Original Research Article

Effect of Pre-sowing Seed Treatments on Physiological Potential of Seed Germination in Okra

ABSTRACT

Aims: Okra is one of the economically important fruit vegetables with a potential to increase farm incomes. A quick germination and uniform crop stand establishment is essential for the efficient use of resources and success of any crop. However, okra seeds often have poor germination and field establishment and even do not germinate below 20°C. Therefore, the present investigation was performed to improve the germination potential of okra seed using different pre-sowing seed treatments.

Methodology: The seeds of okra cv. Pusa Sawani were soaked in two sets of water, PE6000 (-1.0MPa), GA_3 (100ppm) and KH_2PO_4 (1.5%). After a specified period of soaking one set of soaked seeds was dried to their initial moisture content (priming) while other set (soaking) was used directly for germination test. Seeds without soaking or priming were used as control. Treated seeds were kept in petri-dishes and placed in seed germinator at 25°C±2°C for their germination test.

Conclusion: Pre-sowing seed treatments significantly improved the percent, rapidity and uniformity of germination. Seed priming, particularly hydropriming was proved as superior to traditional seed soaking methods.

Key words: Okra, Seed germination, CVG, MGT, Z index

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INTRODUCTION

Okra (*Abelmoschus esculantus* L.) is one of the most important fruit vegetable worldwide and cultivated for its immature fruits (seed pods) generally 3 - 10 inches long, tapering, usually with ribs down its length. It is a good source of vitamin, protein, carbohydrates, fats and minerals and also have medicinal values for many diseases (Singh *et al*., 2014). India stands first in area and production with productivity of about 11.90 tonnes/h followed by Nigeria (Anonymous, 2018). However, the highest productivity is reported from Egypt followed by Saudi Arabia and

India. The area under okra cultivation in Jammu and Kashmir during 2017-18 was 3620 ha and with production of 14985 MT (Anonymous, 2018).

Okra prefers temperature between 22-35°C and susceptible to frost and temperatures below 12°C. The optimal temperature for seed germination, growth and fruit setting in okra is between 25 and 30°C while its seed do not germinate below 20°C. Okra often have poor seed germination and field establishment probably due to hard and impermeable seed coat (Luis-Felipe *et al*., 2010; Khan et al., 2017a), which prevents seed from absorbing water. One of the factors responsible for low okra yield is the poor stand establishment resulting from slow and uneven seed germination particularly in the early spring planting with commercial cultivars reaching only up to 66% initial germination (Sharma *et al.*, 2014).

Pre-sowing seed soaking and/or priming are among the known seed invigoration techniques (Khan et al., 2016, 2017b). Seed soaking allows seed to imbibe water before sowing but imbibition is uncontrolled. Generally seed soaking is practices for an overnight period and seeds are only visibly dried before sowing. However, in case of priming, important part is to dry the seed to original moisture content before sowing and imbibition of seed is controlled (Heydecker, 1973; Khan *et al* 2016). In this seeds are partially hydrated to a point where pre-germination metabolic activities start without actual germination by treating with different chemicals or growth regulators, and then re-dried until close to the original dry weight. However, information available with regard to comparative effectiveness of pre-sowing soaking and priming are scanty. Therefore, the present investigation was carried out to improve the seed germination potential through pre-sowing seed soaking and priming techniques and to determine the comparative efficacy of traditional seed soaking and priming techniques in improving the germination potential of okra.

MATERIALS AND METHODS

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The present study was carried out at Division of BSH, FoH, SKUAST-K during the year 2020-21. Two hundred seeds of okra cv. Pusa Sawani were weighed and soaked in water as well as in different chemical solutions *viz.*, PE6000 (-1.0MPa), GA_3 (100ppm) and KH_2PO_4 (1.5%). Half of the soaked seeds were used directly for germination test while rest half of the seeds were dried back to original seed weight (priming) and then used for germination test.

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Three replicates of 50 seeds were put in petri-dishes lined with 10 layers of filter paper and saturated with distilled water and placed in seed germinator at 25°C±2°C. Germination was observed daily according to the AOSA (1990) until a constant count was achieved. The final germination percentage (FGP), coefficient of velocity of germination (CVG), time to 50 percent seed germination (T_{50}), mean germination time (MGT), mean germination rate (MGR), synchrony of germination (Z-index) and germination index (GI) were calculated using equation I, (Al-Mudaris, 1998), II (Jones and Sanders, 1987), III (Coolbear et al., 1984), IV (Ellis and Roberts, 1981), V (Ranal et al., 2009), VI (Labouriau and Pacheco, 1978) and VII (Bench *et al*., 1991), respectively.

$$\text{FGP (\%)} = \frac{\text{No. of normal seedlings}}{\text{No. of seeds set for the test}} \times 100 \quad \text{..... (I)}$$

$$\text{CVG} = \frac{\sum_{i=1}^{k} niti}{\sum_{i=1}^{k} ni} \times 100 \quad \text{..... (II)}$$

Where, 'n' is the number of seeds germinated on every day and 't' is the number of days from seeding corresponding to 'n'.

$$T_{50} = T_i + \frac{(\frac{N+1}{2} - N_i)(T_j - T_i)}{N_j - N_i} \quad \text{..... (III)}$$

Where, N is the final number of germinated seeds, N_i and N_j are the total number of seeds germinated in adjacent counts at time T_i and T_i, respectively, when $N_i < (N+1)/2 < N_j$.

$$\text{MGT} = \frac{\sum(n \times d)}{N} \quad \text{(..... IV)}$$

Where, n = number of seeds germinated on each day, d = number of days from the beginning of the test, and N = total number of seeds germinated at the termination of the experiment.

$$\text{MGR (day}^{-1}) = \frac{\text{CV}}{100} = \frac{1}{\text{T}} \quad \text{(..... V)}$$

Where, T is mean germination time and CV is coefficient of velocity of germination.

$$Z = \frac{\sum_{i=1}^{k} \text{Cni,2}}{\sum \text{ni,2}} \quad \text{(..... VI)}$$

Where, Cni,2 is the combination of seeds germinated in the i^{th} time, two by two and ni is the number of seeds germinated in the i^{th} time.

$$\text{GI} = (10\times n1)+(9\times n2)+(8\times n3)+(7\times n4)+(6\times n5)+(5\times n6)+(4\times n7)+(3\times n8)+(2\times n9)+(1\times n1) \quad \text{(..... VII)}$$

Where, n1, n2, n3,……, n10 are the number of germinated seeds on the 1st, 2nd and subsequent days until the 10th day.

Comment [S4]: You have taken 200 seeds. Half of the soaked seeds were used directly for germination test while rest half of the seeds were dried back to original seed weight (priming) and then used for germination test. But three replication of 50 seeds. How?

Comment [S5]: In case of okra final count is 21 days. But you have taken upto 10days. Justify.....

Comment [S6]: In case of okra final count is 21 days. But you have taken upto 10days. You have to take the data upto 21days. Why 10 days.. Justify.....

The data obtained were averaged and statistical analyses (ANOVA) was performed to find out the significance of variation among the treatments.

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RESULTS AND DISCUSSION

FGP is an important physiological parameter which is generally used to assess the planting value of seeds. Pre-sowing seed treatments significantly ($p \leq 0.05$) alter the FGP in okra (Table 1). The maximum FGP (93.3%) was recorded with T1 followed by T2 and T4 with a seed germination value of 90.0% that were also statistically at par with FGP value of 88.0% recorded in T7 while as T6 recorded the least FGP value (78.30%) among all treatments against the minimum FGP value (65.0%) in untreated control seeds (T0). Further, average values of the two groups separately *viz*., seed soaking and priming indicated that pre-sowing seed soaking techniques were superior to seed priming in improving the FGP of okra. A lesser FGP in primed seeds may be attributed to a sort of stress experienced by the seeds during re-drying phase of priming. Moreover, growing embryo being a sensitive structure may be adversely affected by different chemicals used as priming agents that is why pure water soaking performed better than other treatments. Higher osmotic concentration can also reduce the germination percentage by altering the rate of water uptake (Aryal *et al*., 2020).

The coefficient of velocity of germination (CVG) gives an indication of the rapidity of germination (Jones and Sanders, 1987). Theoretically, the highest CVG possible is 100 and this would occur if all seeds germinated on the first day. In the present study (Table 1) the maximum CVG value (87.343 % day^{-1}) was recorded with T5 which was significantly followed by T6, T7 and T1 with measured CVG values of 77.14, 76.18 and 75.69% day^{-1}, respectively against a minimum value of CVG (39.56% day^{-1}) in control. Among the treated seeds, T3 showed the least value of CVG (59.47% day^{-1}). However, unlike FGP means of the two sets of treatments tell that seed priming were better pre-sowing seed treatment than seed soaking. Seed priming has been reported to enhance DNA replication and DNA repair and promote mobilization of reserved materials (Chen *et al*., 2010) which contribute to accelerate seed germination. Superiority of seed priming treatments over seed soaking may be attributed to the improved membrane integrity linked with enhanced antioxidant defense mechanism due to seed priming (Khan et al 2017b).

MGT has been proposed as a quick and reliable test to measure seed vigor and predict the rate of emergence, final emergence and uniformity. However, it is not the real time to mean germination but just an index of germination speed. In the present study (Table 1), T5 was found as most

effective in reducing the MGT value (1.15 day^{-1}) followed by T7 and T6 along with T1 with measured MGT values of 1.30 and 1.32 day^{-1}, respectively. Among all the treatments T3 took maximum MGT followed by T8. Like CVG, seed priming was also established as more effective in reducing the MGT compared to seed soaking. Comparable results have also been reported by Sadeghi *et al*. (2011) in soybean and Khan et al. (2017) in okra.

In the present study (Table 2), T5 as well as T7, T4, T1 and T6 were found as most effective pre-sowing seed treatments with measured MGR values of 0.614, 0.598, 0.597, 0.588 and 0.564 day^{-1} while as T3 as well as T8 were found as least effective treatments with measured MGR values of 0.505 and 0.517 day^{-1} in altering the MGR in okra. However, comparison of the mean values of the two sets of treatments *viz.*, pre-sowing seed soaking and seed priming clarified that these two sets of treatments did not differ significantly with each other. Enhanced germination rate due to different pre-sowing seed treatments may be attributed to the fact that many biochemical processes are modified due to these treatments which are basically needed for starting germination process *viz*., dormancy breaking, hydrolysis, enzyme creation, and seed imbibition (Nakaune *et al*., 2012). A faster seedling growth may also be attributed to higher α-amylase activity and total soluble sugar contents in soaked or primed seeds and seedlings (Wang *et al*., 2016).

GI is an estimate of the time (in days) it takes a certain germination percentage to occur and describes the germination percentage/speed relationship. The seed GI ranged among the treatments from 12.91 in T8 to 16.29 in T1 against the minimum GI (6.05) in control (T0). Treatment T2 as well as T7 were proved as the second best treatment with observed GI values of 15.42 and 15.44, respectively. These treatments (T2 and T7) were significantly followed by T4 and T6 with their GI values of 14.36 and 14.03, respectively. Analysis of the data further clarified that T1 was at par with T7 while as T4 was at par with T6. However, average values of the two sets of pre-sowing seed treatments indicated pre-sowing seed soaking and seed priming did not differ significantly with regard to GI. An improved GI in pre-soaked and primed seeds may be attributed to increased metabolic activities, DNA replication and DNA repair (Aryal *et al*., 2020).

Time to 50 percent seed germination (T_{50}), also known as the median germination time is another index to describe the speed of seed germination. Table 2 indicated that T5 was found as

most effective treatment and resulted in the least estimated value of T_{50} (1.18 day) which was statistically at par with T1, T2, T4, T6 and T7 with their absolute T_{50} values of 1.21, 1.22, 1.22, 1.23 and 1.20 day, respectively. Untreated okra seeds (T0) exhibited a T_{50} value of 1.95 day. However, among the treated seeds T8 recorded the highest estimated value (1.36 day) of T_{50} followed by T3 with measured T_{50} value of 1.35 day. However, mean values of the two sets of pre-sowing seed treatments indicated that there was no significant difference between the pre-sowing seed soaking and priming with respect to T_{50}. Corroborating results have also been reported by Khan *et al*. (2017a).

The Z index tells about the dynamics of the germination process. In this, higher the value of Z index, more the uniformity in germination. The maximum value of Z = 1 that means all the seeds germinated at the same time while Z = 0 means at least two seeds could germinate, one at each time. The maximum value of Z index (0.790) was recorded with T5, markedly followed by T6, T7, T1 and T2 with measured Z index of 0.693, 0.600, 0.610 and 0.573 in that order (Table 2). Among the seedlings obtained from treated seeds T3 and T8 showed the least Z index value of 0.433 followed ascendingly by T4 with measured Z index value of 0.513. Mean values of the two sets of pre-sowing seed treatments indicated that pre-sowing seed priming is superior over pre-sowing seed soaking. The synchronization and promotion of germination with seed priming may take place for several reasons, but changes in metabolite levels are important events during seed priming (Pal *et al*., 2017). Higher α-amylase activity and total soluble sugar contents in soaked or primed seeds and seedlings (Wang *et al*., 2016) were associated with the better seed germination and synchrony.

An strong relationship was existed between different seed germination attributes of okra (Table 3.)

CONCLUSION

Different pre-sowing seed treatments *viz*., traditional soaking or priming significantly improved the seed germination potential of okra cv. Pusa Sawani in terms of final germination percent, rapidity of germination and uniformity of germination. Comparison of the treatments with respect to various germination attributes indicated that different germination attributes responded differently to different pre-sowing soaking and priming treatments. In general,

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hydropriming of okra seeds was found as superior to all other treatments. Furthermore, comparison of the two sets of pre-sowing treatments *viz*., traditional soaking and priming clarified that priming treatments were superior to traditional seed soaking methods.

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Table 1: Effect of different pre-sowing seed treatments on final germination per cent (FGP), coefficient of velocity of germination (CVG) and mean germination time (MGT) in okra

Treatment / Parameter		FGP	CVG (%day^{-1})	MGT (day^{-1})
T_0	Control	65.0^{e} (8.12)	39.56^{h} (6.37)	2.55^{a}
T_1	Seed soaking in water (18 hours)	93.3^{a} (9.71)	75.69^{c} (8.76)	1.32^{ef}
T_2	Seed soaking in PEG-6000 solution @-1.0MPa(24 hours)	90.0^{b} (9.54)	73.14^{d} (8.61)	1.37^{e}
T_3	Seed soaking in GA_3 solution @100ppm (18 hours)	85.0^{c} (9.27)	59.47^{g} (7.78)	1.70^{b}
T_4	Seed soaking in KH_2PO_4 solution @1.5% (18hours)	90.0^{b} (9.54)	69.79^{e} (8.41)	1.44^{d}
T_5	Seed priming with pure water (18 hours)	83.3^{c} (9.18)	87.34^{a} (9.39)	1.15^{g}
T_6	Seed priming with PEG-6000 solution @-1MPa (24 hours)	78.3^{d} (8.91)	77.14^{b} (8.84)	1.32^{ef}
T_7	Seed priming with GA_3 solution @ 100ppm (18 hours)	88.3^{b} (9.45)	76.18^{c} (8.78)	1.30^{f}
T_8	Seed priming with KH_2PO_4 solution @1.5% (18hours)	83.3^{c} (9.18)	61.59^{f} (7.91)	1.64^{c}
AvS	Average effect of different soaking treatments	89.6 (9.50)	69.52 (8.39)	1.46
AvP	Average effect of different soaking treatments	83.3 (9.18)	75.56 (8.71)	1.35
C.D ($p \leq 0.05$)		**0.141**	**0.047**	**0.037**

Values given in parentheses are squire root transformed values; Treatments that do not have the same letters are significantly different ($p \leq 0.05$) as determined by Duncan's multiple range test.

Comment [S9]: Difference between T1 and T5

Comment [S10]: Difference between T2 and T6

Comment [S11]: Difference between T3 and T7

Comment [S12]: Difference between T4 and T8

Comment [S13]: AvS and AvP – both are-Average effect of different soaking treatments?

Table 2: Effect of different pre-sowing seed treatments on mean germination rate (MGR), germination index (GI) and time to 50 per cent germination (T_{50}) in okra

Treatment \ Parameter		MGR (day^{-1})	GI	T_{50} (day)	Z index
T_0:	Control	0.394^{f}	6.05^{e}	1.95^{a}	0.300^{f}
T_1:	Seed soaking in water (18 hours)	0.588^{b}	16.29^{a}	1.21^{c}	0.610^{c}
T_2:	Seed soaking in PEG-6000 solution @-1.0MPa(24 hours)	0.573^{c}	15.42^{b}	1.22^{c}	0.573^{c}
T_3:	Seed soaking in GA_3 solution @100ppm (18 hours)	0.505^{e}	12.98^{d}	1.35^{b}	0.433^{e}
T_4:	Seed soaking in KH_2PO_4 solution @1.5% (18hours)	0.597^{b}	14.36^{c}	1.22^{c}	0.513^{d}
T_5:	Seed priming with pure water (18 hours)	0.614^{a}	15.55^{b}	1.18^{c}	0.790^{a}
T_6:	Seed priming with PEG-6000 solution @-1MPa (24 hours)	0.564^{c}	14.03^{c}	1.23^{c}	0.693^{b}
T_7:	Seed priming with GA_3 solution @ 100ppm (18 hours)	0.598^{b}	15.44^{b}	1.20^{c}	0.600^{c}
T_8:	Seed priming with KH_2PO_4 solution @1.5% (18hours)	0.517^{d}	12.91^{d}	1.36^{b}	0.433^{e}
AvS	Average effect of different soaking treatments	0.566	14.76	1.25	0.53
Avp	Average effect of different soaking treatments	0.573	14.48	1.24	0.63
C.D ($p \leq 0.05$)		**0.011**	**0.63**	**0.058**	**0.037**

Treatments that do not have the same letters are significantly different ($p \leq 0.05$) as determined by Duncan's multiple range tests.

Table 3. Pearson **correlation coefficient between different seed germination attributes**

Parameters	r	Explanation
FGP × CVG	0.6319	Significant large positive relationship between FGP and CVG, ($r(9) = .632$, $p = .037$).
FGP × MGT	-0.7636	Significant very small negative relationship between FGP and MGT, ($r(9) = .764$, $p = .006$).
FGP × MGR	0.7965	Significant large positive relationship between FGP and MGR, ($r(9) = .797$, $p = .003$).
FGP × GI	0.8895	Significant large positive relationship between FGP and GI, ($r(9) = .89$, $p < .001$).
FGP × T_{50}	-0.8428	Significant very small negative relationship between FGP and T_{50}, ($r(9) = .843$, $p = .001$).
CVG x MGT	-0.9705	Results of the pearson correlation indicated that there is a significant very small negative relationship between CVG and MGT, ($r(9) = .971$, $p < .001$).
CVG x MGR	0.9504	Results of the pearson correlation indicated that there is a significant large positive relationship between CVG and MGR, ($r(9) = .95$, $p < .001$).
CVG x GI	0.9066	Significant large positive relationship between CVG and GI, ($r(9) = .907$, $p < .001$).
CVG x T_{50}	-0.9081	Significant very small negative relationship between CVG and T_{50}, ($r(9) = .908$, $p < .001$)
CVG × Z index	0.9588	Significant large positive relationship between CVG and Z index, ($r(9) = .959$, $p < .001$).
MGT × MGR	-0.9704	Significant very small negative relationship between MGT and MGR, ($r(9) = .97$, $p < .001$).
MGT × GI	-0.97	Significant very small negative relationship between MGT and GI, ($r(9) = .97$, $p < .001$).
MGT × T_{50}	0.9811	Significant large positive relationship between MGT and T_{50}, ($r(9) = .981$, $p < .001$).
MGT × Z index	-0.8713	Significant very small negative relationship between MGT and Z index, ($r(9) = .871$, $p < .001$).
MGR × GI	0.9524	Significant large positive relationship between MGR and GI, ($r(9) = .952$, $p < .001$).
MGR × T_{50}	-0.9529	Significant very small negative relationship between MGR and T_{50}, ($r(9) = .953$, $p < .001$).
MGR × Z index	0.8352	Significant large positive relationship between MGR and Z index, ($r(9) = .835$, $p = .001$).
GI × T_{50}	-0.98	Significant very small negative relationship between GI and T_{50}, ($r(9) = .98$, $p < .001$).
GI × Z index	0.7628	Significant large positive relationship between GI and Z index, ($r(9) = .763$, $p = .006$).
T_{50} × Z index	-0.7675	Significant very small negative relationship between T_{50} and Z index, ($r(9) = .767$, $p = .006$).