^{gh}	2493.0^{ef}
SM-72	72.7^{ef}	15.6^{j}	1134.0^{ij}	83.3^{g}	25.4^{f}	2117^{g}	82.0$_{ef}$	31.4^{de}	2570.0^{de}

G- Germination, SV-Seedling vigour, VI-Vigour Index (bold faced value treatments were selected for biochemical analyses and field performance. Values are rounded off to nearest integer up to one place of decimal values superscripted with different letter in same column are significantly different at $P \leq 0.05$ (DMRT).

the duration and concentration of the same also influenced seed germination and vigour differently in different cultivars.

The realistic beneficial effects of priming the seeds in laboratory can be realized only if priming treatments are equally effective to the seeds to improve their yield performance in field conditions. Observation of as many as 16 agro-morphological traits were recorded but data of only 6 parameters, viz. field emergence (%), days to first flowering, days to marketable fruit yield, number of fruits/plant, fruit length and fruit yield/plant are presented and discussed. It is evident from the data presented in Table 3 that overall enhancement of field emergence was observed in all the three cultivars but effective treatments were cultivar-specific. Significant increase in field emergence, days to first flowering and marketable fruit, number of fruits/plant, fruit length and fruit yield/plot was influenced due to priming of seeds in all the cultivars as compared to controls. Field emergence significantly increased in primed seeds in all cultivars due to different priming treatments upto 90% from 68.77% in control. Number of days to first flower and days to marketable fruit decreased whereas number of fruits/plant, fruit length and fruit yield/plot increased significantly (Table 3). It is equally important to note that no single treatment was found beneficial for all three cultivars of okra to enhance the yield or other yield contributing traits. Priming treatment specificity was observed for each cultivar. For cv. A-4, hydropriming for 18 h was adjudged best as the marketable fruits are available 6 days earlier and yield could be enhanced up to 104%, as compared to control. Seed priming with calcium aluminium silicate for 48 h (SM-48) for cv. Phule Utkarsha and halopriming with 1% calcium chloride for 6 h (halo-6-1) for cv. VRO-6 were found beneficial to decrease the days for marketable fruit by 4-5 days and enhance the yield up to 42% and 20%, respectively. Cultivar–specific effects of priming were reported in wheat (Toklu *et al*. 2015) and rice (Esmeili and Heidarzade 2012).

The effects on enhanced field emergence in all three cultivars can be correlated with increased number of fruits/plant, fruit length and fruit yield/plot (Table 3). Better emergence of seedlings from seeds subjected to different treatments for various durations suggests that specific priming duration ensures optimum plant establishment. Rapid and synchronous field emergence of seedlings are two important pre-requisites to increase yield (Finch-Savage 1995). Highly significant positive effects on yield and yield components was reported by Seyed *et al*. (2012) reported in soybean. Beneficial effects of hydropriming on seedling emergence, biological yield and grain yield per unit area have also been reported by Kahlon *et al*. (1992) in wheat, Bastia *et al*. (1999) in safflower and Hussain *et al*. (2006) in sunflower.

Cultivar-specificity of the priming agents and duration of treatment was observed for best field performance in okra cultivars. Based on the results, we reached to the conclusions: (i) cultivar-specific priming treatment (agent and duration of treatment) should be optimized for enhancing field performance of cultivars of okra, (ii) hydropriming for 18 hr for cv. A-4, halopriming with 1% Calcium chloride for 6 hr for cv. VRO-6 and SM priming with calcium aluminium silicate (1:0.4:1; Seed:SM:Water) for 48 hr for cv. Phule

Table 3 Effects of priming treatments on field emergence of seeds, days to first flowering, days to marketable fruit, number of fruits/plant, fruit length and fruit yield in seeds of okra cv. A-4, Phule Utkarsha and VRO-6

Seed priming code	Field emergence (%)	Days to first flowering	Days to marketable fruit	Number of fruits/plant	Fruit length (cm)	Fruit yield/ plot (kg)
A-4						
Control	72.7^{c}	45.0^{a}	51.0^{a}	14.8^{e}	7.6^{e}	5.0^{e}
Hydro-18	81.6^{a}	37.8^{d}	44.5^{d}	22.6^{a}	10.9^{a}	10.2^{a}
Osmo-48-1	72.5^{c}	42.3^{b}	48.7^{b}	15.7^{d}	9.6^{d}	6.5^{c}
Halo-12-1	75.8^{b}	40.2^{c}	46.8^{c}	16.2^{c}	9.4^{d}	5.9^{d}
Halo-6-2	75.3^{b}	38.5^{d}	45.2^{d}	19.4^{b}	9.9^{c}	7.3^{b}
SM-48	75.2^{b}	42.0^{b}	48.7^{b}	15.8^{cd}	10.3^{b}	6.3^{c}
Phule Utkarsha						
Control	77.7 ^{c}	40.3^{a}	47.0^{a}	16.2^{d}	10.6^{cd}	6.7^{e}
Hydro-12	79.5^{bc}	40.2^{a}	46.5^{a}	16.1^{d}	11.5^{b}	7.2^{c}
Osmo-24-1	79.3^{bc}	40.5^{a}	47.0^{a}	18.8^{b}	11.6^{b}	7.7^{b}
Halo-6-1	80.3 ^{b}	39.5^{a}	46.2^{a}	18.8^{b}	10.3^{d}	7.7^{b}
Halo-6-2	79.2^{bc}	37.7^{b}	44.5^{b}	17.6^{c}	10.7^{c}	7.0^{d}
SM-48	90.0^{a}	36.7^{b}	43.0^{c}	19.7^{a}	12.8^{a}	9.5^{a}
VRO-6						
Control	68. 5^{e}	40.7^{a}	47.5^{a}	14.9^{b}	9.8^{d}	5.8^{b}
Hydro-6	78.3^{b}	36.7^{b}	42.8^{b}	14.5^{c}	10.2^{c}	5.6^{bc}
Osmo-24-2	71.8^{d}	36.0^{b}	42.2^{b}	14.5^{c}	9.7^{d}	5.1^{d}
Halo-6-1	89.9^{a}	36.3^{b}	43.2^{b}	17.0^{a}	11.6^{a}	6.9^{a}
Halo-6-2	75.0^{c}	37.3^{b}	43.7^{b}	13.6^{d}	10.3^{bc}	5.4^{c}
SM-24	73.5^{cd}	36.3^{b}	43.2^{b}	14.0^{d}	10.5^{b}	5.7^{bc}

Values are rounded off to nearest integer up to one place of decimal. Values superscripted with different letter in same column for each cultivar are significantly different at $P \leq 0.05$ (DMRT).

Utkarsha were found beneficial and the yield could be increased significantly up to 104%, 42% and 20%, respectively, and (iii) the optimum priming treatment as discussed above can be recommended to achieve significantly increased yield of okra in various regions (northern, southern and eastern) of India and similar environments in other countries.

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SUMMARY

Seeds of three cultivars of okra (cv. A-4, Phule Utkarsha and VRO-6) were subjected to four seed priming methods, namely, hydropriming, osmopriming, halopriming and solid matrix (SM) priming comprising a total of 18 treatments of different priming combinations along with control. The observations of selected physiological parameters - seed germination, seedling vigour, vigour index, and field performance of three cultivars were recorded. Cultivar-specificity with reference to priming treatment was observed. On the basis of data recorded for the above parameters, hydropriming for 18 hr for cv. A-4, halopriming with 1% $CaCl_2$ for 6 hr for cv. VRO-6 and SM priming with calcium aluminium silicate (1:0.4:1; Seed : SM : Water) for 48 hr for cv. Phule Utkarsha were found to be the most beneficial which could increase the fruit yield up to 20-104% in the three tested cultivars. The experiment underscored that to harness maximum benefit of seed priming for best field performance, cultivar-specific priming treatment should be adopted.

REFERENCES

Abdul-Baki A A and Anderson J D. 1973. Vigour determination in soybean seed by multiple criteria. *Crop Science* **13**: 630–3.

Afzal I, Basra S M A, Ahmad N, Cheema M A, Warraich E A and Khaliq A. 2002. Effect of priming and growth regulator treatments on emergence and seedling growth of hybrid maize (*Zea mays* L.*). International Journal of Agriculture and Biology* **4**: 303–6.

Afzal I, Rauf S, Basra S M A and Murtaza G. 2008. Halopriming improves vigor, metabolism of reserves and ionic contents in wheat seedlings under salt stress. *Plant, Soil and Environment* **54**: 382–8.

Ajirloo A R, Shaban M and Moghanloo G D. 2013. Effect of priming methods on emergence and seedling growth of maize (*Zea mays* L.). *International Journal of Farming and Allied Sciences* **18**: 658–61.

Bastia D K, Rout A K, Mohanty S K and Prusty A M. 1999. Effect of sowing date, sowing methods and seed soaking on yield and oil content of rainfed safflower grown in Kalahandi, Odisha. *Indian Journal of Agronomy* **44**: 621–3.

Esmeili M and Heidarzade A. 2012. Osmopriming enhance the seeds emergence and seedling parameters of two rice cultivars (*Oryza sativa*) under tough condition. *International Journal of*

Agriculture and Crop Sciences **4**: 247–50.

FAO. 2014. http://faostat.fao.org/ site/ 567/ desktopdefault.aspx? pageid = 567

Farooq M, Basra S M A and Ur-Rehman H. 2006. Seed priming enhances emergence, yield and quality of direct-seeded rice. *Crop Management and Physiology* **3**: *42–4*.

Finch-Savage W E .1995. Influence of seed quality on crop establishment, growth and yield. (*In*) *Seed Quality: Basic Mechanisms and Agricultural Implications*, pp 361-84. Basra A S (Ed). Food Products Press, New York, USA.

Harris D, Pathan, A K, Gothkar P, Joshi A, Chivasa W and Nyamudeza P. 2001. On farm seed priming: using participatory methods to revive and refine a key technology. *Agricultural Systems* **69**: 151–64.

Hussian M, Farooq M, Basra S M A and Ahmad N. 2006. Influence of seed priming techniques on the seedling establishment, yield and quality of hybrid sunflower. *International Journal of Agricicულture and Biology* **8**: 14–8.

ISTA. 1985. International rules for seed testing. *Seed Science and Technology* **13**: 42–6.

Jisha K C, Vijayakumari K and Puthur J T. 2013. Seed priming for abiotic stress tolerance : An overview. *Acta Physiologiae Plantarum* **35**: 1 381–96.

Kahlon P S, Dhaliwal H S, Sharma S K and Randhawa A S. 1992. Effect of pre-sowing seed soaking on yield of wheat (*Triticum aestivum* L.) under late sown irrigated conditions. *Indian Journal of Agricultural Sciences* **62**: 276–7.

Khan A A. 1992. Preplant physiological seed conditioning. *Horticultural Reviews* **14**: 131–81.

Kulkarni G N and Eshanna M R. 1988. Effect of pre-soaking maize seeds quality. *Seed Research* **16**: 37–40.

Lemrasky M G and Hosseini S Z. 2012. Effect of seed priming on the germination behaviour of wheat. *International Journal of Agriculture and Crop Science* **4-9**: 564–7.

Michael B E and Kaufmann M R. 1973. The osmotic potential of polyethyleneglycol-6000. *Plant Physiology* **51**: 914–6.

Nascimento W M and Pereira R S. 2007. Preventing thermo-inhibition in carrot by seed priming. *Seed Science and Technology* **35**: 504–7.

Ndaeyo N U, Harry G I and Idongesit W E. 2007. Growth of *Celosica argentea* L. as influenced by complementary use of organic and inorganic fertilizers. (*In*) *Proceedings of the 41st Annual Conference of Agricultural Society of Nigeria (ASN)*, Samaru, Zaria, pp 62–72.

Rudrapal D and Nakamura S. 1998. The effect of hydration dehydration pre-treatment on eggplant and radish seed viability and vigor. *Seed Science and Technology* **26**: 123–30.

Seyed S M, Davar H K, Ali M K, Yousuf A and Maryam J. 2012. A study on seed hydropriming effects on morphological traits and qualitative and quantitative yield in soybean under farm conditions (Iran). *Life Science Journal* **9**: 1 546–52.

Sharma A D, Rathore S V S, Srinivasan K and Tyagi R K. 2014. Comparison of various seed priming methods for seed germination, seedling vigour and fruit yield in okra (*Abelmoschus esculentus* L. Moench). *Scientia Horticulturae* **165**: 75–81.

Srinivasan K and Saxena S. 2007. Effect of dormancy breaking treatments on seed quality during storage of four acacia species. *Indian Journal of Forestry* **30**: 233–40.

Toklu F, Baloch F S, Karakoy T and Ozkan H. 2015. Effects of different priming applications on seed germination and some agromorphological characteristics of bread wheat (*Triticum aestivum* L.). *Turkish Journal of Agriculture and Forestry* **39**: 1 404–41.