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Full Length Research Paper

Seed priming with phosphorus increased germination and yield of okra

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In order to sort out the problem of uneven and poor germination in okra, a research work "the effect of seed priming on okra cv. Sabaz Pari with different sources of phosphorus and soaking durations" was carried out at Horticulture Research Farm, Khyber Pakhtoonkhwa Agricultural University Peshawar, Pakistan, during summer 2008. The experiment was laid down in randomized complete block design with split plot arrangements. There were four priming sources (distilled water, 1% phosphorus (P) solution of each of diammonium phosphate (DAP), single super phosphate (SSP), SSP+ Na_2CO_3) with soaking durations from 4 h and their twofolds up to 48 h along with unprimed seed (control). Priming sources and durations significantly affected germination percentage, survival percentage, number of days to emergence and first flowering, plant height, leaves number per plant, pods number per plant, pod length, seeds number per pod and pod yield. SSP solutions with 24 h soaking duration gave the best results, followed by DAP, while unsoaked seeds proved to be the poorest. Hence, seed priming in SSP solution (1%P) for 24 h is recommended for okra.

Key words: *Abelmoschus esculentus* (Okra), seed soaking, phosphorus fertilizer.

INTRODUCTION

Okra (*Abelmoschus esculentus*) belongs to Family *Malvaceae*. It is originated in tropical Africa, and wild forms are also found in India. Okra is a popular summer crop; the young tender pods are cooked in curries, stewed and used in soaps. It is a good source of vitamins A, B and C, and is also rich in protein, minerals and iodine (Qayyum, 1990; Malik, 1996). Okra seeds are sown in early April in plain areas and in last week of April at the higher elevations. It does not germinate below 20 ^{0}C (Sadiq et al., 1998). The slow and uneven germination of okra seed are the main hurdle in the early spring planting (Pandita et al., 2010).

Seed priming comprise of seed soaking following drying back to storage moisture (Khan et al., 1992; Ullah et al., 2002a; Arif et al., 2007). The farmers primed seed in (the past for gap-filling or in dry years. Water is used for the soaking of the seed to split or soften the hard seed coat for speeding up and synchronizing the germination process in okra (Rizvi and Jagirdar, 1976). The priming practice is getting popularity after the application of participatory approach in Africa, Nepal, India, Bangladesh and Pakistan (Harris et al., 1999; Harris et al., 2001; Rashid et al., 2002; Saika et al., 2006).

Priming allows some of the metabolic processes to occur necessarily for germination before actual germination to get start (Bradford, 1990; Yari et al., 2010). Priming triggers the synthesis or activation of some enzymes that catalyze the mobilization of storage reserves in seed, while endosperm weakens by hydrolase activities. Besides, priming increases the production of antioxidants like catalase, peroxidase, superoxide dismutase that help in protecting the cell against membrane damage because of lipid peroxidation. Likewise, adenosine triphosphate (ATP) production also amplifies in primed seed (Gallardo et al., 2001; Varier et al., 2010). Priming may increase resistance to abiotic stresses, and increases the performance of late sown wheat by improving chilling tolerance (Farooq et al., 2008),

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Abbreviations: P, Phosphorus; **DAP,** diammonium phosphate; **SSP,** single super phosphate; **PDM,** pearl millet downy mildew.

also may alleviate thermoinhibition in lettuce by increasing maximum germination temperature (Schwember and Bradford, 2010).

Seed soaking might enhance the plant tolerance to salinity (Afzal et al., 2005; Ashraf and Foolad, 2005; Ehsanfar et al., 2006; Rashid et al., 2006; Bejandi et al., 2009), and may also overcome thermodormancy in lettuce by irreversible initiation of cell elongation (Cantliffe et al., 1984).

Phosphorus (P) is one of the major essential elements required for the development of plants (Bieleski, 1973; Chhabra, 1985; Hartmann and Geneve, 2000). Plant need P during the rapid growth period and is a structural component of macromolecules, such as the nucleic acid (DNA and RNA) and ATP. It also creates disease resistance, triggers growth and gives early maturity. Nureint priming in P supports early phase of crop development, synchrocnizes the the germination process and leading to enhance the final yield, especially in P deficint soil (Taylor and Herman, 1998; Asgedom and Becker, 2001; Arif et al., 2005).

The present study was therefore designed to investigate the effect of seed priming using different sources of phosphorus and soaking durations on yield of okra and to evaluate the best soaking source and priming period for okra.

MATERIALS AND METHODS

The experiment “effect of seed priming with different sources at various soaking duration on germination, growth and yield of okra (cv. Sabaz Pari)” was conducted in summer 2008 at Malakandher Farm Khyber Pakhtoonkhwa Agricultural University Peshawar, Pakistan.

Soil analysis

Before sowing of the seeds, soil samples up to 25 cm depth were taken randomly from different parts of the field with a gauge auger (30 mm diameter) and were analyzed in the Soil Science Laboratory at Khyber Pakhtoonkhwa Agricultural University Peshawar, Pakistan for chemical characteristics.

The soil of the experimental field was silty clay loam in texture, with electrical conductitvity ($EC_{1:5}$) 0.32 dSm^{-1}, nitrogen content 1.03%, extractable P 3.54 $mgkg^{-1}$soil, extractable K 71.26 $mgkg^{-1}$soil, organic matter (0.9%) and pH 8.5.

Laboratory procedures for soil analysis

Soil samples were dried, ground, sieved through 2 mm sieve and were stored in the clean, dry and labelled plastic bottles for further analysis.

Bulk density of the soil was measured by core method (Blake and Hartage, 1984). Electrical conductivity was found out in 1:5 soil water suspensions following 30 min of stirring and read on EC meter as reported by Rhodes (1996). N in soil samples was determined by the Kjeldhal method of Bremmer (1996). Extractable P and K were found out by the procedure described by Soltanpour and Schwab in 1997. Wet digestion method was used to determine organic matter content of the soil (Nelson and Sommers, 1982). Soil pH was measured in 1:5 soil water suspension using pH meter (Mclean, 1982).

Experimental design

The experiment was laid in randomized complete block design (RCBD) in split plot arrangement. There were 52 treatments per replication with three replicates. Two factors were studied in this experiment as:

Factor A: Sources for seed soaking were kept in the main plot as follow:

1. Distilled water (DW),
2. 1% P solution of diammonium phosphate (DAP),
3. 1% P solution of single super phosphate (SSP) and
4. 1% P solution of single super phosphate + Sodium bicarbonate (SSP+ Na_2CO_3).

Na_2CO_3 was used to neutralize the acidic pH of SSP solution.

Factor B: The soaking periods were kept in sub plots.

Control treatment was kept as unsoaked seeds that are 0 h soaked. Then seeds for each of next treatment were soaked for additional 4 to 48 h. Hence, soaking periods were 0, 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44 and 48 h.

After priming in different P sources for various durations, the seeds were air dried at room temperature for atleast 3 h close to original moisture level.

Preparation of field

The field ploughed and leveled before seed sowing. Rotten farmyard manure and silt were added to the soil. There were four main plots and each main plot was divided into 13 subplots. Sub plot size was 1.95 m^2. There were 60 cm wide ridges for each treatment in which 21 seeds were sown on their both sides keeping a distance of 60 cm row to row and 30 cm plant to plant distance. Irrigation was practiced regularly after every fifith day. The experimental data were collected on germination percentage (%), survival percentages (%), number of days to emergence, number of days to first flowering, plant height (cm), number of leaves per plant before harvest, while pod number per plant, pod length (cm), number of seeds per pod and pod yield (kg ha^{-1}) were determined after harvest.

Statistical analysis

Data were statistically analyzed by using the software MSTAT-C. Analysis of variance that matched with RCBD with split plot arrangement was used to test the significance of sources of variance, while least signifcant difference (LSD) test ($P = 0.05$) was used to compare the differences among treatment means (Steel and Torrie, 1984).

RESULTS AND DISCUSSION

Germination percentage

Data presented in Tables 1 and 5 show that various priming sources and soaking durations had significant effects on seed germination percentage of okra seed while their interaction had no significant effect. Maximum (85.94%) germination percentage was recorded in plot in which seeds were soaked in SSP solution followed by (85.17%) germination percentage in plot in which seeds were soaked in DAP solution. Minimum (81.58%) germination percentage was recorded in distilled water seed soaked plot (Figure 1). Results of various soaking durations in Figure 2 indicate that maximum germination percentage (91.57%) was recorded in plot in which seeds were soaked for 24 h, traced by (89.83%) germination percentage in plot in which seeds were soaked for 20 h while minimum (75.83%) germination percentage was recorded in 48 h soaked seeds plot. However, in their interaction, highest (93.11%) germination percentage was in plot in which seeds were drenched for 24 h in SSP solution, followed by (91.59%) germination percentage in plot with 24 h seed soaking in DAP solution. The lowest (68.97%) germination percentage was recorded in plot in which seed were soaked for 48 h in distilled water.

The increase in germination rate may be correlated with priming that switched on many biochemical and physiological processes necessary for seed germination. Phosphorus absorption may have triggered these processes. Priming affected the seed germination by early DNA replication and repair, increased RNA and protein synthesis and greater ATP availability (Gallardo et al., 2001; Varier et al., 2010). Priming enhanced the germination percentage of many field crops reported by Khan et al. (1992), Kurdikeri et al. (1995), Ullah et al. (2002b), Ajouri et al. (2004), Rashid et al. (2004), Arif et al. (2005), Yari et al. (2010) and Pandita et al. (2010).

Survival percentages

Soaking durations had significant effect on survival percentage of okra, but different priming source and their interaction were not significant (Table 6). The best (94.05%) survival percentage was recorded in plot in which seeds were soaked in SSP solution (Table 1), followed by (93.77%) survival percentage in plot in which seeds were soaked in SSP+Na_2CO_3 solution while the poorest (91.92%) survival percentage was recorded in distilled water plot. With respect to soaking durations, 24 h seed soaking gave the highest survival percentage (97.35%), traced by 16 h with 97.01% survival percentage, while 48 h exhibited the lowest (82.44%) survival percentage (Figure 3). Likewise, in their interaction, maximum (99.53%) survival percentage was reported with seed soaked for 20 h in DAP solution, followed by (99.47%) survival percentage which was found out with those for 16 h in DAP solution. Minimum (79.90%) survival percentage was obtained with plot in which seeds were soaked for 48 h in SSP solution.

Phosphorus priming proved to be reduced seed infection. Chaluvaraju et al. (2004) reported that the pearl millet downy mildew (PDM) disease was decreased by various phosphorus sources. The chemicals acted as growth stimulants under laboratory conditions by improving seed germination and vigor, hence, leading to better survival of the seedling.

Number of days to germination

Table 7 indicates that vaious priming sources and soaking durations affected number of days to germination significantly, while their interaction was not significant. Data in Table 1 and Figure 4 show that among various soaking sources, maximum (8.78) number of days to emergence were taken by seed soaked in distilled water, followed by 8.382 days to emergence for seed primed in SSP+Na_2CO_3 solution. Minimum numbers of days (7.78) were recorded for seed soaked in SSP solution. Regarding results of various soaking durations (Figure 5), maximum number of days to emergence (9.83) was recorded in un-primed seed plot followed by (9.53) number of days to emergence in 48 h soaked seed. Minimum number of days to emergence (6.65) was recorded with 24 h priming. However, in their interaction, maximum days (10.97) to emergence were recorded in un-primed seed plot followed by (10.13) days to emergence taken by plot in which seed were soaked for 48 h in distilled water. Minimum (6.13) days to emergence were taken by plot in which seeds were soaked for 24 h in SSP solution.

Seed emergence plays crucial role in overcoming the future fate of the plant. Faster emergence may be due to priming as it synchronizes the metabolism of all seeds in the seed lot, thus ensuring uniform emergence and growth in the field. In fact, it synchronizes all the cells of germinating embryo in G_2 phase of the cell cycle for uniform development of the seedling. It also triggers β-tubulin production that has key role in spindle formation during cell division (Gallardo et al., 2001; Varier et al., 2010). Best results in phosphorus solutions endorsed the role of phosphorus as priming source in promoting seed emergence because of optimum availability of P for germination and more ATP and DNA production. However, it can also be assumed that among phosphorus solutions, SSP proved to be the best for okra because besides P supply, the SSP being acidic (pH=2.7-3) may have role in acidic scarification of hard seed coat of okra to break its seed coat dormancy. These results are in line with work of Arif et al. (2003), who found that seed soaking enhanced emergence in mungbean as compared to unprimed seed. They documented that priming may result in the early activation of the metabolic machinery of the seed making it ready for the germination. Likewise, Farooq et al. (2008) reported that seed soaking decreased the germination time that may allow the seedling to escape the deteriorating soil physical condition. These results also confirmed the findings of Khan et al. (1992), Afzal et al. (2002), Murungua et al.

(2004), Rashid et al.(2004), Ashraf and Foolad (2005) and Saikia et al. (2006) who observed faster emergence and increased germination of primed seed than un-primed (control) in many field crops.

Number of days to first flowering

Data presented in Table 2 and Table 8 show that various priming sources and soaking durations had significant effects on number of days to first flowering of okra, but their interaction was non significant. Maximum (36.97) number of days to first flowering were noted in plots in which seed were soaked in distilled water, followed by (36.66) days to first flowering in plot having soaked seed in SSP+Na_2CO_3 solution (Table 2 and Figure 6). Minimum (33.65) days to first flowering were recorded by plots in which seeds were soaked in SSP solution. Results of various soaking durations (Figure 7) showed that maximum (44.93) number of days to first flowering were taken in un-primed seed plot, traced by (40.57) number of days to first flowering in plot having seeds soaked for 48 h.The lowest number of days to first flowering (29.32) were recorded in 24 h soaked seeds plot. Similarly, in their interaction maximum number of days (45.93) to first flowering was recorded in un-primed seed plot and minimum time (27.73) to first flowering was taken by plot in which seed were soaked for 24 h in SSP solution.

Time termed in days to flowering character is highly correlated with physiological maturity of the crop. It is considered as the termination of vegetative cycle and start of reproductive cycle. Priming triggers the metabolic processes and may break the dormancy of the seeds. Growth harmones are released and hence, the growth rate may become much faster than normal. Similar results are also reported by Harris et al. (2001), Ullah et al. (2002b) and Saikia et al. (2006), who noted that primed crops emerge faster, flower earlier and give higher yield. Mauromicale et al. (2000) evaluated seed osmopriming as a mean to improve early flowering, maturity time and yield of summer squash (*Cucurbita pepo* L.). They also reported that plants from primed seed exhibited advances of 2.5 to 7.5 days in anthesis of first female flower.

Plant height (cm)

Table 9 indicates that various priming sources and soaking durations significantly affected plant height of okra; however, their interaction had no significant effect. The maximum plant height (138.9 cm) was observed in plot having seeds soaked in SSP solution (Table 2 and Figure 8), followed by (133.5 cm) plant height obtained from seeds soaked in DAP solution. Minimum plant height (123.6 cm) was recorded with plants produced from seeds soaked in distilled water plot. Results of various soaking durations (Figure 9) indicated that the tallest plants (161.08 cm) were recorded in plot in which the seeds were soaked for 24 h, followed by 152.9 cm in plot with soaked seed of 20 h. Minimum plant height (113.8 cm) was recorded in control plot. The interaction result show that plot having seed soaked in DAP solution for 24 h gave the longest plant (172.3 cm), followed by SSP solution seed primed for 24 h (168.10 cm). Un-primed seed plot had the shortest suture plants (108.5 cm).

Viability and vigor of plant have profound influence on the establishment and yield of crop. Priming might have increased seedling vigor by enhancing the capability of the plants to compete for plant basic needs of nutrients, water and light. Phosphorus primimg may have satisfied the phosphorus needs of the plants in their early growth stage. Moreover, priming may also increase resistance of the young seedling to biotic and abiotic factors. So, the resultant healthy plants with well developed roots and shoots can absorb nutrients in sufficient amounts and can overcome the adverse conditions. The findings are in line with those of Hong et al. (1996), who concluded that Zn priming increased seedling fresh weight and height of maize as it might increase respiration and activities of amylase, lipase and glutamic pyruvic transaminase. Harris et al. (2001), Asgedom and Becker (2001), Rashid et al.(2004) and Ashraf and Foolad (2005) also reported that seedlings grown from primed seeds of different field crops showed higher vigor than unprimed seeds. Likewise, Bejandi et al. (2009) also found highest shoot length in soybean following priming.

Number of leaves per plant

Various soaking sources, durations and their interaction had significant effects on number of leaves per plant (Table 10). Data in Table 2 show that the highest (26.69) number of leaves per plant was recorded in plot with SSP solution soaked seed, followed by (25.29) number of leaves per plant in plot of DAP solution. The lowest number of leaves per plant (22.92) was recorded with distilled water. Similarly, results of various soaking times show that maximum number of leaves per plant (33.82) was recorded in plot in which seeds were soaked for 24 h, followed by (32.51) numbers of leaves per plant in plot in which seed were soaked for 20 h. Minimum number of leaves per plant (17.15) was recorded in plot in which seed were soaked for 48 h. For their interaction (Figure10), plot with primed seed in SSP solution for 24 h gave the highest number of leaves per plant (36.13), traced by the plot of seed soaked in DAP solution for 24 h with34.70 number of leaves per plant and plot with seed priming using SSP+Na_2CO_3 solution for 48 h showed the lowest number of leaves per plant (16.12).

These findings are in line with works of Ghosh et al. (1997), Harris et al. (2001), Basra et al. (2003), Harris et al. (2004) and Farooq et al. (2008) who reported in

Table 1. Effect of various priming sources and soaking durations on germination, survival percentage and days to germination of okra.

Soaking Durations (h)	Sources for germination percentage					Sources for survival percentage					Sources for days to germination				
	Distilled water	DAP	SSP	SSP + Na_2CO_3	Mean	Distilled water	DAP	SSP	SSP + Na_2CO_3	Mean	Distilld water	DAP	SSP	SSP + Na_2CO_3	Mean
0	77.86	79.29	79.31	77.59	78.51 F	83.98	85.60	87.95	84.90	85.61 C	10.97	9.700	9.73	9.13	9.88 A
4	80.70	79.85	81.03	81.10	80.67 EF	93.53	91.85	94.90	98.23	94.63 AB	8.47	7.98	7.70	8.20	8.09 EF
8	81.03	85.94	87.05	82.05	84.02 D	91.97	95.10	95.07	98.80	95.23 AB	8.17	7.53	7.53	7.90	7.78 FG
12	81.61	87.39	88.74	87.80	86.39 C	98.07	95.97	95.43	94.77	96.06 AB	7.82	6.97	6.87	7.77	7.35 GH
16	84.63	88.64	89.31	89.44	88.00 BC	92.27	99.47	99.27	97.05	97.01 A	7.70	6.72	6.47	7.60	7.12 HI
20	87.73	90.47	91.47	89.66	89.83 AB	97.60	99.53	92.50	92.33	95.49 AB	7.40	6.40	6.20	7.37	6.84 I
24	90.56	91.59	93.11	91.04	91.57 A	96.60	96.50	98.33	97.97	97.35 A	7.10	6.23	6.13	7.13	6.65 I
28	86.14	87.15	89.52	86.65	87.36 C	98.10	96.43	95.70	94.60	96.21 AB	8.83	7.80	7.53	8.50	8.17 EF
32	84.53	87.05	86.81	84.39	85.69 CD	94.10	96.60	99.07	95.97	96.43 A	8.84	8.03	8.03	8.67	8.39 DE
36	82.21	84.53	86.16	83.08	83.99 D	89.02	92.27	97.43	93.93	93.16 B	9.17	8.57	8.45	8.83	8.75 CD
40	79.29	84.00	82.76	77.59	80.91 E	92.40	96.93	97.07	96.97	95.84 AB	9.59	8.97	8.54	9.23	9.08 BC
44	77.31	81.97	81.03	76.04	79.09 EF	85.98	88.30	90.10	88.03	88.10 C	9.97	9.13	8.97	9.35	9.35 B
48	68.97	79.31	80.90	74.14	75.83 G	81.33	83.03	79.90	85.50	82.44 D	10.13	9.52	8.97	9.48	9.53 AB
Mean	81.58 C	85.17 AB	85.94 A	83.12 BC		91.92	93.66	94.05	93.77		8.78 A	7.97 BC	7.78 C	8.38 B	
LSD value for different sources =2.080						LSD value for various soaking durations= 3.122					LSD value for different sources =0.2453				
LSD value for various soaking durations=2.327											LSD value for various soaking durations= 0.4876				

Values followed by different letters are significantly different at P ≤ 0.01 level (upper case) according to LSD test.

Table 2. Effect of various priming sources and soaking durations on number of days to flowering, plant height (cm) and number of leaves per plant of okra.

Soaking duration (h)	Sources for days to flowering					Sources for plant height (cm)					Sources for number of leaves per plant				
	Distilled water	DAP	SSP	SSP + Na_2CO_3	Mean	Distilled water	DAP	SSP	SSP + Na_2CO_3	Mean	Distilld water	DAP	SSP	SSP + Na_2CO_3	Mean
0	44.76	45.93	43.60	45.41	44.93^{A}	108.46	115.47	120.43	110.90	113.81^{G}	20.15^{m-r}	20.52^{m-r}	21.89^{k-p}	21.43^{l-q}	20.99^{F}
4	38.05	35.87	35.90	39.80	37.40^{D}	118.66	125.24	126.17	122.70	123.20^{EF}	21.40l-q	23.32^{j-m}	24.33^{i-l}	22.54^{k-o}	22.88^{E}
8	38.82	34.41	33.63	36.81	35.92^{E}	119.97	127.07	135.15	125.90	127.02^{DE}	24.41^{ijk}	25.87^{hij}	26.04^{hij}	23.18^{j-m}	24.87^{D}
12	35.10	32.08	30.55	34.78	33.13^{G}	121.73	134.30	136.47	135.77	132.07^{D}	25.74^{hij}	27.38^{fgh}	29.03^{efg}	26.56^{ghi}	27.17^{C}
16	32.07	30.75	29.04	32.55	31.10^{H}	134.43	141.87	149.98	142.60	142.22^{C}	29.82^{def}	30.60^{cde}	31.84^{b-e}	29.06^{efg}	30.23^{B}
20	31.55	29.60	28.20	31.61	30.24^{HI}	136.57	160.03	163.77	151.07	152.86^{B}	30.23^{def}	33.48^{abc}	34.55^{ab}	32.50^{cd}	32.51^{A}
24	30.12	28.87	27.73	30.55	29.32^{I}	140.13	172.27	168.10	163.80	161.08^{A}	30.33^{def}	34.70^{ab}	36.13^{a}	34.10^{ab}	33.82^{A}
28	35.98	31.85	29.77	33.76	32.84^{G}	141.73	134.10	159.87	130.97	141.67^{C}	26.07^{hij}	27.63^{fgh}	30.73^{cde}	25.93^{hij}	27.59^{C}
32	35.86	32.65	32.40	36.47	34.35^{F}	120.26	130.57	144.10	128.73	130.92^{D}	20.08^{o-t}	24.10^{i-l}	26.55^{ghi}	24.03^{i-l}	23.69^{DE}
36	37.47	34.83	34.47	37.03	35.95^{E}	118.26	127.33	133.20	127.63	126.60^{E}	19.02^{p-v}	22.60^{k-o}	25.97^{hij}	23.13^{j-n}	22.68^{E}

Table 2. Contd.

40	38.05	35.87	35.90	39.80	37.40^{D}	116.66	125.24	127.17	122.97	123.01^{EF}	18.57^{q-v}	21.41^{l-q}	22.33^{k-o}	21.73^{k-p}	21.01^{F}
44	41.06	37.43	37.55	40.88	39.23^{C}	113.12	120.37	124.40	119.50	119.35^{FG}	17.52^{s-v}	20.20^{n-s}	19.23^{p-u}	17.97^{r-v}	18.73^{G}
48	41.78	40.19	38.72	41.61	40.57^{B}	116.68	122.03	117.90	112.70	117.33^{FG}	17.07^{uv}	17.22^{tuv}	18.19^{r-v}	16.12^{v}	17.15^{H}
Mean	36.97^{A}	34.64^{B}	33.65^{B}	36.66^{A}		123.58^{C}	133.53^{AB}	138.97^{A}	130.40^{B}		22.92^{C}	25.29^{B}	26.69^{A}	24.35^{B}	
LSD value for different sources =1.565						LSD value for different sources =6.675					LSD value for different sources =1.280				
LSD value for various soaking durations=1.065						LSD value for various soaking durations=6.871					LSD value for various soaking durations= 1.476				
											LSD value for interaction= 2.952				

Values followed by different letters are significantly different at P≤ 0.05 level (lower case) and P ≤ 0.01 level (upper case) according LSD test.

Table 3. Effect on various priming sources and soaking durations on number of pods per plant, pod length (cm) and number of seed per pod of okra.

Soaking duration (h)	Sources for number pods per plant					Sources for pod length (cm)					Sources for number of seed per pod				
	Distilled water	DAP	SSP	SSP + Na_2CO_3	Mean	Distilled water	DAP	SSP	SSP + Na_2CO_3	Mean	Distilled water	DAP	SSP	SSP + Na_2CO_3	Mean
0	19.97^{xyz}	19.18^{yz}	20.11^{xyz}	20.77^{xyz}	20.01^{I}	9.3^{q-u}	9.9^{m-s}	9.8^{n-t}	9.6^{p-u}	9.6^{EF}	34.3^{wxy}	32.3^{y}	35.5^{v-y}	36.0^{v-y}	35.52^{IJ}
4	21.39^{v-y}	31.14^{ijk}	31.56^{ijk}	$27.78l^{-p}$	27.97^{E}	9.1^{r-u}	10.9^{g-l}	11.4^{c-j}	8.6^{u}	9.9^{DE}	41.8^{r-u}	$49.3i^{-p}$	50.9^{i-m}	46.2^{n-r}	47.06^{FG}
8	22.33^{u-x}	32.01^{hij}	32.53^{ghi}	$29.78j^{-m}$	29.16^{E}	9.7^{o-t}	11.0^{f-l}	11.6^{a-i}	8.7^{tu}	10.2^{D}	46.5^{m-r}	50.8^{i-n}	54.5^{c-i}	47.2^{m-q}	49.75^{DE}
12	28.45^{lmn}	34.01^{e-h}	35.18^{def}	32.87^{f-i}	32.63^{D}	10.6^{i-p}	11.7^{a-i}	11.8^{a-g}	10.3^{k-q}	11.1^{C}	49.1^{j-p}	53.2^{f-k}	56.4^{c-g}	51.2^{h-n}	52.46^{C}
16	29.85^{jkl}	36.19^{cde}	37.04^{cd}	32.87^{f-i}	33.99^{C}	11.7^{a-h}	11.5^{b-i}	12.6^{ab}	12.1^{a-e}	11.9^{A}	53.6^{e-j}	56.3^{c-g}	58.3^{a-e}	52.6^{f-l}	55.22^{B}
20	31.94^{hij}	38.44^{c}	42.46^{b}	34.53^{efg}	36.84^{B}	10.9^{g-m}	10.6^{i-p}	12.1^{a-f}	11.8^{a-g}	11.3^{BC}	56.1^{c-h}	57.5^{c-f}	63.1^{a}	54.1^{d-j}	57.71^{AB}
24	33.17^{f-i}	43.06^{ab}	45.26^{a}	36.08^{cde}	39.39^{A}	11.2^{d-k}	12.6^{a}	12.4^{abc}	$11.^{7a-h}$	11.8^{AB}	58.7^{a-d}	61.5^{ab}	59.3^{abc}	58.5^{a-e}	59.49^{A}
28	27.37^{m-q}	29.24^{klm}	31.56^{ijk}	27.54^{l-q}	28.93^{E}	11.1^{e-k}	11.6^{a-i}	11.5^{a-i}	12.2^{a-d}	11.5^{ABC}	47.0^{m-q}	51.5^{g-m}	54.5^{c-i}	50.2^{i-o}	50.79^{CD}
32	26.02^{o-s}	26.03^{n-s}	28.02^{l-o}	25.20^{q-t}	26.32^{F}	9.9^{l-r}	12.2^{a-d}	10.6^{i-p}	11.0^{f-l}	10.9^{C}	45.5^{o-r}	46.9^{m-q}	$50.4i^{-o}$	47.8^{l-q}	47.63^{EF}
36	23.50^{t-w}	26.01^{o-s}	$28.02l^{-o}$	25.18^{q-t}	25.68^{F}	10.7^{g-n}	11.4^{c-j}	11.2^{d-k}	11.8^{a-g}	11.2^{BC}	43.9^{qrs}	44.5^{p-s}	48.3^{k-q}	43.7^{qrs}	45.08^{G}
40	20.47^{xyz}	25.42^{p-t}	26.34^{n-r}	23.94^{r-u}	24.04^{G}	9.9^{m-s}	9.6^{o-u}	10.2^{k-q}	8.6^{u}	9.5^{EF}	41.7^{r-u}	39.76^{s-v}	43.4^{q-t}	38.7^{t-w}	40.89^{H}
44	20.20^{xyz}	21.21^{w-z}	23.53^{t-w}	23.80^{s-v}	22.18^{H}	9.6^{o-u}	10.7^{h-o}	9.3^{q-u}	10.2^{k-q}	9.9^{DE}	38.7^{t-w}	36.8^{u-y}	34.4^{xy}	35.9^{v-y}	36.45^{I}
48	18.83^{z}	17.45^{z}	21.47^{v-y}	19.37^{yz}	19.28^{I}	10.4^{j-q}	8.8^{stu}	8.9^{r-u}	9.3^{q-u}	9.3^{F}	33.3^{xy}	33.1^{xy}	33.1^{xy}	33.8^{wxy}	33.31^{J}
Mean	24.88^{C}	29.18^{AB}	31.01^{A}	27.67^{BC}		10.2^{B}	10.9^{A}	11.0^{A}	10.4^{B}		45.4^{B}	47.2^{AB}	49.5^{A}	45.8^{B}	
LSD value for different sources =2.987						LSD value for different sources =0.3725					LSD value for different sources =2.722				
LSD value for various soaking durations=1.213						LSD value for various soaking durations=0.5460					LSD value for various soaking durations= 2.520				
LSD value for interaction= 2.247						LSD value for interaction= 1.092					LSD value for interaction= 5.040				

Values followed by different letters are significantly different at P≤ 0.05 level (lower case) and P ≤ 0.01 level (upper case) according LSD test.

Table 3. Effect on various priming sources and soaking durations on number of pods per plant, pod length (cm) and number of seed per pod of okra.

Soaking duration (h)	Sources for number pods per plant					Sources for pod length (cm)					Sources for number of seed per pod				
	Distilled water	DAP	SSP	SSP + Na_2CO_3	Mean	Distilled water	DAP	SSP	SSP + Na_2CO_3	Mean	Distilled water	DAP	SSP	SSP + Na_2CO_3	Mean
0	19.97^{xyz}	19.18^{yz}	20.11^{xyz}	20.77^{xyz}	20.01 ^{I}	9.3^{q-u}	9.9^{m-s}	9.8n-t	9.6^{p-u}	9.6 ^{EF}	34.3^{wxy}	32.3^{y}	35.5^{v-y}	36.0^{v-y}	35.52^{IJ}
4	21.39^{v-y}	31.14^{ijk}	31.56^{ijk}	27.78^{l-p}	27.97 ^{E}	9.1^{r-u}	10.9^{g-l}	11.4c-j	8.6^{u}	9.9 ^{DE}	41.8^{r-u}	49.3^{i-p}	50.9^{i-m}	46.2^{n-r}	47.06^{FG}
8	22.33^{u-x}	32.01^{hij}	32.53^{ghi}	29.78^{j-m}	29.16 ^{E}	9.7^{o-t}	11.0^{f-l}	11.6^{a-i}	8.7^{tu}	10.2 ^{D}	46.5^{m-r}	50.8^{i-n}	54.5^{c-i}	47.2^{m-q}	49.75^{DE}
12	28.45^{lmn}	34.01^{e-h}	35.18^{def}	32.87^{f-i}	32.63 ^{D}	10.6^{i-p}	11.7^{a-i}	11.8^{a-g}	10.3^{k-q}	11.1 ^{C}	49.1^{j-p}	53.2^{f-k}	56.4^{c-g}	51.2^{h-n}	52.46^{C}
16	29.85^{jkl}	36.19^{cde}	37.04^{cd}	32.87^{f-i}	33.99 ^{C}	11.7^{a-h}	11.5^{b-i}	12.6^{ab}	12.1^{a-e}	11.9 ^{A}	53.6^{e-j}	56.3^{c-g}	58.3^{a-e}	52.6^{f-l}	55.22^{B}
20	31.94^{hij}	38.44^{c}	42.46^{b}	34.53^{efg}	36.84 ^{B}	10.9g^{-m}	10.6^{i-p}	12.1^{a-f}	11.8^{a-g}	11.3 ^{BC}	56.1^{c-h}	57.5^{c-f}	63.1^{a}	54.1^{d-j}	57.71^{AB}
24	33.17^{f-i}	43.06^{ab}	45.26^{a}	36.08^{cde}	39.39 ^{A}	11.2^{d-k}	12.6^{a}	12.4^{abc}	11.7^{a-h}	11.8 ^{AB}	58.7^{a-d}	61.5^{ab}	59.3^{abc}	58.5^{a-e}	59.49^{A}
28	27.37^{m-q}	29.24^{klm}	31.56^{ijk}	27.54^{l-q}	28.93 ^{E}	11.1^{e-k}	11.6^{a-i}	11.5^{a-i}	12.2^{a-d}	11.5 ^{ABC}	47.0^{m-q}	51.5^{g-m}	54.5^{c-i}	50.2^{i-o}	50.79^{CD}
32	26.02^{o-s}	26.03^{n-s}	28.02^{l-o}	25.20^{q-t}	26.32 ^{F}	9.9^{l-r}	12.2^{a-d}	10.6^{i-p}	11.0^{f-l}	10.9 ^{C}	45.5^{o-r}	46.9^{m-q}	50.4^{i-o}	47.8^{l-q}	47.63^{EF}
36	23.50^{t-w}	26.01^{o-s}	28.02^{l-o}	25.18^{q-t}	25.68 ^{F}	10.7^{g-n}	11.4^{c-j}	11.2^{d-k}	11.8^{a-g}	11.2 ^{BC}	43.9^{qrs}	44.5^{p-s}	48.3^{k-q}	43.7^{qrs}	45.08^{G}
40	20.47^{xyz}	25.42^{p-t}	26.34^{n-r}	23.94^{r-u}	24.04 ^{G}	9.9^{m-s}	9.6^{o-u}	10.2^{k-q}	8.6^{u}	9.5 ^{EF}	41.7^{r-u}	39.76^{s-v}	43.4^{q-t}	38.7^{t-w}	40.89^{H}
44	20.20^{xyz}	21.21^{w-z}	23.53^{t-w}	23.80^{s-v}	22.18 ^{H}	9.6^{o-u}	10.7^{h-o}	9.3^{q-u}	10.2^{k-q}	9.9 ^{DE}	38.7^{t-w}	36.8^{u-y}	34.4^{xy}	35.9^{v-y}	36.45^{I}
48	18.83^{z}	17.45^{z}	21.47^{v-y}	19.37^{yz}	19.28 ^{I}	10.4^{j-q}	8.8^{stu}	8.9^{r-u}	9.3^{q-u}	9.3 ^{F}	33.3^{xy}	33.1^{xy}	33.1^{xy}	33.8^{wxy}	33.31^{J}
Mean	24.88^{C}	29.18^{AB}	31.01^{A}	27.67^{BC}		10.2^{B}	10.9^{A}	11.0^{A}	10.4^{B}		45.4 ^{B}	47.2 ^{AB}	49.5 ^{A}	45.8 ^{B}	
LSD value for different sources =2.987						LSD value for different sources =0.3725					LSD value for different sources =2.722				
LSD value for various soaking durations=1.213						LSD value for various soaking durations=0.5460					LSD value for various soaking durations= 2.520				
LSD value for interaction= 2.247						LSD value for interaction= 1.092					LSD value for interaction= 5.040				

Values followed by different letters are significantly different at P≤ 0.05 level (lower case) and P ≤ 0.01 level (upper case) according LSD test.

Table 4. Effect of various priming sources and soaking durations on pod yield (kg ha^{-1}) of okra.

Soaking durations (h)	Sources for pod yield (kg ha^{-1})				
	Distilled water	DAP	SSP	SSP + Na_2CO_3	Mean
0	1567.6^{r-v}	1620.4^{q-u}	1656.5^{q-t}	1549.1^{r-v}	1598.4^{H}
4	2248.0^{klm}	1647.5^{q-t}	1930.8^{nop}	2492.2^{jkl}	2079.6^{F}
8	2631.2^{j}	2593.7^{j}	2956.7^{i}	2558.5^{j}	2685.0^{D}
12	3026.3^{i}	3306.7^{gh}	3479.1^{efg}	3513.2^{efg}	3331.3^{C}
16	3089.2^{hi}	3472.6^{efg}	3437.4^{efg}	3650.4^{c}	3412.4^{C}
20	3373.7^{fg}	3865.9^{cd}	3883.1^{cd}	3922.5^{b}	3761.3^{B}
24	3615.7^{def}	4840.6^{a}	5063.5^{a}	4526.2^{ij}	4511.5^{A}
28	2236.7^{lm}	3005.2^{i}	3010.6^{i}	2561.3^{jk}	2703.4^{D}
32	1837.8^{opq}	3068.6^{hi}	2668.9^{j}	2514.2^{klm}	2522.4^{E}
36	1765.9^{pqr}	2531.9^{j}	2085.1^{mno}	2146.2^{mn}	2132.3^{F}

Table 4. Contd.

40	1627.9^{q-u}	2466.2jkl	1753.1^{p-s}	1873.2 ^{opq}	1930.1^{G}
44	1491.6^{s-w}	1481.5^{t-w}	1652.8^{q-t}	1640.1^{q-t}	1566.5^{H}
48	1366.5^{uvw}	1547.8^{r-v}	1457.4^{t-w}	1274.4^{w}	1411.5^{I}
Mean	2293.7^{B}	2688.4^{A}	2702.7^{A}	2617.0^{A}	
LSD value for different sources =313.0					
LSD value for various soaking durations=134.1					
LSD value for interaction= 268.1					

Values followed by different letters are significantly different at P≤ 0.05 level (lower case) and P ≤ 0.01 level (upper case) according LSD test.

Table 5. ANOVA for germination percentage (%).

S.O.V	Degree of freedom	Sum of squares	Mean square	F value	Probability
Replication	2	66.779	33.390	2.369	0.174
Sources	3	457.636	152.545	10.823	0.017*
Error 1	6	84.571	14.095		
Soaking durations	12	3295.272	274.606	33.308	0.009**
S x S.D	36	303.516	8.431	1.023	0.451
Error 2	96	791.457	8.244		
Total	155	4999.231	32.253		

Coefficient of variation 1 = 4.5%; coefficient of variation 2 = 3.4%.

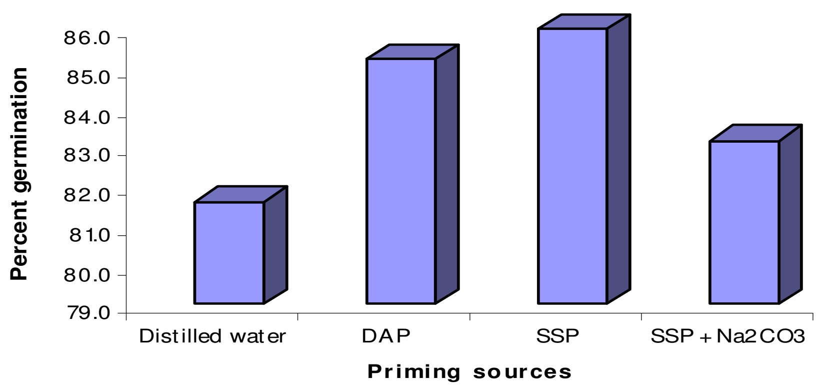

Figure 1. Effect of different priming sourceson germination percentage of okra.

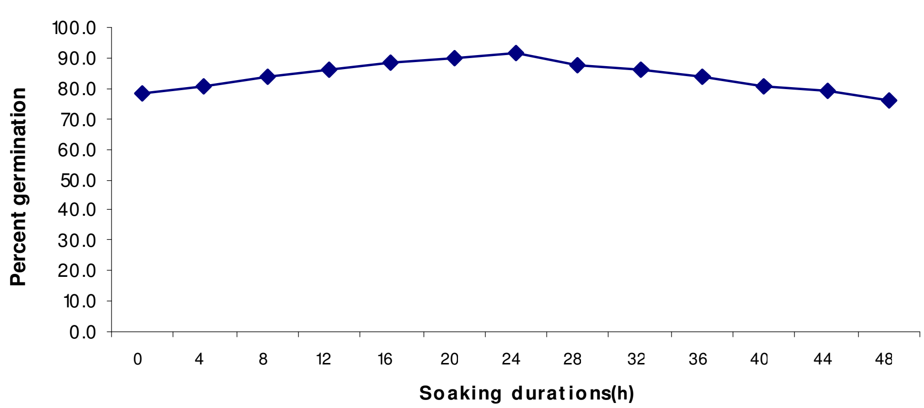

Figure 2. Effect of various soaking durations on germination percentage of okra.

Table 6. ANOVA for survival percentage (%).

S.O.V	Degree of freedom	Sum of squares	Mean square	F value	Probability
Replication	2	110.455	55.227	2.746	0.142
Sources	3	109.864	36.621	1.821	0.244
Error 1	6	120.662	20.110		
Soaking durations	12	3323.805	276.984	18.657	0.018*
SxS.D	36	591.390	16.427	1.107	0.341
Error 2	96	1425.243	14.846		
Total	155	5681.419	36.654		

Coefficient of variation 1 = 4.8%; coefficient of variation 2 = 4.1%.

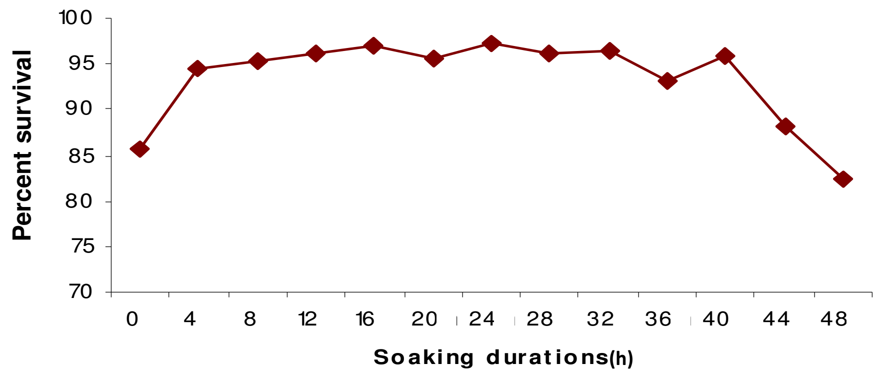

Figure 3. Effect of various soaking durations on survival percentage of okra.

Table 7. ANOVA for number of days to germination.

S.O.V	Degree of freedom	Sum of squares	Mean square	F value	Probability
Replication	2	0.778	0.389	1.981	0.218
Sources	3	23.371	7.790	39.655	0.012*
Error 1	6	1.179	0.196		
Soaking durations	12	160.342	13.362	36.884	0.016*
SxS.D	36	7.065	0.196	0.542	0.980
Error 2	96	34.778	0.362		
Total	155	227.513	1.468		

Coefficient of variation 1 = 5.4%; coefficient of variation 2 = 7.3%.

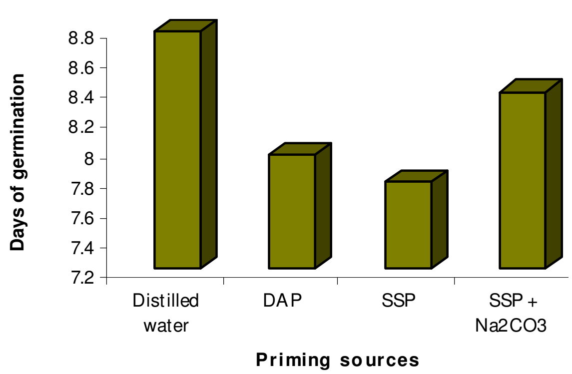

Figure 4. Effect of different priming sources on days to germination of okra.

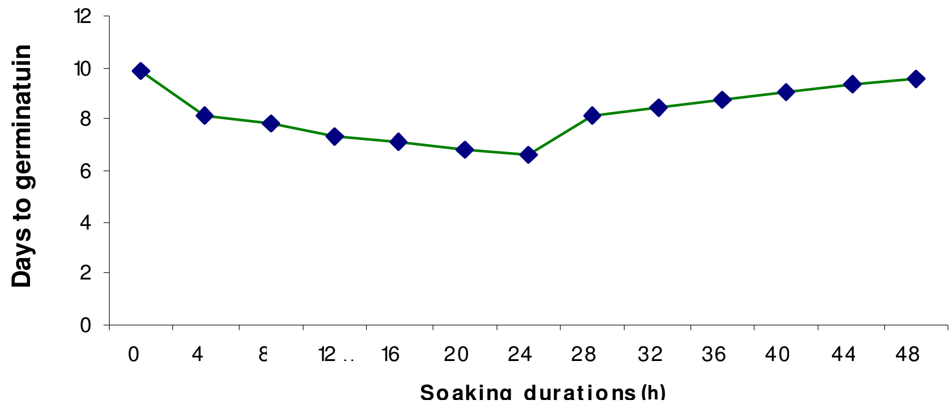

Figure 5. Effect of different priming sources on days to germination of okra.

Table 8. ANOVA for number of days to flowering.

Sources of var.	Degree of freedom	Sum of squares	Mean square	F value	Probability
Replication	2	7.481	3.741	0.469	0.647
Sources	3	296.048	98.683	12.365	0.009**
Error 1	6	47.884	7.981		
Soaking durations	12	2780.620	231.718	134.073	0.013*
SxS.D	36	82.776	2.299	1.330	0.137
Error 2	96	165.917	1.728		
Total	155	3380.727	21.811		

Coefficient of variation 1 = 7.9%; coefficient of variation 2 = 3.7%.

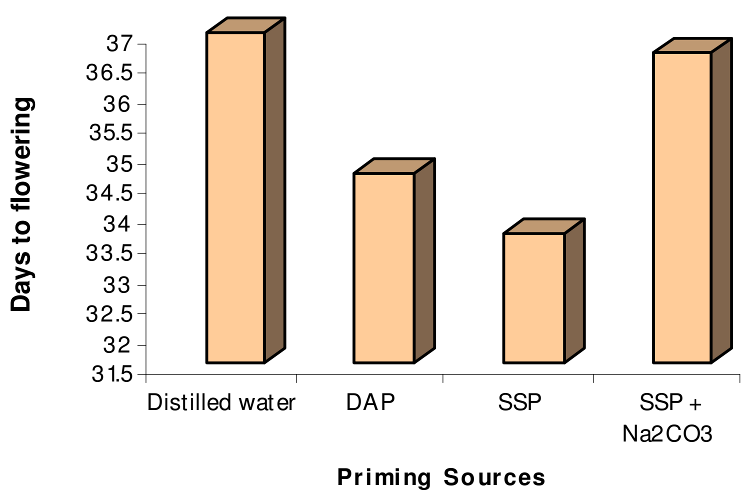

Figure 6. Effect of different priming source on days to flowering of okra.

different crops that the effects of soaking increased the number of tillers m^{-2} and leaf area index than control. They correlated these improvements with the faster and uniform emergence and better seedling vigor and growth of the primed seeds. Same is true in that improved germination and well established seedlings from primed seed led to more efficient nutrient absorption and light utilization, hence resulted in more vegetative growth.

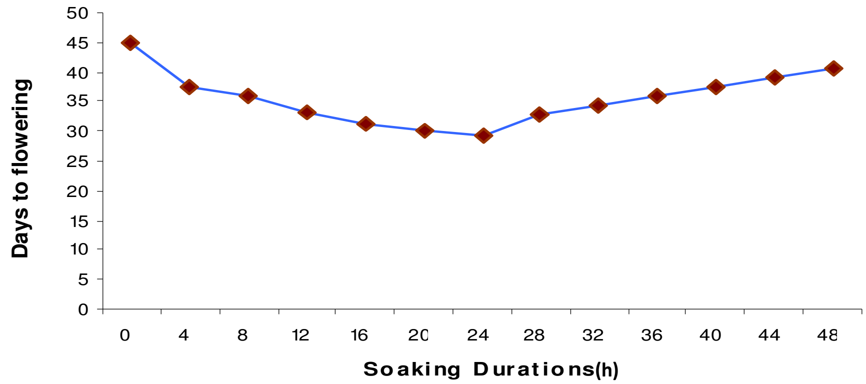

Figure 7. Effect of various soaking duration on days to flowering of okra.

Table 9. ANOVA for plant height (cm).

S.O.V	Degree of freedom	Sum of squares	Mean square	F value	Probability
Replication	2	1103.962	551.981	3.804	0.086
Sources	3	6562.768	2187.589	15.075	0.007**
Error 1	6	870.689	145.115		
Soaking durations	12	41446.172	3453.848	48.041	0.015*
SxS.D	36	3570.597	99.183	1.380	0.110
Error 2	96	6901.770	71.893		
Total	155	60455.958	390.038		

Coefficient of variation 1 = 9.2%; coefficient of variation 2 = 6.4%.

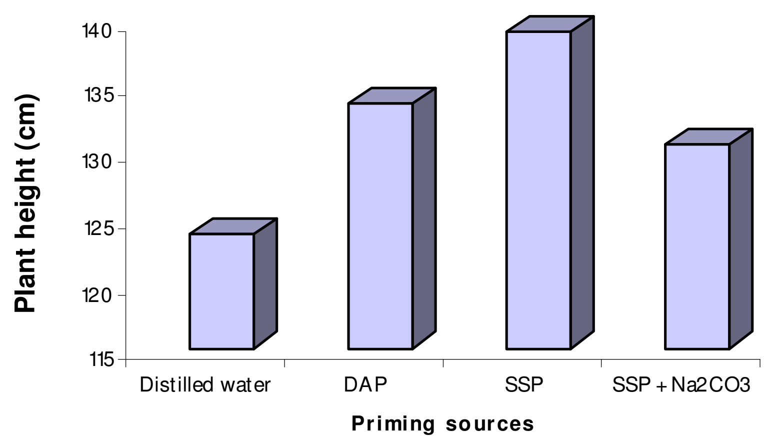

Figure 8. Effect of different priming source on plant height of okra.

Number of pod per plant

Table 11 shows that various priming sources, soaking durations as well as their interaction significantly affected number of pods per plant. Data presented in Table 3 shows that maximum (31.01) number of pods per plant was recorded in plot in which seeds were soaked in SSP solution, followed by (29.18) number of pods per plant in plot in which seeds were soaked in DAP solution. The lowest number of (24.88) pod per plant was recorded in distilled water. Likewise, results of various soaking durations showed that maximum number of pods per plant (39.39) was noted in plot in which seeds were soaked for 24 h, followed by (36.84) number of pods per

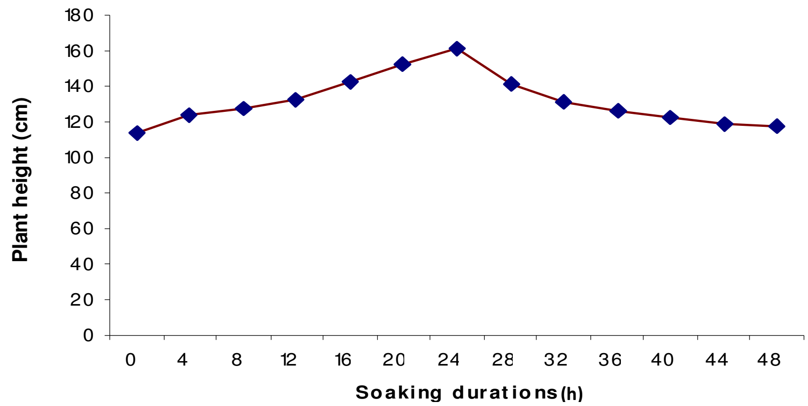

Figure 9. Effect of various soaking durations on plant height.

Table 10. ANOVA for number of leaves per plant.

Sources of var.	Degree of freedom	Sum of squares	Mean square	F value	Probability
Replication	2	1.145	0.572	0.107	0.900
Sources	3	294.578	98.193	18.400	0.022*
Error 1	6	32.020	5.337		
Soaking durations	12	3870.210	322.517	97.221	0.008**
SxS.D	36	121.245	3.368	1.015	0.032
Error 2	96	318.468	3.317		
Total	155	4637.664	29.920		

Coefficient of variation 1 = 9.3%; coefficient of variation 2 = 7.3%.

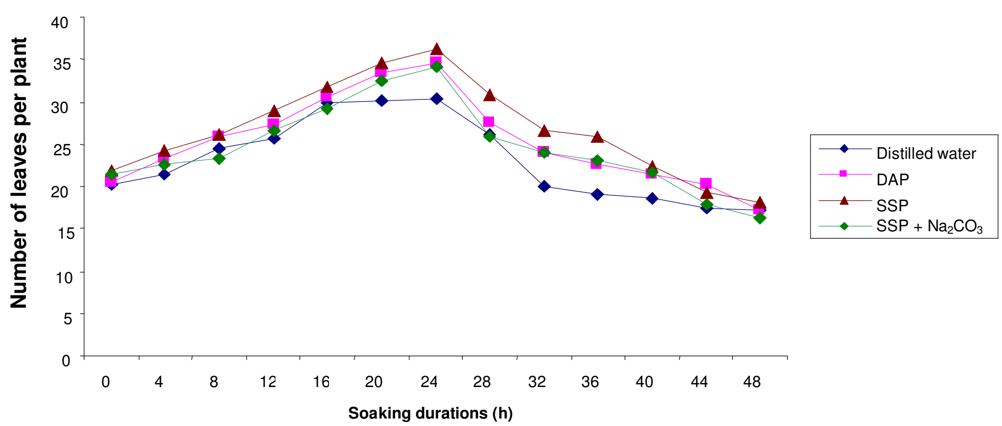

Figure 9. Effect of various priming sources and soaking durations on plant number of leaves per plant of okra.

plant in plot in which seeds were soaked for 20 h. Minimum number of pods per plant (19.28) was recorded in plot in which seeds were soaked for 48 h. Their interaction results (Figure 11) indicate that highest number of (45.26) pods per plant was produced in plot received seed soaked for 24 h in SSP solution, followed by (43.06) number of pods per plant in plot with seed primed for 24 h in DAP solution. Minimum number of pods per plant (17.45) was noted in plot having plants produced from seeds soaked for 48 h in DAP solution.

Number of pods per plant is a major component which determines the final yield. Numbers of pod has direct

Table 11. ANOVA for number of pods per plant.

Sources	Degree of freedom	Sum of squares	Mean square	F value	Probability
Replication	2	27.376	13.688	0.471	0.646
Sources	3	784.742	261.581	9.005	0.028*
Error 1	6	174.298	29.050		
Soaking durations	12	5574.883	464.574	207.244	0.009**
SxS.D	36	467.578	12.988	5.794	0.027*
Error 2	96	215.200	2.242		
Total	155	7244.077	46.736		

Coefficient of variation 1 = 19.1%; coefficient of variation 2 = 5.3%.

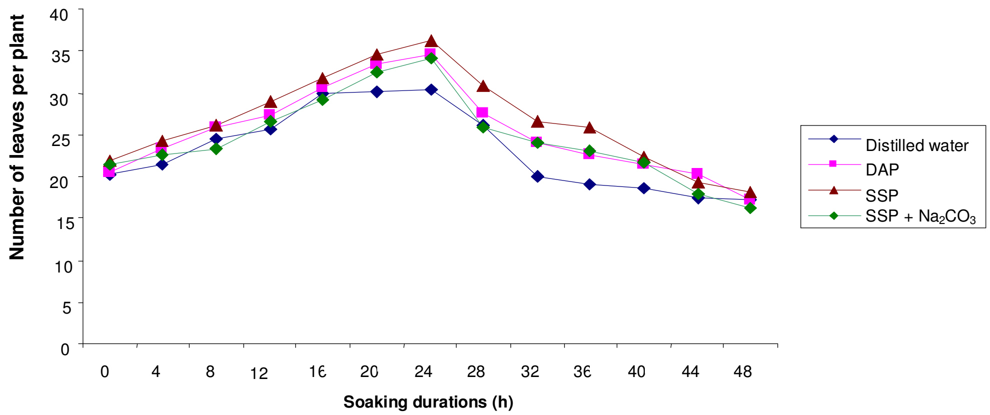

Figure 10. Effect of various priming sources and soaking durations on plant number of leaves per plant of okra.

Table 12. ANOVA for pod length (cm).

Source of var.	Degree of freedom	Sum of squares	Mean square	F value	Probability
Replication	2	2.928	1.464	3.237	0.111
Sources	3	17.009	5.670	12.539	0.008**
Error 1	6	2.713	0.452		
Soaking durations	12	121.505	10.125	22.322	0.024*
SxS.D	36	59.921	1.664	3.669	0.018*
Error 2	96	43.547	0.454		
Total	155	247.622	1.598		

Coefficient of variation 1 = 6.3%; coefficient of variation 2 = 6.3%.

relationship with number of leaves. In this case, the higher number of leaves may have resulted in more number of pods per plant. Priming effect on seed emergence and further on the seedling growth and vigor may have been translated to higher number of leaves and hence more pod production. Ullah et al. (2002b) also reported the same kind of findings from which priming increased yield parameters in raya like number of primary branches per plant and number of pods per plant.

Pod length (cm)

Various soaking sources, durations and their interaction significantly affected pod legth in okra (Table 12). The longest pod (11.0 cm) was recorded in plot with seeds soaked in SSP solution (Table 3), traced by (10.9 cm) pod length in plot received seeds primed in DAP solution, while the shortest pod (10.2 cm) was recorded with distilled water plot. In the similar way results of various

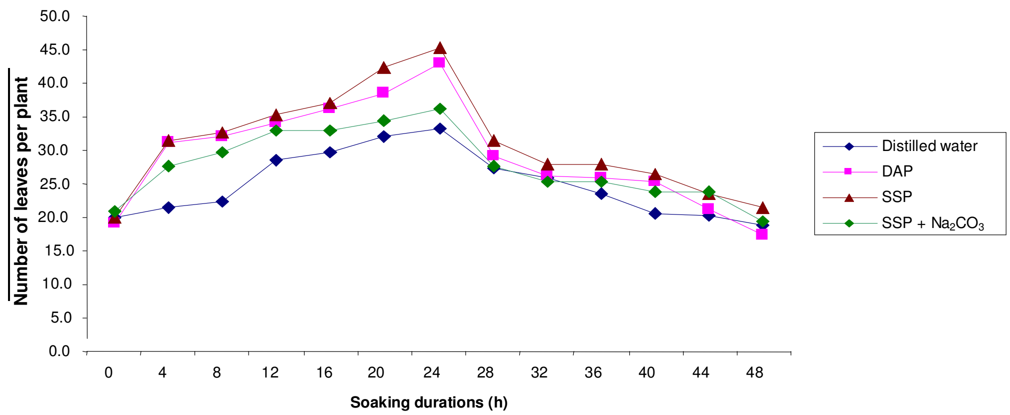

Figure 11. Effect of various priming sources and soaking durations on number of pods per plant of okra.

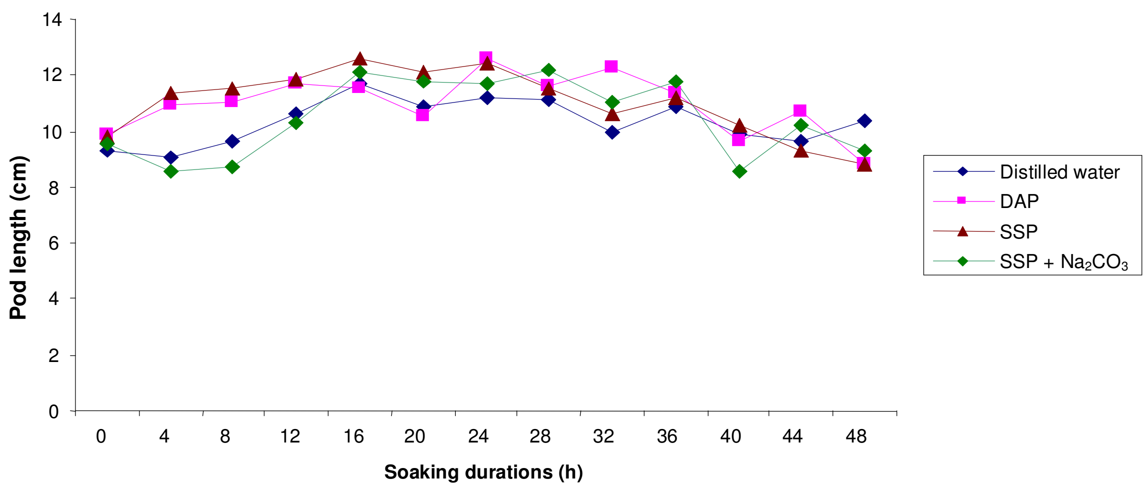

Figure 12. Effect of various priming sources and soaking durations on pod per plant of okra.

soaking durations showed that maximum pod length (11.9 cm) was recorded in plot in which seeds were soaked for 16 h, followed by (11.8 cm) pod length in plot in which seeds were soaked for 24 h, while minimum pod length (9.3 cm) was recorded in plot in which seeds were soaked for 48 h. Likewise, in their interaction (Figure 12) the longest pod (12.6 cm) was found in plot having seeds soaked for 16 h in SSP solution, followed by (12.40 cm) pod length in plot of seeds soaked for 24 h in DAP solution and the shortest pod (8.44 cm) was recorded in plot having seed soaking for 4 h in SSP+ Na_2CO_3 solution.

Pod length is a tone character for economic yield which may depend on enviormental factors and genetic makeup. Here, the reason could be the earlier germination, better seedling vigor and production in primed seed sown plots. These findings confirm the work of Harris et al. (2001) and Saikia et al. (2006) who documented larger ear production in wheat following priming.

Number of seeds per pod

Table 13 indicates that the priming source, soaking durations and interaction effect of P solution and times of priming were significant. Data in Table 3 shows that maximum number of seeds per pod (49.52) were in plot having seeds soaked in SSP solution, followed by (47.20) number of seeds per pod in plot with seeds soaked in DAP solution. Minimum number of seeds per pod (45.40) was recorded in distilled water soaked seeds plot. Results of various soaking durations revealed that 24 h seed soaking gave maximum number of seeds per pod (59.49), followed by 20 h seed priming duration with 57.71 number of seeds per pod, while 48 h priming

Table 13. ANOVA for number of seeds per pod.

Sources	Degree of freedom	Sum of squares	Mean square	F value	Probability
Replication	2	134.013	67.006	2.776	0.140
Sources	3	346.942	115.647	4.792	0.049*
Error 1	6	144.808	24.135		
Soaking durations	12	9269.744	772.479	79.867	0.025*
SxS.D	36	732.974	20.360	2.105	0.011*
Error 2	96	928.513	9.672		
Total	155	11556.994	74.561		

Coefficient of variation 1 = 10.5%; coefficient of variation 2 = 6.6 %.

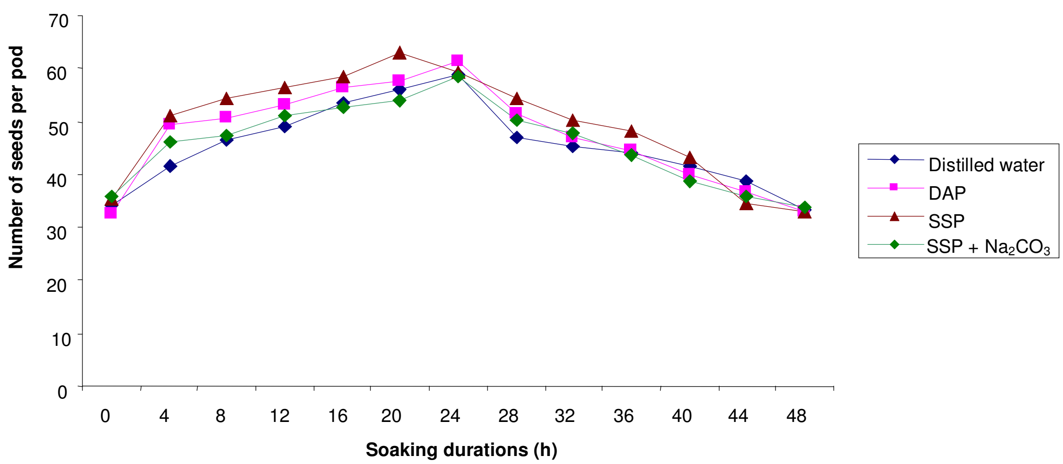

Figure 13. Effect of different priming sources and soaking durations on number of seed per pod of okra.

resulted in the lowest number of seeds per pod (33.31). Regarding their interaction (Figure 13), the highest number of seeds per pod (63.06) was recorded in plot in which seeds were soaked for 20 h in SSP solution, traced by 61.54 number of seeds per pod in plot in which seeds were soaked for 24 h in DAP solution. The lowest number of seeds per pod (32.24) was recorded in un-primed seed plot.

Probable reason of these findings could be that nutrient seed priming improve okra performance. It not only affected its vegetative characters, but also reproductive ones. The vigorous seedling led to healthy plant with early flowering, many leaves and pods and also longer pods with more number of seeds per pod compared to un-primed seeds. These results are in line with the findings of Khan et al. (1992), Ullah et al. (2002b), Basra et al. (2003) and Rashid et al. (2004), who reported in different field crops that priming enhanced grains per pod.

Pod yield (kg ha^{-1})

Various soaking sources, durations and their interaction significantly affected pod yield in okra (Table 14). Data presented in Table 4 show that maximum pod yield per hectare (2702.7 kg) was recorded in plot having seeds soaked in SSP solution, followed by 2688.4 kg yield per hectare in plot with seeds primed in DAP solution. Minimum pod yield per hectare (2293.7 kg) was recorded in distilled water plot. Results of various soaking durations indicated that 24 h seed soaking gave the highest pod yield per hectare (4511.5 kg); traced by 20 h priming with 3761.3 kg pod yield per hectare, while 48 h seed soaking resulted in the least pod yield per hectare (1411.5 kg). Likewise, in their interaction (Figure 14), maximum pod yield per hectare (5063.5 kg) was recorded in plot in which seeds were soaked for 24 h in SSP solution, followed by 4840.63 kg pod yield per hectare in plots in which seed soaked for 24 h in DAP solution. Minimum pod yield per hectare (1274.4 kg) was recorded in plot in which seeds were soaked for 48 h in SSP+Na_2CO_3 solution.

Yield is the key parameter in which both the scientists and the farmers are interested in. It depends upon both the environmental and genetic factors. In this experiment, while keeping the other conditions almost homogeneous, priming affected the yield. Priming speeded and synchronized seed germination, enhanced the seedling vigor and improved their vegetative and reproductive characters, which finally led to the higher yield.

Table 14. ANOVA for pod yield per hectare (kg).

S.O.V	Degree of freedom	Sum of squares	Mean square	F value	Probability
Replication	2	1337298.927	668649.5	2.096	0.204
Sources	3	4434479.233	1478160	4.633	0.053
Error 1	6	1914191.692	319031.9		
Soaking durations	12	108970937.2	9080911	331.776	0.011*
SxS.D	36	11644791.9	323466.4	11.818	0.016*
Error 2	96	2627575.270897	27370.58		
Total	155	130929274.207868	844705		

Coefficient of variation 1 = 21.8%; coefficient of variation 2 = 6.4%.

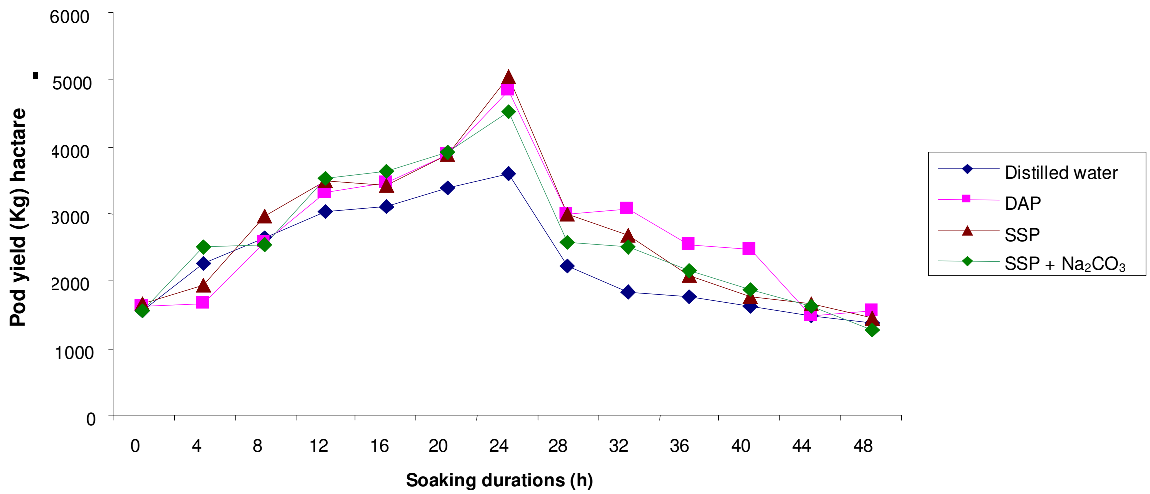

Figure 9. Effect of various priming sources and soaking durations on pod yield of okra.

Phosphorus priming may have satisfied the need of seeds for phosphorus in the early stage of the growth, which is usually unavailable in alkaline soil. This would results in more DNA and ATP production and hence would have triggered the metabolic processes. These findings are in line with the work of Zhang et al. (1998), Harris et al. (2001), Basra et al. (2003) and Arif et al. (2010), who reported that priming treatment significantly increased total biomass. Arif et al. (2010) analyzed the situation that yield in soybean, may be increased due to optimum P transferred to seedling just before germination that triggered faster growth and resulted in higher yield. Farooq et al. (2008) also documented that improved yield in wheat may be attributed to early germination and better stand establishment following seed priming.

CONCLUSIONS AND RECOMMENDATIONS

It has been concluded from the research work here that phosphorus seed priming resulted in early germination and produced more yield than un-primed and water primed seed. Seed priming using both SSP and DAP solutions performed almost equal and better. While with 24 h seed soaking duration total biomass got improved. But, performance got poorer with increasing soaking period beyond 24 h.

Hence, seed priming using SSP or DAP solution may be used for enhancing emergence, better seedling growth and higher yield in okra. Okra seed priming in either SSP or DAP fertilizer solutions can be recommend-ded to farmers, but usually SSP is more easily and cheaply available for them. Seed soaking duration should be upto 24 h. Moreover, research is needed to further unveil secretes of seed priming at molecular as well as physiological level.

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