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MORPHOLOGICAL CHARACTERISTICS AND FRUIT QUALITY OF SELECTED LEMON GENOTYPES

E. Kayesh[1*], S. Das[1], M. M. R. Rajib[1] and M. M. Islam[2]

Abstract

Twelve genotypes of lemon were evaluated to know the morphological variation and fruit quality. Phenotypic variations were observed among the twelve genotypes. The leaf lamina marginsof CR-Ban 002 and CR-Bag 003 were wavy whereas others were slightly wavy. The leaves of CR-Ban 002 were short (5.02 cm × 2.4 cm) but the leaves of BARI Lebu-1werebroad (11.8 cm × 4.6 cm). Among the twelve genotypes CR-Bag 003, CR-Nor 004, BARI Lebu-3 and BAU Lebu-1 produced fruits round the year. Although, CR-Ban 006 produced the largest (460 g) fruit coupled with early flowering but, the highest yielding genotype was CR-Nor 004 (34.6 kg/plant). Out of 12 genotypes only CR-Ban 001 and CR-Nor 004 were seedless. CR-Ban contained more juice, total soluble solid (TSS) and ascorbic acid compared to other genotypes. This study would be helpful to understand the phenotypic variability and fruit quality among the genotypes of lemon grown in different agro-climatic regions of Bangladesh.

Keywords: Genotype, lemon, seedless, juice.

The lemon (*Citrus limon*) is a small evergreen tree which belongs to the family *Rutaceae*. Lemon fruit plants are grown grow well in the Tropical, Sub-tropical and border line of sub-tropical and temperate region (Reitz, 1984; Lee and Leader, 2004).

The climatic condition of many areas of Bangladesh is very suitable for lemon cultivation. Major lemon producing regions of Bangladesh are Sylhet, Chittagong, and the Chittagong Hill Tracts in the orchards as well as in the homestead areas of many households (Umar *et al*., 2015). The production of lemon in Bangladesh is very low in comparison with other lemon producing countries in the world.

Though the climatic condition of Bangladesh is very suitable for lemon production but less attention is paid on the development of suitable cultivars. For the improvement of lemon, it is necessary to collect and screen new germplasms which would be superior to the existing varieties. Selection is one of the better methods to find a new improved variety compared to that of the existing germplasm pool (Umar *et al*., 2015). Therefore, a research program was initiated to characterize the germplasm based on different morphological traits.

Twelve lemon genotypes were collected from Ruma of Bandarban, Fakirhat of Bagerhat, Shibpur of Narsingdhi, BAU, BARI and BSMRAU orchard. These germplasms

[1]Department of Horticulture, [2]Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gaipur-1706. [*]Corresponding Author: e.kayesh@yahoo.com

included three types of lemon viz., Kagozi, Elachi and Zara were characterized for different traits under this experiment following descriptions of International Board for Plant Genetic Resources for citrus (IPGRI, 1999). The experiment was carried out following Randomized Complete Block Design (RCBD) with three replications. The plot size was 2 m × 2 m.

Data were recorded from the selected plants of each genotypes on plants, leaf, flower, fruit and seed characters. Data also were recorded on.

(i) Juice content.

(ii). Ascorbic acid content

The following steps were followed for estimation of Vitamin C content:

$$\text{Vitamin C content (mg/100 g)} = \frac{T \times D \times V_1}{V_2 \times W \times 100}$$

(Where, T = Titre, D = Dye factor, V_1 = Volume made up. V_2 = Volume of extract, W = Weight of a sample).

(iii). Total soluble solids (TSS)

Total soluble solid content of lemon pulp/juice was estimated by using a hand refractometer.

The recorded data from different characters were analyzed statistically using MSTAT-C program. Means were separated using Least Significant Difference (LSD) test at 1% or 5% level of probability.

All the twelve genotypes were bushy shrub, spreading growth habit and spiny with alternative and single leaf arrangement. Elliptic shape of leaf lamina was observed in all the genotypes except CR-Ban 001 and CR-Nor 005 which was ovate type. Wavy type of leaf lamina margin was observed in CR-Ban 002 and CR-Bag 003 and others were slight wavy in nature. The highest length (11.28 cm) and width (4.60 cm) of leaf lamina was observed in BARI Lebu-1 and the lowest length (5.02 cm) and width (2.40 cm) was observed in CR-Ban 002 with mean of 7.98 and 3.80, respectively (Fig. 1).

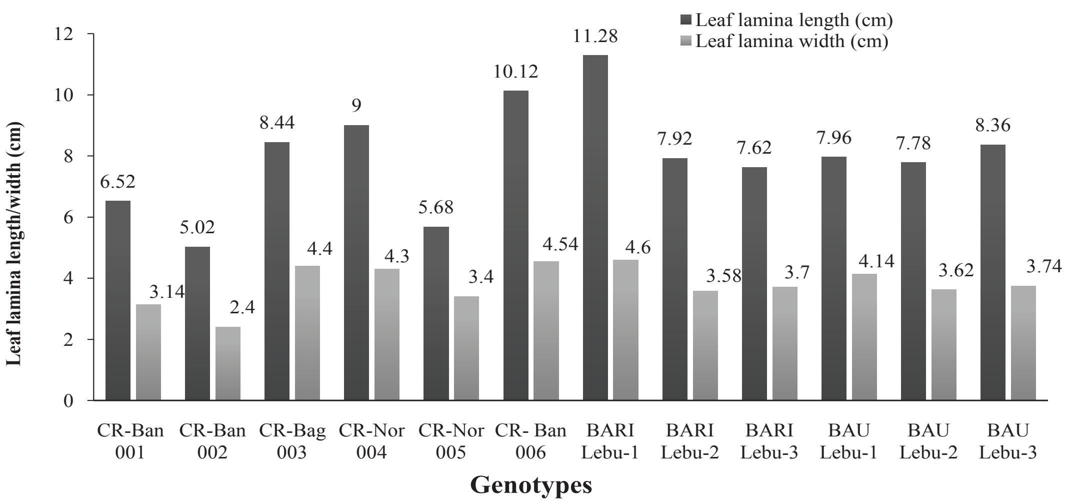

Fig. 1. Leaf lamina length and width in different genotypes of lemon.

The genotypes CR-Ban 003, CR-Ban 004, BARI Labu 3 and BAU Labu 1 were found to produce fruits round the year (Table 1). CR-Ban 006 was initiated flower on 30 January to 25 February and flower completion was occurred on 14 March. CR-Nor 005 was initiated flower on 2 February to 15 February and flower completion was occurred 15 March. CR-Ban 002 and BARI Lebu-3 initiated flower on 20 February to 3 March and flower completion was occurred on 15 March. CR-Ban 01, BARI Lebu -1, BAU Lebu- 2 and BAU Lebu- 3 flower initiation occurred on 15 February and flower completion was occurred on 15 March. CR-Bag 003, CR-Nor 004, BARI Lebu -2 and BAU Lebu-1 was year round genotype. Flowering period of all lemon was same due to that they facilitated natural cross pollination.

The highest petiole length (1.52 cm) was observed in CR-Bag 003 while the lowest (0.36 cm) was observed in BARI Lebu-2 (Fig. 2). The highest (0.78 cm) and the lowest (0.16 cm) were observed in CR-Bag 003 and BARI Lebu 2, respectively (Fig. 2).

Among the twelve genotypes the fruit shape CR-Ban 001, CR-Ban 002, CR-Bag 003, CR-Nor 005, BARI Lebu-1, BARI Lebu-2 and BAU Lebu-3 were oval in shape while CR-Nor 004, CR-Ban 006, BARI Lebu-3, BAU Lebu-1 and BAU Lebu-2 were obloid in shape. Pointed nipple in the fruit apex was recorded in CR-Ban 001, CR-Nor 005, CR-Ban 006 and BAU Lebu-3. The vestigial nipple fruit apex was observed in CR-Nor 004, BARI Lebu-1, BARI Lebu-2 and BAU Lebu-2. The cruncate apex type was found in CR-Bag 003, BARI Lebu-3 and BAU Lebu-1. However, round to slightly pointer nipple shape was observed in CR-Ban 002 (Table 3). The fruits of all twelve genotypes were green in color. But, the length of each fruit was varied from 5-9.9 cm and the diameter of fruit ranged from 3.5-6.6 cm. The largest fruit was observed in CR-Ban 006 but the smallest was recorded in CR-Ban 002 (Table 3).

Rind thickness was varied from 0.30 cm to 0.60 cm. The highest thickness (0.60 cm) was found in CR-Nor 004, BAU Lebu-2, and BAU Lebu-3 followed by that in BARI Lebu-2, BARI

Table 1. Flowering characteristics of different lemon genotypes in Bangladesh

Genotypes	Flower Initiation date	Flower completion date
CR-Ban 001	15 February	15 March
CR-Ban 002	20 February	15 March
CR-Bag 003	Year round	Year round
CR-Nor 004	Year round	Year round
CR-Nor 005	30 January	14 March
CR-Ban 006	30 January	14 March
BARI Lebu-1	15 February	15 March
BARI Lebu-2	20 February	15 March
BARI Lebu-3	Year round	Year round
BAU Lebu-1	Year round	Year round
BAU Lebu-2	15 February	15 March
BAU Lebu-3	15 February	15 March

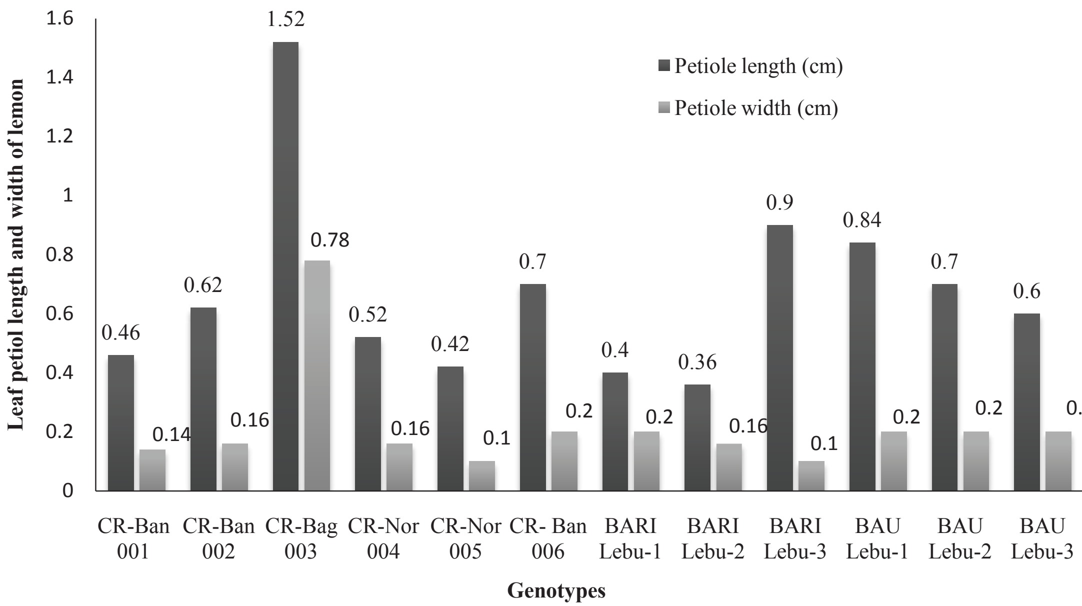

Fig. 2. Leaf petiole length and width in different lemon genotypes.

Lebu-3, BAU Lebu-1, and CR Ban 002 (0.50 cm), while the lowest rind thickness (0.30 cm) was observed in CR-Bag 003 (Table 3). The rind thickness was higher in Elachi type than that of Kagozi type lemon (Rashid, 2013).

The fruits per plant ranged from 360 (CR-Nor 004) to 45 (BARI Lebu 1) with a mean of 120/plant. The highest yield (34.67 kg) was obtained in CR-Nor 004 while the lowest (4.05 kg) was obtained in CR-Ban 002. Though, the highest fruit weight (460.1g) was found in CR- Ban 006 but it produced 60 fruits per year only (Table 3). The variability of fruit characteristics was occurred due to the differences of genetic potentiality of each genotype. According to Rashid (2013) the fruit weight was 41.90-61.79 g in Kagozi lemon where as it had 139.93-153.64 g in Elachi lemon (Sultana,2012).

The seed shapes of twelve germplasms were clavate, deltoid and globose. Among the genotypes clavate shape was present in CR-Ban006, BARI Lebu-1, BARI Lebu-2,BAU Lebu-1 and BAU Lebu-2. The globose shape was found in CR-Nor 005 whereas BAU Lebu-3 was deltoid shaped. Both the characters of globose and deltaoid shapes were present in CR-Ban 002 and CR-Bag 003 while CR-Ban001, CR-Nor004 and BARI Lebu-3 were seedless (Table 3). According to Altaf *et al*., (2008) different seed shapes were occurred due to the variability of pollen characters.

Although CR-Ban001, CR- Nor-004 and BARI Lebu-3 were seedless genotypes but wide range of variation was observed in seed per fruit (Table 3). The highest number of seed (44/fruit) was present in BARI Lebu-2 followed by BAU Lebu-2. However, the least number of seeds was present in CR-Ban002 genotypes.

Juice content was varied among the twelve genotypes. The highest juice content (70%) was found in CR-Bag 003 and CR-Nor 005 (Table

Table 2. Fruit, yield and seed characteristics of different lemon genotypes in Bangladesh

Genotypes	Fruit Shape	Rind color	Fruit length (cm)	Fruit diameter (cm)	Rind thickness (cm)	Fruit/plant (number)	Fruit weight (g)	Yield/ plant (kg)	Seeds/ fruit	100 seeds weight (g)
CR-Ban 001	Oval (Pointed nipple)	Green	6.0e	4.5efg	0.50b	80i	62.6i	5.08j	Seed less	0.00
CR-Ban 002	Oval (Round/ slightly Pointed nipple)	Green	5.0fg	3.5g	0.40c	105f	38.6k	4.05k	5.9g (Clavate and deltoid)	8.5f
CR-Bag 003	Oval (Cruncate)	Green	5.5ef	4.4efg	0.30e	120d	45.7j	5.48i	9.5f (Clavate and deltoid)	8.1f
CR-Nor 004	Obloid	Green	6.0e	5.6bcd	0.60a	360a	96.3g	34.67a	Seed less	0.00
CR-Nor 005	Oval(Pointed nipple)	Green	8.9b	5.0cde	0.50b	160b	112.9f	18.06c	7.6fg (Globose)	15.3b
CR- Ban 006	Obloid (Pointed nipple)	Green	9.9a	6.6ab	0.35d	60j	460.1a	27.6b	40.7b (Clavate)	18.3a
BARI Lebu-1	Oval (Vestigial nipple)	Green	9.0b	5.6bcd	0.50b	45k	258.7b	11.65g	15.2e (Clavate)	18.5a
BARI Lebu-2	Oval (Vestigial nipple)	Green	5.0fg	4.7def	0.40c	90h	80.3h	7.23h	44.0a (Clavate)	10.1de
BARI Lebu-3	Obloid (Cruncate)	Green	4.5g	3.8fg	0.40c	130c	31.50l	4.09k	Seed less	0.00
BAU Lebu-1	Obloid (Cruncate)	Green	7.0d	6.0bc	0.4c	100g	148.4d	14.84e	34.1c (Clavate)	13.8c
BAU Lebu-2	Obloid (Vestigial nipple)	Green	8.0c	7.5a	0.60a	80i	207.3c	16.59d	40.4b (Clavate)	9.2ef
BAU Lebu-3	Oval (Pointed nipple)	Green	9.0b	5.7bcd	0.60a	110e	128.38e	14.12f	18.3d (Deltoid)	11.5d
Mean			6.98	5.24	0.463	120.0	139.23	13.62	17.98	9.44
CV(%)			8.69	7.09	8.78	16.91	13.00	9.37	8.17	6.44
$LSD_{0.05}$			0.80	1.09	0.03	0.83	1.12	0.28	2.16	1.40

Table 3. Juice content, Vitamin C and TSS of different genotypes of lemon

Genotypes	Juice content (%)	Ascorbic acid (mg/100g)	TSS (%)
CR-Ban 001	50.00	21.00	5.00
CR-Ban 002	54.00	36.00	4.50
CR-Bag 003	70.00	86.00	6.90
CR-Nor 004	58.00	54.00	4.00
CR-Nor 005	70.00	41.36	4.20
CR- Ban 006	68.00	28.25	4.50
BARI Lebu-1	25.00	72.00	6.81
BARI Lebu-2	62.60	84.00	4.50
BARI Lebu-3	38.00	62.00	5.20
BAU Lebu-1	50.00	70.00	5.00
BAU Lebu-2	40.00	67.72	6.00
BAU Lebu-3	36.00	64.36	6.50
Mean	51.80	56.72	5.23
CV(%)	3.38	2.57	6.22
$LSD_{0.05}$	0.71	1.18	0.35

4). However, the lowest amount of juice (25%) was found in BARI Lebu-1. Variability of the juice contents may be due to the variation of the genetic potentiality of individual genotype (Al-Mouei and Choumane, 2014). According to Shrestha *et al* (2012) a seedless variety of citrus contained 60-66% juice.

The highest amount of ascorbic acid (86 mg/100 g) was found in CR-Bag 003 followed by BARI Lebu-2 (84 mg/100 g) (Table 4). However, the lowest amount of ascorbic acid was recorded in CR-Ban 001 (21 mg/100 g). Shrestha *et al.* (2012) reported that a seedless variety of lime (Cha- kradhar) contained118.2 - 140.8 mg/100 g of ascorbic acid.

The total soluble solid range was 4.00-6.90 % with a mean value 5.23%. The highest TSS (6.9%) was found in CR-Bag 003 which was significantly similar with BARI Lebu-1 (6.81%) genotypes (Table 4). The lowest TSS (4.0%) was recorded in CR-Nor 004. The lemon genotypes had the lowest TSS (4.11%) than other varieties (Al-Mouei and Choumane, 2014). In order to select a suitable variety, percent TSS is an important character as the highest market value would be achieved when the genotype would have the highest percent of TSS.

Acknowledgments
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INVIGORATION TREATMENT ON SEED QUALITY OF OKRA

M. Abduhu[1], A. A. Khan[2*], M. T. Rubayet[2] and M. R. Islam[3]

Abstract

Experiments on pre-sowing invigoration treatment on okra seed with three chemicals viz., thiourea, hydrogen peroxide (H_2O_2), and polyethylene glycol (PEG) at different levels was conducted to evaluate their efficacy on improving seed quality of the crop. Okra seed variety BARI Derosh-1was treated with thiourea at concentrations of 0.2, 0.3 and 0.4% for 24 h and H_2O_2 at 1.5, 2.0 and 2.5% for 6 h and PEG at 20.0%, 25.0% and 30.0% for 24 h. Germination, vigor index, and field emergence were increased due to pre-soaking of okra seed with all the three chemicals. Germination of seed, vigor index and field emergence were increased by 4.92-19.67%, 14.33-93.98% and 11.53-34.61%,respectively, with the three treatments. Among different treatments, better germination, vigor index and field emergence were obtained with 30.0 and 20.0% PEG and 2.0% H_2O_2 solution. Pre-soaking of the seed with PEG at 30.0% increased the germination, vigor index and field emergence by 19.67, 87.18, and 34.61%, while at 20% by 18.03, 74.02, and 30.77%, and those increased by 16.39, 93.98 and 30.77% with 2.0% H_2O_2, respectively. It is concluded that seed quality parameters, such as germination, vigor index and field emergence of okra were improved substantially due to invigoration treatment with thiourea, H_2O_2 and PEG.

Keywords: H_2O_2, PEG, seed germination, thiourea, vigor index.

Okra [*Abelmoschus esculentus* (L.) Moench] is an important vegetable crop in Bangladesh. Among various constrains, unavailability of quality seeds and diseases are mainly responsible for low yield of okra (Rashid and Fakir, 2000). Generally, the quality seeds with higher germinability and greater vigor index are important for better crop stand and higher yield. Use of high quality seed of a high yielding variety and improved production technologies ensure high yield and quality seed of okra. According to George (2009) use of quality seeds of high yielding varieties may increase production up to 25-50 %.

Seed invigoration implies a form of post- harvest treatment of seeds with specific chemicals that improve storability, germinability and vigor index of seeds. According to Vanangamudi (2006) invigoration treatment should bring about a qualitative improvement in the seed, which should persist even after the treatment is removed, and the treatments are basically physiological in nature. Metabolism that occurs during priming is not enough to cause radicle emergence (McDonald, 2000).

Water imbibition is the first step in seed germination. To combat these problems, farmers pre-soak the seed in plain water for a few hours. But this may cause seed damage in more than one ways. Of them, the major one is excess water that may be trapped in the area of embryonic

[1]Department of Agricultural Extension, Dhaka, Bangladesh,[2] Department of Plant Pathology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, [3]Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706. [*]Corresponding Author: ashraf@bsmrau.edu.bd

axis, nodal zone and cotyledons. This leads to suffocation due to deficient supply of oxygen resulting in delayed and poor germination as well as weak seedling. On the other hand, soaking for prolong period will allow excess of water that may exceeds the quantity required for the initiation of lag phase of germination, and radicle protrusion will occur due to which seeds lose their desiccation tolerance thereby resulting in loss of seed viability (Dekkers *et al*., 2015). So, aqueous solution of any chemical having capability to supply O_2 at the embryonic axis during seed imbibition could be worthwhile measures. As such aqueous solutions of thiourea, H_2O_2, and polyethylene glycol (PEG) at varying concentration(s) and imbibition period(s) have been found fruitful in various seeds, which improves germination percentage, vigor index, reduces time to germinate and also increases early seedling growth and field establishment.

Pre-soaking treatment of seed with thiourea has been reported to enhance seed germination in onion, potato, ash gourd, bitter gourd, and ribbed gourd (Renugadevi, 1992). Pre-soaking seed treatment with H_2O_2 is another effective invigoration treatment used in groundnut (Rahman *et al*., 1997). The salt or polyethylene glycol (PEG) solution is used in order to control water uptake and prevent radical protrusion (Bray, 1995). PEG is most commonly used because of its non-toxic nature and large molecular size which lowers water potential without penetrating into the seeds during soaking. Okra is planted in direct dibbling of seed in the field during January to June, the driest period of the year in Bangladesh. Hence, soaking its seed before sowing may be of helpful for good plant stand establishment. The present experiment was conducted with the view to finding out the effect of pre-sowing seed soaking in aqueous solution of thiourea, H_2O_2, and polyethylene glycol (PEG) to improve germination, vigor index, and field emergence of okra seeds.

Invigoration effect of thiourea, hydrogen peroxide (H_2O_2), polyethylene glycol (PEG) was tested on seed germination, field emergence and seedling vigor of okra. Okra seeds cv. BARI Dherosh-1 were pre-soaked in thiourea, H_2O_2 and PEG solutions at different concentrations maintaining the following treatments: T_1= 0.2% thiourea for 24 h, T_2= 0.3% thiourea for 24 h, T_3= 0.4% thiourea for 24 h, T_4= 1.5% H_2O_2 solution for 6 h, T_5= 2.0% H_2O_2 solution for 6 h, T_6= 2.5% H_2O_2 solution for 6 h, T_7= 20.0% PEG solution for 24 h, T_8= 25.0% PEG solution for 24 h, T_9= 30.0% PEG solution for 24 h and T_{10}= control (soaked in sterilized water for 12 h). After pre-soaking, seeds were washed with distilled water and then air dried.

A total of 400 seeds under each treatment (100 seeds/ replication) were randomly selected. The pre-soaked seeds were sown in plastic trays containing sterilized coarse sand. Seven days after sowing number of seedling emerged in each tray was recorded. Number of seedlings emerged from 400 seeds were counted. The germination capacity was expressed in percentage based on total seeds used for germination test. After seven days of emergence, 10 normal seedlings randomly selected from each 100 seeds were used for germination test. Altogether 40 seedlings were selected from each treatment. Seedlings were uprooted carefully, washed and placed on blotter paper. Shoot length was measured in centimeter (cm) from the base of hypocotyls to the tip of the shoot, and root length was from the base of hypocotyls to the tip of the longest root with the help of a measuring scale. Then, the mean values of the two parameters were computed. After measuring the shoot and root lengths, all the ten seedlings (shoot + root) were packed together in brown paper bags and dried completely at 60° C for 48 h in an electric oven. The dried seedlings were brought out from the oven, cooled at room temperature (25 ± 2 °C) for 1-2 h and weighed with an electronic weighing balance. Then seedling dry weight of 10 normal seedlings per replication was recorded. Vigor index was computed following a standard formula as suggested by Abdul-Baki and Anderson (1973) as shown below:

Vigor index = Mean germination (%) ′ Mean dry weight of 10 normal seedlings in gram.

The experimental field was prepared using a tractor driven plough by three plowings followed by laddering for good tilth. The experimental plot was fertilized with NPK @ 0:50:30 kg/ ha, respectively. A basal dose of cow dung @ 10 t/ha was also incorporated in the soil at the time of final land preparation. The experiment was laid out in RCBD with four replications. Presoaked and air dried seeds of okra were sown @ 100 seeds per unit plot (60 cm x 40 cm). Intercultural operations and watering were done as and when necessary. Data on field emergence were recorded after 15 days of sowing. Data were analyzed using MSTAT-C computer programme and means were compared using Duncan's Multiple Range Test (Gomez and Gomez 1984).

All the invigoration treatments increased the seed germination percentage significantly over control. Significantly the highest germination percentage (73.0%) was obtained with seeds presoaked in 30.0% PEG solution, which was followed by that in 20.0% PEG solution, 2.0% H_2O_2, 25.0% PEG solution, 2.5% H_2O_2, 0.2% thiourea solution, and 1.5% H_2O_2. The lowest germination of 61.0% was found under control (Table 1). Significantly the highest shoot and root length 13.9 cm and 13.2 cm, respectively, were obtained when seeds treated with 30.0% PEG solution, which was followed by those of 20.0% PEG solution, 2.0% H_2O_2 and 25.0% PEG solution. The lowest seedling shoot and root length of 8.1 cm and 7.9 cm, respectively, were recorded from 0.4% thiourea and control (Table 1). All treatments with thiourea, H_2O_2 and PEG significantly increase seedling dry weight over control. The highest seedling dry weight (1.30 g/10 seedlings) was obtained from the treatment with 2.0% H_2O_2 solution, which was followed by 30.0% PEG solution (1.22 g/10 seedlings), and 20.0% PEG solution (1.15 g/10 seedlings). The lowest seedling dry weight was found in control (Table 1).

The vigor index was significantly increased over control with all the invigoration treatment. Significantly the highest vigor index (92.30) was recorded from the seeds treated in 2.0% H_2O_2, solution which was followed by seed soaking in 30.0% PEG solution (89.06) and 20.0% PEG solution (82.80). The lowest vigor index was found in control (47.58) (Table 1).

Field emergence was also significantly increased by invigoration treatments. Significantly the highest field emergence (70%) was recorded from the seeds treated in 30.0% PEG solution, which was followed by 20.0% PEG solution, 2.0% H_2O_2 solution, 25.0% PEG solution, 2.5% H_2O_2, and 0.2%

thiourea. The minimum field emergence (52.0%) was recorded in untreated control (Table 1).

Seed is the basic input of crop production and thus, efficient use of other inputs depends on the quality of seeds. High germination of seed results high yield, while slow and erratic emergence cause low yield of a crop. Invigoration treatments with thiourea, H_2O_2, and polyethylene glycol (PEG) increased the seed germination significantly over control. Similar results were reported by other workers (Rahman *et al*., 1997; Rahman *et al*., 2016). Priming improves seed germination performance by starting early processes of germination but not cell division (Yuan-Yuan *et al*., 2010). Lee *et al*. (1996) obtained higher germination percentage in artificially aged and unaged seeds of rice, barley and wheat due to osmotic pretreatment with PEG. Osmopriming strengthens the antioxidant system and increases seed germination potential, resulting in an increased stress tolerance in germinating seeds (Chen and Arora, 2011). The possible reason for improved germination through priming may be synthesis of proteins and leaching of growth inhibitors, repair of deteriorative DNA in seeds (Di Girolamo and Barbanti, 2012) and activation of antioxidant enzymes, such as Peroxidase, Catalase as well as Malate dehydrogenase (Santhy *et al*., 2014).

Significantly the higher shoot- root length, seedling dry weight, and vigor index were also obtained when seeds treated with thiourea, H_2O_2, and polyethylene glycol (PEG). The results corroborated with findings of Mahdi *et al*. (2008), Rahman *et al*. (1997) and Santhy *et al*. (2014).

Field emergence is an indicator of seed vigor and seed viability. The seeds having low vigor values cannot emerge well under adverse field condition. High percentage of field emergences and good seedling establishment

Table 1. Effect of pre-soaking of seed with thiourea, H_2O_2, and polyethylene glycol (PEG solutions on germination, vigor index, and field emergence of okra

Treatment	Germination (%)	Seedling shoot length (cm)	Seedling root length (cm)	Seedling dry wt (g/10 seedlings)	Vigor index	Field emergence (%)
T_1 = 0.2 % Thiourea	67.0 de	10.4 f	9.6 f	0.91 g	60.97 g	64.0 c
T_2 = 0.3 % Thiourea	66.0 e	10.4 f	9.4 h	0.89 h	58.74 h	61.0 d
T_3 = 0.4 % Thiourea	64.0 f	8.1 h	9.5 g	0.85 i	54.40 i	58.0 e
T_4 = 1.5 % H_2O_2	67.0 de	10.7 e	8.2 i	0.93 f	62.31 f	62.0 d
T_5 = 2.0 % H_2O_2	71.0 b	12.6 c	12.5 c	1.30 a	92.30 a	68.0 b
T_6 = 2.5 % H_2O_2	68.0 cd	9.3 g	10.8 e	1.09 d	74.12 d	64.0 c
T_7 = 20.0 % PEG	72.0 ab	13.7 b	12.9 b	1.15 c	82.80 c	68.0 b
T_8 = 25.0 % PEG	69.0 c	11.8 d	12.0 d	0.98 e	67.62 e	62.0 d
T_9 = 30.0 % PEG	73.0 a	13.9 a	13.2 a	1.22 b	89.06 b	70.0 a
T_{10} = Control	61.0 g	8.2 h	7.9 j	0.78 j	47.58 j	52.0 f
CV (%)	1.20	0.70	0.62	1.25	0.45	1.67

Means followed by the same letter(s) in a column are not significantly different at 5 % level in the field from high seed vigor was reported by Lee *et al*. (1996). The findings of the present experiment well agreed with the previous findings.

The present study revealed that all the treatments showed greater seed invigoration over control. However, better results can be achieved with 30.0 and 20.0% solutions of PEG soaked for 24 hours and 2.0% solution of H_2O_2 for 6 hours. But osmotic seed treatment is expensive, especially when osmotica, such as PEG is used. On the other hand, pre-soaking of seed in 2.0% H_2O_2 solution is less expensive than that in PEG. The chemical is available locally and thus suggested as priming agent of invigoration of okra seed.

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