EFFECT OF VERMICOMPOST LEACH ON SEED GERMINATION AND SEEDLING EMERGENCE OF ONION SEEDS AGAINST DROUGHT STRESS

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Abstract

A laboratory experiment was conducted at the Seed Technology Division, BARI, Gazipur, Bangladesh during rabi 2021-2022 to find out a suitable vermicompost treatment for better seed germination and seedling emergence under drought stress condition. The experiment was carried out in a 2-factorial completely randomized design with four replications. The seeds of onion were imposed by five levels of priming viz., untreated control, 5% vermicompost priming (VCP), 10% VCP, 15% VCP, and hydropriming. After that two levels of drought viz., 10% PEG 6000 and 15% PEG 6000 were imposed on onion seeds. Onion variety was BARI Piaj-4. Seed priming with vermicompost leach had a positive impact enhancing seed germination and seedling emergence percentage under drought stress condition. Vermicompost leach @ 10% under 10% PEG drought stress condition showed better performance than any other treatment combinations regarding seed germination (78%), seedling emergence percentage (72%), seedling length (7.35 cm), seedling vigor index (573) and germination rate index (22.22).

Introduction

A crop, now a days, faces so many challenges to show its potentiality and one of the major challenges is threat from adverse environmental conditions (Jesha *et al*., 2012; Muhie, 2018). Abiotic stresses have a major negative impact on crop production worldwide (Joshi and Sawant, 2012). The most critical stage of crop that is influenced by environmental stress is seed germination and seedling stage. Drought is one of the critical environmental factors that affect seed germination (Lianes *et al*., 2015, Thirusendura and Saraswathy, 2017). Seed priming is a good technique to improve seed germination and seedling performance under environmental stress condition (Joshi *et al*., 2012). Priming has been used successfully for improving seed quality in different vegetable crops (Ermis *et al*., 2016; Saranya *et al*., 2017). There are many priming agents used in improving seed germination, vermicompost is one of them. Vermicompost priming improved seed germination of *Brassica napus* seeds at salt stress conditions (Benazzouk *et al*., 2019). Onion (*Allium cepa* L.) is a spice crop and its seed lose viability and vigour at faster rates than seeds of most other crops, even at relatively optimum storage conditions (Ellis *et al*., 1996; Yapping *et al*., 2000) and germination of its seeds can be affected by extreme abiotic factors (Thirusendura and Saraswathy, 2017). Poor seed performance is one of the crucial factors that limit onion production and development. For enhancing seed germination and seedling emergence, vermicompost priming showed good result in onion (Muhie *et al*., 2020), in cucumbers (Edwards *et al*., 2006), marigolds (Shivsubramanian, 2004), lettuces, tomatoes and cucumbers (Edwards *et al.*, 2006; Arancon *et al*., 2012), and beans and peas (Ievinsh *et al*., 2017). In Bangladesh there are 3.50 million hectares under drought condition and onion seed germination under drought stress is badly affected. Vermicompost priming can be a way of solving this problem. But literature about the influence of vermicompost priming enhancing seed germination and seedling emergence of onion under drought in Bangladesh is very sporadic. Therefore, the present study was undertaken to find out a suitable vermicompost leach treatment for better seed germination and seedling emergence under drought stress condition.

Materials and Methods

A laboratory experiment was conducted at the Seed Technology Division, BARI, Gazipur, Bangladesh during 2021-2022 find out a suitable vermicompost treatment for better seed germination and seedling emergence under drought stress condition. The experiment was carried out in a 2-factorial completely randomized design with four replications. Onion seeds were imposed by five levels of priming viz., untreated control, 5% vermicompost priming (VCP), 10% VCP, 15% VCP, and hydropriming (HP). After that polyethylene glycol with a molecular weight of 6000 (PEG 6000) was used as a drought stimulator. Drought imposed on onion seeds (var. BARI Piaj-4) @ 10% PEG 6000 and 15% PEG 6000. Onion seeds were treated with vermicompost leach under drought stress following procedures of Muhie *et al*. (2020).

Vermicompost priming (VCP) was done using a solid matrix priming method. Treatments were conducted by mixing onion seed: vermiculite No. 5: vermicompost leach (w:w:w) at the ratio of 2:1:3, in plastic boxes. Boxes were kept at 15^{o}C for 2 days in dark. The same ratio was used with distilled water in hydropriming (HP). Non-primed (NP) dry seeds were used as control for primed treatments. Seeds were dried near to initial moisture content after VCP and HP treatments.

Drought stress was stimulated using polyethylene glycol-6000 (PEG) at different concentrations (W:V) at par treatment. Onion seeds (four replicates of 50 seeds) were placed on a filter paper in 90 mm-diameter petri dishes containing 3 ml of PEG solution. The dishes were sealed with parafilm to prevent moisture loss. Germination was carried out at 20^{o}C for 12 days according to ISTA (2017). Seeds were considered germinated when the radicle would emerge 2 mm.

The seedling emergence test was carried out in four replicates of 25 seeds each in plastic trays for 21 days. The appearance of the cotyledon above the cocodust was considered as the emergence criterion. Trays were kept at 20$\pm$2^{o}C. Trays were watered with the appropriate solutions during the test. Seedling vigor index (SVI) was calculated by multiplying average seedling length (cm) with seedling emergence per cent according to Abdul Baki and Anderson (1973). Germination rate index (GRI) was calculated using the formula given by Al-Mudaris (1998). Germination rate index (GRI) = G1/1+G2/2+ …….+ Gi/I, G1 is the germination percentage at day 1, G2 is the germination percentage at day 2, and so on. Recorded data were analysed statistically with the help of Statistix 10 software. Treatment means were compared following Least Significant Difference (LSD) Test and t-Test.

Results and Discussion

Effect of priming

Priming showed significant difference on seed germination percentage, seedling emergence percentage, average seedling length, seedling vigor index and germination rate index of onion seed irrespective of drought stress (Table 1). Vermicompost priming had positive impact on seed germination percentage of onion seed. Maximum seed germination (68%) was observed in 10% vermicompost priming and it was statistically similar with 15% vermicompost priming (66% seed germination). Non-primed seed showed minimum seed germination percentage (55%). Vermicompost priming @10% increased 19.12% seed germination over non primed seed, whereas hydropriming increased 7.27% seed germination. Similar trend was observed in case of seedling emergence percentage. The highest seedling emergence percentage (63%) was noted in 10% VCP, and lowest (47%) in non-primed seed. Vermicompost priming @10% improved 34.04% seedling emergence over non primed seed, whereas hydropriming increased 12.77% seedling emergence. Stimulatory effects of enhancing seed germination and seedling emergence have been mentioned in different crops such as cucumbers (Edwards *et al*., 2006), lettuce, tomato and cucumbers (Edwards *et al.*, 2006; Arancon *et al.*, 2012, and beans and peas (Ievinsh *et al*., 2017). The positive effect of VCP enhancing germination and seedling emergence of onion seeds might be due to due to high activity of enzymes

(Arancon *et al*., 2012) in addition to presence of adequate concentration of macro-and micro-nutrients, growth promoting hormones like auxin and gibberellins (Pant *et al*., 2009). The highest average seedling length (6.76 cm) was observed in10% VCP treatment which was statistically at par with 15% VCP treatment (6.61 cm), but the lowest average seedling length (4.52 cm) was noted in nonprimed control treatment. Maximum seedling vigor index (463) was found in 10% VCP treatment and minimum was in nonprimed control treatment (256). The highest germination rate index (GRI) was observed in 10% VCP treatment (18.75) which was statistically at par with 5% VCP treatment (17.53), but the lowest GRI (14.45) was noted in nonprimed control treatment.

Table 1. Effect of priming on seed germination, seedling emergence, seedling length, seedling vigor index and germination rate index of onion

Priming	**Seed germination (%)**	**Seedling emergence (%)**	**Seedling length (cm)**	**Seedling Vigor Index**	**Germination rate index**
Non Priming	55	47	4.52	256	14.45
5% VCP	63	58	6.10	390	17.53
10% VCP	68	63	6.76	463	18.75
15% VCP	66	57	6.61	408	16.69
Hydropriming	59	53	5.37	322	16.15
$LSD_{0.05}$	3.54	4.36	0.59	19.69	1.64
CV (%)	5.58	7.64	9.85	5.22	9.57

Where, VCP means vermicompost priming

Effect of drought stress

Drought stress showed significant difference on seed germination percentage, seedling emergence, average seedling length, seedling vigor index and germination rate index of onion seed irrespective of priming (Table 2). Drought stress @ 10 PEG showed higher seed germination (72%), seedling emergence (65%), average seedling length (6.39 cm), seedling vigor index (455) and germination rate index (19.51). PEG @ 15% significantly reduced seed germination percentage, seedling emergence, average seedling length, seedling vigor index and germination rate index of onion seed over 10% PEG. Reduction of seed germination, seedling emergence, average seedling length, seedling vigor index and germination rate index were 27.78%, 27.69%, 16.12%, 38.46%, and 28.65%, respectively in 15% PEG over 10% PEG.

Table 2. Effect of drought stress on seed germination, seedling emergence, seedling length, seedling vigor index and germination rate index of onion

Drought stress	**Seed germination (%)**	**Seedling emergence (%)**	**Seedling length (cm)**	**Seedling Vigor Index**	**Germination rate index**
10% PEG	72	65	6.39	455	19.51
15% PEG	52	47	5.36	280	13.92
t value	2.24	2.76	0.38	12.45	1.04
CV (%)	5.58	7.64	9.85	5.22	9.57

Where, PEG means polyethylene glycol 6000

Interaction effect

The Interaction effect of priming and drought stress was found nonsignificant on seed germination percentage, seedling emergence percentage, average seedling length and germination rate index of onion, but found significant on seedling vigor index (Table 3). Though insignificant, seeds of onion treated with 10% vermicompost priming along with 10% polyethylene glycol gave the highest seed germination percentage (78%), seedling emergence percentage (72%), average seedling length (7.35 cm), and germination rate index (22.22). So, there was a great scope of increasing above seed quality characters by using vermicompost leach under drought stress condition. Non primed seeds of onion treated with 15% PEG showed the lowest seed quality characters mentioned above. Similarly, the highest seedling vigor index (573) was noted in 10% VCP treatment under 10% PEG condition. Non-primed seeds of onion treated with 15% PEG showed the lowest seedling vigor index (172).

Table 3. Interaction effect of priming and drought stress on seed germination, seedling emergence, seedling length, seedling vigor index and germination rate index of onion

Drought stress	Priming	Seed germination (%)	Seedling emergence (%)	Seedling length (cm)	Seedling Vigor Index	Germination rate index
10% PEG	Non Priming	64	56	5.24	341	17.52
	5% VCP	73	66	6.32	462	20.18
	10% VCP	78	72	7.35	573	22.22
	15% VCP	76	68	7.12	499	19.05
	Hydropriming	68	62	5.92	403	18.55
15% PEG	Non Priming	45	39	3.81	172	11.38
	5% VCP	54	50	5.88	318	14.88
	10% VCP	57	54	6.18	351	15.27
	15% VCP	56	47	6.11	318	14.32
	Hydropriming	50	45	4.83	242	13.75
$LSD_{0.05}$		NS	NS	NS	27.84	NS
CV (%)		5.58	7.64	9.85	5.22	9.57

Conclusion

Seed priming with vermicompost leach has a positive impact of increasing seed germination, seedling emergence percentage, seedling length, seedling vigor index, and germination rate index under drought stress condition. Seed priming with 10% vermicompost along with 10% PEG showed better performance than any other treatment combinations with respect to seed germination (78), seedling emergence (72%), seedling vigor index (573), and germination rate index (22.22). But non-priming seeds with 15% PEG showed least performance with respect to seed germination (45%), seedling emergence (39%), seedling vigor index (172), and germination rate index (11.38).

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EFFECT OF VERMICOMPOST LEACH ON SEED GERMINATION AND SEEDLING EMERGENCE OF ONION SEEDS AGAINST SALT STRESS

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Abstract

A laboratory experiment was conducted at the Seed Technology Division, BARI, Gazipur, Bangladesh during *Rabi* 2021-2022 to find out a suitable vermicompost treatment for better seed germination and seedling emergence under salt stress condition. The experiment was carried out in a 2-factorial completely randomized design with four replications. Onion seeds (var. BARI Piaj-4) were imposed by five levels of priming viz., untreated control, 5% vermicompost priming (VCP), 10% VCP, 15% VCP, and hydropriming (HP), and then salt stress was imposed @ 40 mM NaCl and 80 mM NaCl. Seed priming with vermicompost leach has a positive impact enhancing seed germination percentage, seedling emergence percentage, and seedling vigor index under salt stress condition. Seed priming with 10-15% vermicompost leach along with 40 mM NaCl showed better performance than any other treatment combinations with respect to seed germination (74-76%), seedling emergence percentage (63-64%) and seedling vigor index (236-241). Therefore, these treatments showed better performance considering less reduction than any other treatment combination regarding seed germination percentage, seedling emergence percentage, and seedling vigor index.

Introduction

A crop, now a days, faces so many challenges to show its potentiality and one of the major challenges is threat from adverse environmental conditions (Jesha *et al*., 2012; Muhie, 2018). Abiotic stresses have a major negative impact on crop production worldwide (Joshi and Sawant, 2012). The most critical stage of crop that is influenced by environmental stress is seed germination and seedling stage. Salinity is one of the critical environmental factors that affect seed germination (Lianes *et al*., 2015, Thirusendura and Saraswathy, 2017). Seed priming is a good technique to improve seed germination and seedling performance under environmental stress condition (Joshi *et al*., 2012). Priming has been used successfully for improving seed quality in different vegetable crops (Ermis *et al*., 2016; Saranya *et al*., 2017). There are many priming agents used in improving seed germination, vermicompost is one of them. Vermicompost priming improved seed germination of *Brassica napus* seeds at salt stress conditions (Benazzouk *et al*., 2019). Onion (*Allium cepa* L.) is a spice crop and its seed lose viability and vigour at faster rates than seeds of most other crops, even at relatively optimum storage conditions (Ellis *et al*., 1996; Yapping *et al*., 2000) and germination of its seeds can be affected by extreme abiotic factors (Thirusendura and Saraswathy, 2017). Poor seed performance is one of the crucial factors that limit onion production and development. For enhancing seed germination and seedling emergence, vermicompost priming showed good result in onion (Muhie *et al*., 2020), in cucumbers (Edwards *et al*., 2006), marigolds (Shivsubramanian, 2004), lettuces, tomatoes and cucumbers (Edwards *et al.*, 2006; Arancon *et al*., 2012), and beans and peas (Ievinsh *et al*., 2017). In Bangladesh there are 1.05 million hectares of land are under salinity and onion seed germination under this abiotic stress is badly affected. Vermicompost priming can be a way of solving this problem. But literature about the influence of vermicompost priming enhancing seed germination and seedling emergence of onion salt stress in Bangladesh is very sporadic. Therefore, the present study was undertaken to find out a suitable vermicompost treatment for better seed germination and seedling emergence under salt stress condition.

Materials and Methods

A laboratory experiment was conducted at the Seed Technology Division, BARI, Gazipur, Bangladesh during December 2020 to February 2021to find out a suitable vermicompost treatment for better seed germination and seedling emergence under salt stress condition. The experiment was carried out in a 2-factorial completely randomized design. Onion seeds (var. BARI Piaj-4) were imposed by five levels of priming viz., untreated control, 5% VCP, 10% VCP, 15% VCP, and hydropriming, and then salt stress was imposed @ 40 mM NaCl and 80 mM NaCl. Onion seeds were treated with vermicompost leach under salt stress following procedures of Muhie *et al*. (2020).

Vermicompost priming (VCP) was done using a solid matrix priming method. Treatments were conducted by mixing onion seed: vermiculite No. 5: vermicompost leach (w:w:w) at the ratio of 2:1:3, in plastic boxes. Boxes were kept at 15^{o}C for 2 days in dark. The same ratio was used with distilled water in hydropriming (HP). Non-primed (NP) dry seeds were used as control. Seeds were dried near to initial moisture content after VCP and HP treatments.

Salt stress was stimulated using NaCl solutions at different concentrations at par treatment. Onion seeds (four replicates of 50 seeds) were placed on a filter paper in 90 mm-diameter petri dishes containing 3 ml of salt solution. The dishes were sealed with parafilm to prevent moisture loss. Germination was carried out at 20^{o}C for 12 days according to ISTA (2017). Seeds were considered germinated when the radicle would emerge 2 mm.

The seedling emergence test was carried out in three replicates of 25 seeds each in plastic trays for 21 days. The appearance of the cotyledon above the cocodust was considered as the emergence criterion. Trays were kept at 20$\pm$2^{o}C. Trays were watered with the appropriate solutions during the test. Seedling vigor index (SVI) was calculated by multiplying average seedling length (cm) with seedling emergence per cent according to Abdul Baki and Anderson (1973). Recorded data were analyzed statistically with the help of Statistix 10 software. Treatment means were compared following Least Significant Difference (LSD) Test and t-Test.

Results and Discussion

Effect of priming

Vermicompost priming showed significant difference on seed germination percentage, seedling emergence percentage and seedling vigor index of onion seed irrespective of salt stress, but showed insignificant in case of average seedling dry weight (Table 1). Vermicompost priming had positive impact on seed germination percentage of onion seed. Maximum seed germination percentage (71%) was observed in 15% vermicompost priming and it was statistically similar with 10% vermicompost priming. Non-primed seed showed minimum germination percentage (58%). Vermicompost priming @15% increased 22.41% seed germination over non primed seed, whereas hydropriming increased 6.90% seed germination. Similar trend was observed in case of seedling emergence percentage. The highest seedling emergence percentage (61%) was noted in 15% VCP which was statistically similar with 10% VCP, and lowest (37%) in non-primed seed. Stimulatory effects of enhancing seed germination and seedling emergence have been mentioned in different crops such as cucumbers (Edwards *et al*., 2006), lettuce, tomatoes and cucumbers (Edwards *et al.*, 2006; Arancon *et al.*, 2012, and beans and peas (Ievinsh *et al*., 2017). The positive effect of VCP enhancing germination and seedling emergence of onion seeds might be due to due to high activity of enzymes in addition to presence of adequate concentration of macro-and micro-nutrients, growth promoting hormones like auxin and gibberellins (Pant *et al*., 2009). Seedling vigor index was found highest (224) in 15% VCP which was statistically similar with 10% VCP treatment (220). Non-priming treatment showed lowest seedling vigor index.

Table 1. Effect of priming on seed germination, seedling emergence, average seedling dry weight and seedling vigor index of onion

Priming	**Seed germination (%)**	**Seedling emergence (%)**	**Seedling dry wt. (Av.; mg)**	**Seedling Vigor Index**
Non Priming	58	37	3.29	123
5% VCP	67	53	3.48	183
10% VCP	70	60	3.65	220
15% VCP	71	61	3.68	224
Hydropriming	62	47	3.41	160
$LSD_{0.05}$	3.55	3.75	NS	20.13
CV (%)	5.30	7.09	8.90	10.79

Where, VCP means vermicompost priming

Effect of salt stress

Salt stress showed significant difference on seed germination percentage, seedling emergence percentage, and seedling vigor index of onion seed except average seedling dry weight irrespective of priming (Table 2). Salt stress by sodium chloride @ 80 mM reduced seed germination percentage, seedling emergence percentage, average seedling dry weight and seedling vigor index of onion seed over 40 mM NaCl. Reduction of seed germination percentage, seedling emergence percentage, average seedling dry weight and seedling vigor index were 11.59%, 12.73%, 5.56%, and 17.09%, respectively in 80 mM NaCl over 40 mM NaCl.

Table 2. Effect of salt stress on seed germination, seedling emergence, average seedling dry weight and seedling vigor index of onion

Salinity stress	Seed germination (%)	Seedling emergence (%)	Seedling dry wt. (Av.; mg)	Seedling Vigor Index
40 mM NaCl	69	55	3.60	199
80 mM NaCl	61	48	3.40	165
t value	2.25	2.37	NS	12.73
CV (%)	5.30	7.09	8.90	10.79

Interaction effect

The Interaction effect of priming and salt stress was found significant on seedling emergence percentage, but nonsignificant on seed germination percentage, average seedling dry weight, and seedling vigor index and of onion (Table 3). Seeds of onion treated with 15% vermicompost priming along with 40 mM NaCl gave the highest seedling emergence (64%) and it was statistically at par (63%) with 10% vermicompost priming along with 40 mM NaCl. Though insignificant, seed germination percentage and seedling vigor index were highest with 15% vermicompost priming along with 40 mM NaCl. There was a scope of increasing seed germination percentage, seedling emergence percentage and seedling vigor index by using 10-15% vermicompost leach under salt stress (40 mM NaCl) condition.

Table 3. Interaction effect of priming and salt stress on seed germination, seedling emergence, average seedling dry weight and seedling vigor index of onion

Salinity stress	Priming	Seed germination (%)	Seedling emergence (%)	Seedling dry wt. (Av.; mg)	Seedling Vigor Index
40 mM NaCl	Non Priming	61	42	3.35	141
	5% VCP	70	56	3.60	199
	10% VCP	74	63	3.75	236
	15% VCP	76	64	3.75	241
	Hydropriming	66	50	3.55	177
80 mM NaCl	Non Priming	54	33	3.23	104
	5% VCP	63	50	3.35	166
	10% VCP	67	58	3.55	205
	15% VCP	66	58	3.60	208
	Hydropriming	58	44	3.28	143
$LSD_{0.05}$		NS	5.30	NS	NS
CV (%)		5.30	7.09	8.90	10.79

Where, VCP means vermicompost priming

Conclusion

Seed priming with vermicompost leach has a positive impact to increase seed germination and seedling emergence percentage under salt stress condition. Seed priming with 10-15% vermicompost leach along with 40 mM NaCl showed better performance than any other treatment combinations with respect to seed germination (74-76%), seedling emergence percentage (63-64%) and seedling vigor index (236-241). In contrast, non-primed seed along with 80 mM NaCl showed lowest performance with respect to seed germination (54%), seedling emergence percentage (33%) and seedling vigor index (104).

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EFFECT OF WATER STRESS ON SEED YIELD AND SEED QUALITY OF CHICKPEA

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Abstract

The experiment was carried out at the research field and laboratory of Seed Technology Division, BARI, Gazipur during 2021-2022 to find out the effect of water stress on seed yield, seed quality of chickpea varieties and the suitable variety of chickpea for better seed yield and seed quality under water stress condition. The experiment was set in a Completely Randomized Design (CRD) with two chickpea varieties BARI Chola-5 and BARI Chola-9 and five moisture regimes *viz,* Control (without irrigation), 50% field capacity, 70% field capacity, and 90% field capacity. The study revealed that BARI Chola-9 produced highest number of branches plant^{-1} (4.42), number of pods plant^{-1} (74.39), number of seeds pod^{-1} (2.00), 100-seed weight (10.12 g), seed yield pod^{-1} (10.40 g) and germination percentage (97.6). Therefore it may be concluded that BARI Chola-9 along with 90% field capacity (FC) was found suitable for better seed yield and seed quality.

Introduction

Chickpea (*Cicer arietinum* L.) is the second most widely grown legume crop in the world, with a total production of 17.19 million tons from an area of 17.81 million t ha^{-1} (FAOSTAT, 2018). The major chickpea producing countries include India, Australia, Pakistan, Turkey, Myanmar, Ethiopia, Iran, Mexico, Canada, and the United States. Chickpea seeds are protein-rich alternatives of animal protein in human diet. Chickpea is a good source of protein (20 to 22%) and is rich in carbohydrates (around 60%), dietary fiber, minerals and vitamins (Jukanti *et al.*, 2012). Chickpea does not contain any specific major anti nutritional factors such as Oxalyldiaminopropionic acid (ODAP) in grass pea (*Lathyrus sativus* L.), vicin in faba bean (*Vicia faba* L.), and trypsin inhibitors in soybean (*Glycine max* L.), although it has oligosaccharides which cause flatulence (Jukanti *et al.,* 2012). There is a growing international demand for chickpea and the number of chickpea importing countries has increased from about 60 in 1989 to over 140 in 2009. This is partially due to increased awareness about the health benefits of pulses, including chickpea. Chickpea has several potential health benefits, including beneficial effects on some of the important human diseases such as cardiovascular diseases, type 2 diabetes, digestive diseases and some forms of cancer (Jukanti *et al.*, 2012). Recently, chickpea appeared as the third most important pulse crop of Bangladesh in terms of area and production. Bangladesh grows chickpea on about 5917 ha producing 6237 tons of grains with an average yield of about 1054 kg ha^{-1} (FAOSTAT, 2017), which constitute about 0.04% of the total chickpea production. the trend of chickpea area coverage and production was 15026 acres and 63822 MT in 2015-16, 14615 acres and 6237 MT in 2016-17 and 12421 acres and 4964 MT in 2017-18 (BBS, 2018). The major chickpea growing areas of Bangladesh are Rajshahi (26%), Jessore (20%) and Faridpur (17%) region (BBS, 2018). Moisture deficit affects seed germination, growth and yield of chickpea. Soil moisture stress is a major constraint for the production of chickpea. However, variety may vary in their capacity to tolerate water stress. Keeping in view the above facts the present experiment has been undertaken with the objective to find out the effect of water stress on seed yield seed quality of chickpea varieties and the suitable variety(s) of chickpea for better seed yield and seed quality under water stress condition.

Materials and Methods

The experiment was carried out at the research field and laboratory of Seed Technology Division, BARI, Gazipur during 2021-2022 to find out the suitable variety (s) of chickpea for better seed yield and seed quality under water (drought) stress condition. The experiment was laid out in completely randomized design (CRD) where each treatment was replicated three times. At first 24 plastic pots were set in pot at the front yard of Seed Technology Division, BARI, Gazipur. The size of each pot was 35 cm depth and 30 cm upper radius. The collected soil was well pulverized and dried in the sun. Plant propagules, inert materials, visible insects and pests were removed from the soil. Each pot was then filled up with 6 kg processed soil. After filling all the pots seeds were sown in the pot properly. Before setting the experiment, weight of each pot was recorded individually. Then 6.0 kg sun dried soil was placed into each pot. This soil sample was oven dried and the moisture percentage was determined (15%). An empty core was weighted with a digital balance. A filter paper was placed on end of the core and the core was filled up with the fresh sample soil. The core was then placed in water for 72 hours. After drainage of excess water the constant saturated weight was determined and the core with saturated soil was oven dried for 72 hours at 80° C. Then the field capacity (100 %) for 6000 g (5100 g oven dry soil) soil was determined and it was 2040 ml water. These measured amounts of water then multiplied by 0.9, 0.7 and 0.5 to know the amount of water to maintain 90% FC, 70% FC, and 50% FC respectively. Water requirement was 1836 ml for 90% FC, 1428 ml for 70% FC and 1020 ml for 50 % FC. A mixture of cow dung, triple super phosphate (TSP) and muriate of potash (MoP) fertilizers were applied in all the spaced pots @ cowdung 60 g pot^{-1} (6.0 t ha^{-1}), TSP 0.33 g pot^{-1} (55 kg ha^{-1}) and MoP 0.15 g pot^{-1} (25 kg ha^{-1}). The whole amount of cow dung, TSP and MoP were added on the day of final pot preparation. Fifteen gram urea was mixed well with 12L water and applied 0.18 g pot^{-1} i.e., @30 kg ha^{-1} at 38 DAS (BARC, 2018). Seeds of BARI Chola-5 and BARI Chola-9 were sown on 15 November, 2022. Ten seeds were sown in each pot by hand at 3 to 4 cm depth. Before sowing the seeds, all the pots were pre irrigated to make them in optimum soil moisture condition, necessary for germination. After the germination, three healthy seedlings per pot were kept for the experiment. An appropriate amount of water was applied to all the pots every day until the beginning of the treatments. The stress treatments were applied from 30 day after sowing and continued up to maturity. One day before starting the treatment, 500 ml of water was applied to each pot so that the soil moisture content (%) of all the genotypes was equal. Moisture content (% FC) of all pot was measured with the help of digital moisture meter. The amount of water applied (if necessary) according to the treatment in each pot with the help of measuring cylinder. Harvesting was carried out when more than 80% of pods on the plant had turned from green to light yellow or brown color. At maturity, the whole plant was cut at the ground level with a sickle. The following observations were recorded: Days to 50% flowering, days to maturity, number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight (g), seed yield plant^{-1} (g) and germination percentage. Recorded data were analyzed statistically with the help of open-source R software Separation of significant means was carried out using Least Significant Different (LSD).

Results and Discussion

Effect of soil moisture regimes (% field capacity) on chickpea seed yield and seed quality

Soil moisture regimes (% field capacity) showed significant difference on seed yield, and other parameters like days to 50% flowering, days to maturity, number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight (g) and germination percentage purity (%) (Table 1). The longest days (76.33 DAS) was required to reach 50% flowering at the treatment 90% FC followed by 70% FC and the lowest days (71.66 DAS) to reach 50% flowering stage at treatment T_1 (control). Treatment T_1 (control) took significantly the lowest number of days (112.0 DAS) to attain maturity while treatment T_4 (90% FC) took the highest time (123.0 DAS) to attain maturity. The effect of soil moisture levels on number of branches plant^{-1} was found non-significant. At maturity stage, the highest number of branches plant^{-1} (4.22) was found at treatment 90% FC followed by 70% FC and the lowest number of branches plant^{-1} (3.47) was observed at treatment T_1 (control).

Number of pods plant^{-1} was significantly affected by different treatments (% field capacity). The maximum number of pods plant^{-1} (73.72) was observed at 90% FC followed by treatment 70% FC. The minimum number of pods plant^{-1} (68.0) was observed in treatment T_1 (control).

Water stress had significant effect on 100-seed weight (Table 1). The highest 100-seed weight (9.59 g) was found at treatment T_4 (90% FC) followed by treatment T_3 (70% FC). The lowest 100-seed weight (7.93 g) was obtained from control treatment. The effect of different filed capacity (treatment) on number of seeds pod^{-1} was found significant (Table 1). The maximum number of seeds pod^{-1} (2.0) was obtained from 90% FC and 70% FC. The minimum number of seeds pod^{-1} (1.3) was recorded from the treatment T_1 (control). Significantly the highest seed yield plant^{-1} (8.49 g) found from treatment T_4 (90% FC) followed by treatment T_3 (70% FC), while the lowest seed yield plant^{-1} (5.49 g) was noted at treatment T_1 (control). The highest germination percentage (97.7) was obtained from the treatment T_4 (90% FC) and the lowest (89.5) was obtained from the treatment T_1 (control)

Table 1. Effect of soil moisture regimes on chickpea seed yield and seed quality

Field Capacity	Days to 50% flower	Days to maturity	Number of branch plant^{-1}	Number of pod plant^{-1}	Number of seed pod^{-1}	100-seed wt. (g)	Seed yield (g plant^{-1})	Germination (%)
Control	71.66	112	3.47	68.0	1.3	7.93	5.49	89.5
50%	73.66	115	3.74	71.05	1.5	8.33	6.66	93.16
70%	75.33	120	3.99	72.78	2.0	9.22	7.41	95.8
90%	76.33	123	4.22	73.72	2.0	9.59	8.49	97.7
CV (%)	1.86	2.11	5.89	0.98	8.69	5.52	6.71	1.56
$LSD_{(0.05)}$	1.69	3.03	NS	0.86	0.43	0.59	0.57	1.80

Effect of chickpea variety

It was observed that days to 50% flowering were not significantly influenced by the variety of chickpea. BARI Chola-5 required minimum days (73.75 DAS) to reach for 50% flowering, where BARI Chola-9 took maximum days (74.75 DAS) to reach at 50% flowering stage. The effect of variety on days to maturity was found significant. BARI Chola-5 took significantly the lowest time (114 DAS) to attain at maturity whereas the BARI Chola-9 took the longest time (121.0 DAS) to attain the maturity stage (Table 2). The maximum number of branches plant^{-1} (4.04) was noted in BARI Chola-9. The least number of branches per plant^{-1} (3.66) was found in BARI Chola-5. BARI Chola-9 provided the maximum number of pods plant^{-1} (72.11) whereas BARI Chola-5 gave the minimum number of pods plant^{-1} (71.04). The maximum number of seeds pod^{-1} (1.83) was found in BARI Chola-9 and the minimum number seeds pod^{-1} (1.58) was recorded from BARI Chola-5. 100-seed weight reflects the size of the seeds of a variety. The effect of variety on 100-seed weight was found statistically significant. The highest 100-seed weight (9.26 g) was recorded at BARI Chola-9. The lowest 100-seed weight (8.27 g) was obtained from BARI Chola-5. The highest seed yield plant^{-1} (8.98 g) was recorded BARI Chola-9. The minimum seed yield plant^{-1} (5.04 g) was recorded from BARI Chola-5.

Table 2. Varietal difference in seed yield and seed quality of chickpea

Variety	Days to 50% flower	Days to maturity	Number of branches plant^{-1}	Number of pods plant^{-1}	Number of seeds pod^{-1}	100-seed wt. (g)	Seed yield (g plant^{-1})	Germination (%)
BARI Chola-5	73.75	114	3.66	71.04	1.58	8.27	5.04	93.7
BARI Chola-9	74.75	121	4.047	72.11	1.83	9.26	8.98	94.42
CV (%)	1.86	2.11	5.89	0.98	8.69	5.52	6.71	1.56
$LSD_{(0.05)}$	1.19	2.14	0.19	0.61	0.30	0.41	0.40	1.27

Interaction effect of variety and moisture regimes on yield and seed quality of chickpea

Interaction effect between genotypes and moisture regimes (% FC) was found significant for days to 50% flowering. The maximum days required for 50% flowering (76.6 DAS) was observed at the treatment combination of BARI Chola-9 with 90% FC. The shortest time (71.0 DAS) required reaching to 50% flowering was noted at BARI Chola-5 with control treatment (Table 3).

BARI Chola-9 with treatment T_4 (90% FC) took significantly the longest time (127 DAS) required to maturity and the lowest (110 DAS) time required to maturity was in BARI Chola-5 with control treatment (Table 3).

In case of number of branches plant^{-1}, interaction effect between variety and moisture levels was found significant (Table 3). At maturity stage, the highest number of branches plant^{-1} (4.42) was at treatment combination of V_2 x T_4 (BARI Chola-9 × 90% FC) and the lowest (3.34) was in the treatment combination of V_1× T_1 (BARI Chola-5 ×Control).

Number of pods plant^{-1} was found significant in case of interaction between variety and treatment (Table 4.3c). The maximum number of pods plant^{-1} (74.39) was observed at BARI Chola-9 with 90% FC and the minimum number of pods plant^{-1} (68.15) was observed in BARI Chola-5 with control treatment.

The effect of interaction between genotypes and different soil moisture levels on number of seeds pod^{-1} was found significant (Table 3). The maximum number of seeds pod^{-1} (2.0) was observed at BARI chola-9 with 90% FC and the minimum number of seeds pod^{-1} (1.0) was observed in BARI Chola-5 with control treatment. The interaction effect between varieties and soil % FC (treatment) on 100-seed weight of chickpea was found significant (Table 3). The highest 100-seed weight (10.12 g) was found in treatment combination of V_2T_4 (BARI Chola-9 × 90% FC). The lowest 100-seed weight (7.47g) was obtained from the treatment combination of V_1× T_1 (BARI Chola-5 × Control). The effect of interaction between variety and soil moisture level (% FC) on seed yield plant^{-1} was found significant (Table 3). The highest seed yield plant^{-1} (10.40 g) was observed in 90% FC with BARI Chola-9. The lowest seed yield plant^{-1} (3.55g) was observed in BARI Chola-5 at T_1 (control).

Interaction effect of found significant in response to (Table 3). It was observed that the treatment combination of boosted up for the accumulation of the highest content of carotenoids (2.63 mg g^{-1}) whereas the lowest level of carotenoids (1.10 mg g^{-1}) was detected from the treatment combination of G_4T_1 (BD-6092 × control).

In case of germination percentage, interaction effect between variety and moisture regime was found significant. The highest germination percentage (97.6) was found in the treatment combination of V_2T_4 (BARI Chola-9 × 90% FC) and the germination percentage (88.3 g) was recorded from the treatment of combination V_1T_1 (BARI Chola-5 × control) (Table 3).

Table 3. Interaction effect of soil moisture regimes and variety on seed yield and seed quality of chickpea

Treatments	Days to 50% flower	Days to maturity	Number of branch plant^{-1}	Number of pod plant^{-1}	Number of seed pod^{-1}	100-seed wt. (g)	Yield (g plant^{-1})	Germination (%)
V_1× T_1	71.0	110	3.34	68.15	1.0	7.47	3.55	88.3
V_1× T_2	73.0	113	3.52	70.61	1.33	7.90	4.70	92.7
V_1× T_3	75.0	114	3.78	72.33	2.0	8.70	5.31	96.0
V_1× T_4	76.0	119	4.03	73.0	2.0	9.06	6.61	97.7
V_2× T_1	72.3	114	3.62	69.3	1.66	8.39	7.44	90.7
V_2× T_2	74.3	118	3.95	71.4	1.67	8.80	8.62	93.7

$V_2 \times T_3$	75.6	125	4.21	73.23	2.0	9.73	9.50	95.7
$V_2 \times T_4$	76.6	127	4.42	74.39	2.0	10.12	10.40	97.6
CV (%)	1.86	2.11	5.89	0.98	8.69	5.52	6.71	1.56
LSD $_{(0.05)}$	2.39	4.29	0.39	1.22	0.611	0.83	0.81	2.54

Here, T_1 = Control, T_2 = 50% field capacity, T_3 = 70% field capacity, T_4 = 90% field capacity, V_1= BARI Chola-5 and V_2= BARI Chola-9

Conclusion

The results indicated that BARI Chola-9 with 90% FC produced highest number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight, seed yield plant^{-1}. The highest germination percentage was found from the treatment combination. BARIChola-9 along with 90% field capacity (FC) was found suitable for better seed yield and seed quality.

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DETERMINATION OF SEED MATURITY INDEX OF CAPSICUM

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ABSTRACT

A field experiment was conducted at the research field and laboratory of Seed Technology Division, BARI, Gazipur during 2021-2022 to determine optimum fruit maturity index of capsicum for proper seed maturity. The experiment was carried out in a randomized complete block design (RCBD) with 3 replications. Treatments were four viz. T_1= turning yellow, T_2= 50% yellow, T_3=100% yellow and T_4= fully yellow and shrinkage. Individual fruit weight, number of seeds per fruit, 1000 seed weight, and days to fruit maturity from anthesis, seed germination, seedling dry weight and vigor index were significantly influenced by different treatments. The best maturity index was observed from 100% yellow (at 72 days to seed maturity after anthesis) in respect of 1000 seed weight, seed germination, seedling dry weight and vigor index.

Introduction

Capsicum is one of the important high value crops of Bangladesh which became popular day by day. It is known as capsicum in Bangladesh. It is also called bell pepper or sweet pepper. Production of high quality seeds depends upon the appropriate time of harvest. In general, seed crops should be harvest when seed quality is maximal. However, the stage during seed development at which seeds attain maximum quality is subject of some controversy. Seeds developed in fleshy-fruited species generally attain maximum germination and vigor at the end of the seed-filling period, when physiological maturity is reached (Welbaum, 1999). However, in some those species, maximum seed dry matter accumulation and seed quality do not coincide, such as pepper (*Capsicum annuum* L.) (Demir and Ellis, 1992b; Oliveira *et al*., 1999), melon (*Cucumis melo* L.) (Welbaum and Bradford, 1988) and tomato (*Lycopersicon esculentum* Mill.) (Kwon and Bradford, 1987; Berry and Bewley, 1991; Demir and Ellis, 1992a; Demir and Samit, 2001; Dias *et al*., 2006a). In tomato seeds, Kwon and Bradford (1987) found that maximum germination and vigor occurred 15 days after attainment of maximum dry mass. It was also verified by Demir and Ellis (1992a), to whom the highest germination percentage was obtained at 70 DAA, while the maximum dry matter content occurred at 50 DAA. Similar results were reported in pepper seeds, where maximum values of germination and dry matter was attained at 60 DAA and 50 DAA, respectively (Oliveira *et al*., 1999). In general, degenerative changes occur in the seeds once full physiological maturity has been attained (Harrington, 1972). Under field conditions, the transition from high quality to aged or even dead muskmelon seeds occurs swiftly over a matter of a few days (Welbaum, 1999). Then, the occurrence of maximum seed quality during development and its association with seed and fruit features are important factors to define the optimum maturity index. It is needed to find out optimum time of seed maturity index for quality seed production of BARI Mistimorich-2. So, this experiment was undertaken to determine the optimum time of fruit maturity index for quality seed production of capsicum

Materials and Methods

The study was conducted at the research field of Seed Technology Division, BARI, Joydebpur, Gazipur during the period of October 2021 to May 2022. The experiment was carried out in a randomized complete block design (RCBD) with 3 replications. The treatments were four viz. T_1= turning yellow, T_2= 50% yellow, T_3=100% yellow and T_4= fully yellow and shrinkage. Seeds were sown in polybag each 12.75 x 10.15 cm size and filled with potting media comprising soil. One month old seedlings were transplanted in the experimental plot. The unit plot size was 4m x 1m maintaining 50cm x 40cm plant spacing. The variety of capsicum was BARI Mistimorich-2. The fertilizer NPKSB@ 100, 70, 100, 20, 2 kg/ha was applied in the form of Urea, TSP, MoP, Gypsum and Boric acid along with cowdung 10t/ha. Half of the quantity of cowdung was applied during land preparation. The remaining cowdung, the entire of TSP, Gypsum, Boric acid and one third of Urea and MoP applied as basal dose. Rest of N and K were applied in two equal splits at 25 and 50 days after transplanting. Intercultural operation was done when necessary. At flowering stage first two buds in all the plants were pinched off in order to allow luxuriant vegetative growth. Thereafter, when the buds were produced, only the specified number of buds was allowed to grow for anthesis and fruit development (Table 1) and remaining were pinched off as and when they formed. No pinching of flowers was done in control. Data on individual fruit weight, number of seed/fruit, 1000 seed weight, and moisture content of seed, electrical conductivity, germination percentage, and vigour index were recorded in the laboratory of Seed Technology Division. Germination test was conducted using sand medium in germination room maintained at 25^0 C and 90% RH. Final count was taken at fourteenth day and number of normal seedlings counted and expressed in percentage recommended by ISTA (1996). Vigour index (VI) was computed following the method suggested by Abdul Baki and Anderson (1973). The data were analyzed statistically with statistix 10 and treatment means were separated by LSD.

Results and Discussion

Individual fruit weight:

Individual fruit weight was found significantly different among the different maturity index of capsicum (Table 1). The highest fruit weight (157.0 g) of capsicum was observed from T_3 treatment at 72 DMA when fruits are 100% yellow which was followed by T_4 treatment. The lowest fruit weight (84.27 g) was found from T_1 treatment when fruits are turning yellow.

Number of seeds per fruit:

Number of seeds per fruit showed significant variation among the different maturity index of capsicum (Table 1). The maximum number of seeds per fruit (136.23) was recorded from T_4 treatment at 81 days to maturity from anthesis when fruits are fully yellow and shrinkage which was statistically identical to T_3 treatment. The lowest number of seeds per fruits (93.73) was observed in $T_{1.}$

Thousand seed weight:

Thousand seed weight showed significant variation among the different maturity index of capsicum (Table 1). The highest 1000 seed weight (8.53g) of capsicum was recorded from T_3 treatment at 72 DMA when fruits are 100% yellow which was statistically similar to T_4 and T_2 treatments respectively. The lowest 1000 seed weight (5.66 g) was found from T_1 treatment when fruits are turning yellow.

Table 1. Effect of maturity index on individual fruit weight, no. of seeds per fruits and thousand seed weight and days to maturity from anthesis

Treatments (Fruit maturity index)	Individual fruit weight (g)	No. of seeds per fruit	1000 seeds weight (g)	Days to maturity from anthesis
Turning yellow	84.27	93.73	5.66	62
50% yellow	120.23	95.93	6.61	67
100% yellow	157.00	123.97	8.53	72
Fully yellow and shrinkage	136.87	136.23	8.28	81
LSD (0.05)	18.3	24.0	2.02	2.6
CV (%)	7.35	10.76	13.92	1.87

In a column, values with same letter (s) do not differ significantly at 5% level of probability $\mathbf{T_1}$= Turning yellow, T_2 = 50% yellow, T_3 = 100 % yellow and T_4 = Fully yellow and shrinkage

Germination percentage:

Germination percentage showed significant variation among the different maturity index of capsicum (Table 2).The maximum germination (90.00 %) of capsicum was recorded from T_3 treatment at 72 DMA when fruits are 100% yellow which was statistically similar to T_4 treatment. The lowest germination (69.00 %) was found from T_1 treatment when fruits are turning yellow.

Seedling dry weight:

Seedling dry weight also showed significant variation among the different maturity index of capsicum (Table 2). The maximum seedling dry weight (23.43 mg) of capsicum was recorded from T_3 treatment at 72 DMA when fruits are 100% yellow which was statistically similar to T_4 treatment and the lowest seedling dry weight (20.06 mg) was found from T_1 treatment when fruits are turning yellow.

Vigor Index:

Vigor index showed significant variation among the different maturity index of capsicum (Table 2). The maximum vigor index (2110.5) of capsicum was found from T_3 treatment at 72 DMA when fruits are 100% yellow which was statistically identical to T_4 treatment and the lowest vigor index (1375.6) was also found from T_1 treatment when fruits are turning yellow.

Table 2. Effect of maturity index on germination, seedling dry weight and vigor index

Treatments (Fruit maturity index)	Germination (%)	Seedling dry weight (mg)	Vigor index
Turning yellow	69.0	20.06	1375.6
50% yellow	76.0	20.20	1538.0
100% yellow	90.0	23.43	2110.5
Fully yellow and shrinkage	84.66	21.80	1836.5
LSD (0.05)	10.71	2.48	351.36
CV (%)	6.71	5.82	10.25

In a column, values with same letter (s) do not differ significantly at 5% level of probability $\mathbf{T_1}$= Turning yellow, T_2 = 50% yellow, T_3 = 100 % yellow and T_4 = Fully yellow and shrinkage

Conclusion

From the above discussion of this study, it is revealed that among the different maturity index of capsicum when fruits are 100 % yellow (at 72 days to maturity from anthesis) was best for individual fruit weight, thousand seed weight, germination percentage, seedling dry weight and vigor index. This was first year trial. The experiment need to be continued further for more conformation.

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GROWTH, SEED YIELD AND SEED QUALITY PARAMETERS OF OKRA AS INFLUENCED BY DIFFERENT GROWTH REGULATORS

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Abstract

A field experiment was conducted in the field and laboratory of Seed Technology Division, BARI, Gazipur during *Kharif*-I season of 20211-2022 to study the effect of different plant growth regulators on growth, seed yield and seed quality of okra. The experiment was laid out in a Randomized Complete Block Design with three replications. The experiments were consisted of eight (8) treatment combinations. The treatments were T_1 = Control (No foliar Application), T_2 =100 ppm GA_3, T_3 = 200 ppm GA_3, T_4 = 100 ppm NAA, T_5 = 200 ppm NAA, T_6 = 100 ppm GA_3+100 ppm NAA, T_7 = 200 ppm GA_3+100 ppm NAA and T_8 = 200 ppm GA_3+ 200 ppm NAA. The number of branches plant^{-1}, the number of leaves plant^{-1} and plant height was higher in plants when sprayed with 200 ppm GA_3 + 100 ppm NAA as well as with 200 ppm GA_3 + 200 ppm NAA. The number of pods plant^{-1}, pod length, the number of seeds pod^{-1} and seed quality (in terms of 100-seed weight, germination percentage and seed yield) were maximum in plants receiving foliar spray of 200 ppm GA_3 + 200 ppm NAA.

Introduction

Okra popularly known as lady's finger is an important annual vegetable crop belongs to Malvaceae. Growth and yield of okra depends upon many factors including seed quality, nutrition, climatic conditions and cultural practices (Kusvuran, 2012). Chemical substances like plant growth regulators can bring changes in the phenotypes of plants and affect growth either by enhancing or by stimulating the natural growth regulatory systems from seed germination to senescence (Das and Das, 1995). Plant growth regulators are the chemical substances, when applied in small amounts modify the growth of plants by stimulating or inhibiting part of the natural growth regulatory system. The growth regulators include both growth promoters and retardants, which have been shown to modify the canopy structure and however, yield (Aurovinda and Rajendra, 2003). Though plant growth regulators have great potentials, its application and actual assessments etc. have to be judiciously planned in terms of optimal concentrations, stage of application, species specificity, season etc. for obtaining higher seed yield and quality (Kore *et al.,* 2003). Quality seed often determines the stability of yield in crops. So supply of quality seeds is an important aspect of vegetable seed production. It has been experience of research workers that regulating fruit number by proportionate retention of fruits on the plant has a direct bearing on the yield and quality of fruits and seeds (Venkata and Bhatt, 1997). Various aspects of methodology for seed production *viz.*, seed treatment, time and method of sowing, nutritional management, cultural practices and stage of harvest were widely studied in okra, but not the research on the effect of growth plant regulators. Asghar *et al*. (1997) reported increased pod length, pod diameter and pod yield of okra plants sprayed with GA_3 at different concentrations as compared with the control. But, the studies regarding the use of NAA and its use in combination with GA_3 on okra are lacking. In view of this, the present investigation was aimed to evaluate the effect of GA_3 and NAA alone and at their different combinations on crop growth, seed yield and quality in okra.

Material and Methods

The experiment was conducted at the field of seed Technology Division, BARI, Joydebpur, Gazipur during kharif season 2021-2022. The experiment was laid out in Randomized Complete Block Design with three replications adopting the recommended package of practices. The treatment involving different concentrations of plant growth regulators, *viz.,* gibberellic acid (GA_3) and naphthalene acetic acid (NAA), applied as foliar sprays on 30 and 45 days after sowing either alone or in combination as mentioned below (Table 1).

Table 1. Treatments (concentrations of growth regulators sprayed on okra)

Treatments	Gibberellic Acid (GA_3) ppm	Naphthalene Acetic Acid (NAA) ppm
T_1	Control (no foliar application)	
T_2	100	
T_3	200	
T_4	-	100
T_5	-	200
T_6	100	100
T_7	200	100
T_8	200	200

The 100 ppm and 200 ppm solutions of plant growth regulators were prepared by dissolving 100 mg and 200 mg is in small quantity of acetone dissolve all granules of PGR in acetone completely. It was made a final volume of 1 liter by adding double distilled water slowly. Finally the 100 ppm and 200 ppm concentrations of plant growth regulator solutions were prepared. The variety BARI Derosh-2 was used as the test crop. The unit plot size was 2.8×1.8 m and seeds were sown with a spacing of 60×40 cm. Urea, TSP, MoP, Gypsum and Boric acid were used as a sources of N, P, K, S and B respectively. Fertilizers were applied based on soil test and BARC fertilizer recommendation guide 2018. Crop was harvested after maturity. Data on yield and yield components, seed quality parameters were recorded five randomly selected plants from each plot. For analyzing the growth patterns of the crop *viz.,* plant height, number of branches per plant and number of leaves per plant were recorded on five randomly selected plants in a plot of each treatment at maturity stages. The observation on days to flower initiation was recorded on plot basis, while days to maturity were recorded based on the visual observations from five randomly selected plants in a plot of each treatment at harvest. The fruit maturity was decided based on the drying of fruits and development of hairline cracks on the fruits. The observations on yield parameters like number of pods per plant, length of pod (cm), number of seeds per pod, and seed yield (t/ha) were recorded based on five randomly selected plants in a plot of each treatment at the time of harvest. The observations on seed quality attributes like germination percentage, seedling dry weight was followed as per the standard procedures (Anonymous, 1999), and seedling vigour index (Abdul-Baki and Anderson, 1973). The data were then statistically analyzed by using statistical package Statistix 10 and means were separated by LSD.

Results and discussions

Vegetative growth of okra:

The results presented in the Table 2 revealed that the application of both PGRs, either alone or in combination on number of leaves plant^{-1} differed significantly. The maximum number of leaves plant^{-1} (36.2) was recorded in plants sprayed with solution containing 200 ppm GA_3 + 100 ppm NAA. However, it was statistically at par with T_3, T_4, T_5 T_6 and T_8 treatments and the minimum number of leaves plant^{-1} (24.7) was observed from control treatment (T_1).

The results presented in the Table 2 revealed that the effect of both PGRs, either alone or in combination on number of branches plant^{-1} differed significantly. The maximum number of branches plant^{-1} (3.9) was recorded in plants sprayed with solution containing 200 ppm GA_3 + 100 ppm NAA. However, it was statistically at par with $T_{2,}$ T_3, T_4, T_5 and T_6 treatments and the lowest number of branch plant^{-1} (2.7) was obtained from control treatment (T_1).

The application of both PGRs, either alone or in combination showed significant variations on plant height of okra (Table 2). The highest plant height (119.15 cm) was observed in plants sprayed with solution containing 200 ppm GA_3 + 100 ppm NAA. However, it was statistically at par with either the combined application of both regulators @ 200+200 ppm, and the lowest plant height (103.17 cm) was obtained from control treatment (T_1).

The induction of foliage and branching as well as increased plant height at maturity was more pronounced in plants treated with 100 ppm of NAA alone and/or in combination with different concentrations of GA_3. So, the synergistic effect of different concentrations of NAA (100 and 200 ppm) in combination with increasing dose of GA_3 resulted in specific vegetative inductive response of okra. Moreover, it can be depicted that application of each chemical individually @ 200 ppm was inhibitory to foliage production, branching and plant height. But, the same dose (200 ppm) of both (GA_3 and NAA), when combined together, was stimulatory and resulted in 16 to 36% increase in these characters over the individual application of GA_3 or NAA @ 200 ppm (Table 2). Our results are in line with the findings of Pandita *et al*. (1980) and Yamgar and Desai (1987) in chilli and Sharma *et al.* (1988) in bottle gourd who reported that number of branches was increased by the application of plant growth regulators that might be due to enhanced photosynthetic activity and efficient assimilation of photosynthetic products but need further confirmation

Table 2. Vegetative growth of okra in response to plant growth regulators

Treatments	**Number of leaves plant^{-1}**	**Number of branches plant^{-1}**	**Plant height at maturity (cm)**
Control (No foliar Application)	24.7	2.7	103.17
100 ppm GA_3	27.8	3.4	110.48
200 ppm GA_3	33.8	3.3	115.13
100 ppm NAA	32.8	3.8	115.77
200 ppm NAA	32.8	3.6	111.15
100 ppm GA_3 + 100 ppm NAA	30.8	3.4	115.07
200 ppm GA_3 + 100 ppm NAA	36.2	3.9	119.15
200 ppm GA_3 + 200 ppm NAA	31.8	3.0	118.48
LSD (0.05)	7.58	0.74	6.76
CV (%)	13.8	12.41	3.40

Reproductive growth of okra:

The data presented in the Table 3 indicated that the foliar application of growth regulators minimized the number of days taken to first flowering in comparison with control, but the results were non-significant. Significantly, minimum days to flowering (41.0) were recorded when 200 ppm GA_3 + 100 ppm NAA, whereas, maximum days to flowering (43.9) were observed in control. This might be due to increase in the endogenous gibberellins level in the plant as stated by Deepak *et al*. (2007).

Yield and yield contributing factors viz., number of pods plant^{-1}, pod length and number of seeds pod^{-1} in response to different treatments were also observed. Number of pods plant^{-1}, pod length and number of seeds pod^{-1} varied significantly among different treatments (Table 3).

Table 3. Reproductive growth of okra in response to plant growth regulators

Treatments	Number of days taken to first flowering	Number of pods plant^{-1}	Number of seeds pod^{-1}	Pod length (cm)
Control (No foliar Application)	43.9	18.86	38.53	18.04
100 ppm GA_3	41.4	20.86	44.46	19.24
200 ppm GA_3	41.2	21.46	50.80	19.48
100 ppm NAA	42.4	22.13	51.06	19.29
200 ppm NAA	41.3	19.733	49.13	18.98
100 ppm GA_3 + 100 ppm NAA	42.6	21.60	49.80	18.62
200 ppm GA_3 + 100 ppm NAA	41.0	23.40	51.00	20.13
200 ppm GA_3 + 200 ppm NAA	41.3	26.40	57.86	21.53
LSD (0.05)	NS	1.90	8.47	1.72
CV (%)	4.41	4.98	9.87	5.06

Number of pods per plant showed significant variation by the application of both PGRs, either alone or in combination. The maximum number of pods per plant (26.4) was recorded in plants sprayed with solution containing both 200 ppm GA_3 + 200 ppm NAA (T_8) which was also followed by sprayed with solution containing 200 ppm GA_3 + 100 ppm NAA (T_7) and the minimum number of pods per plant (18.86) was obtained from control treatments (T_1).

The maximum number of seeds per pod (57.86) was recorded in plants sprayed with solution containing 200 ppm GA_3 + 200 ppm NAA (T_8) which was also followed by sprayed with solution containing 200 ppm GA_3 + 100 ppm NAA (T_7) and the minimum number of seed per pods (38.53) was obtained from control treatments (T_1).

The highest pod length (21.53 cm) was observed in plants sprayed with solution containing 200 ppm GA_3 + 200 ppm NAA (T_8) which was followed by sprayed with solution containing 200 ppm GA_3 + 100 ppm NAA (T_7) and the lowest pod length (18.04 cm) was observed from control treatments (T_1).

The growth regulators play role in enhancing photosynthetic activity and subsequently the accumulation of photosynthates in plant organs to account for more fresh weight and dry weight. Gibberellins activate the growth mechanism, by efficient photosynthetic activity thereby increasing carbohydrate accumulation and thus dry matter contents (Yadava and Sreenath, 1975; Saleh and Abdul, 1980). The combined application of GA_3 (1.5 mM) and IAA (2.85 mM) significantly increased the length and number of internodes as well as the number of compound leaves in lentil (Naeem *et al*., 2004).

Seed yield and quality in response to plant growth regulators:

100 seed weight, seed yield/ha, germination percentage also varied significantly among different treatments (Table 4).

Hundred seed weight showed significant variation by the application of both PGRs, either alone or in combination, The maximum 100 seed weight (6.215 gm) was recorded in plants sprayed with solution containing 200 ppm GA_3 + 100 ppm NAA (T_7) which was followed by sprayed with solution containing GA_3 @ 200 ppm (T_3) and the minimum 100 seed weight (3.979 g) was obtained from control treatments (T_1). Similar results were reported by Godara *et al.,* (2013). This may be due to better diversion of photosynthesis to the fruit and better accumulation of food reserves in the seeds. Similar results have been confirmed by Bhat and Singh (1997).

Foliar application of gibberellic acid had been reported to affect number of seeds plant^{-1} as well as pods and seed yield plant^{-1} per unit area in several crops (Marie *et al*., 2007; Hoque and Haque, 2002). Therefore, impact of PGRs was also assessed on okra seed yield and quality. Seed yield (t/ha) was found maximum from plants sprayed with solution containing 200 ppm GA_3 + 200 ppm NAA and statistically it surpassed all other treatments (Table 4), while minimum seed yield was noted in control (T_1).

Germination percentage showed significant variation by the application of both PGRs, either alone or in combination. The maximum germination (98.66 %) was recorded in plants sprayed with solution containing 200 ppm GA_3 + 200 ppm NAA (T_8) which was also followed by sprayed with solution containing 200 ppm GA_3 + 100 ppm NAA (T_7) and the minimum germination (58.66 %) was obtained from control treatment (T_1)

It is clear from the results that treatments comprising of both GA_3 and NAA at high concentration improved seed yield significantly as compared to their application alone or in combination at low concentrations. Almost same trend was seen for seed quality indices i.e. 100 seed weight, germination percentage (Table 4). The more seed yield seemed to correlate with number of pods per plant.

Table 4. Seed yield and quality parameters of okra in response to plant growth regulators

Treatments	**100 seed weight (g)**	**Seed yield (t ha^{-1})**	**Germination (%)**
Control (No foliar Application)	3.979	0.850	58.66
100 ppm GA_3	5.137	0.959	73.33
200 ppm GA_3	5.522	0.974	65.33
100 ppm NAA	4.855	1.133	76.00
200 ppm NAA	4.727	1.037	72.00
100 ppm GA_3 + 100 ppm NAA	5.261	1.129	76.00
200 ppm GA_3 + 100 ppm NAA	6.215	1.301	90.66
200 ppm GA_3 + 200 ppm NAA	5.310	1.543	98.66
LSD (0.05)	0.74	0.30	19.70
CV (%)	8.35	15.57	14.74

The application of growth regulators might have improved the metabolism and resulted in accumulation of photosynthates ultimately yielding seeds of large size with better germination. The similar beneficial effects of growth regulators on enhancement of seed germination percentage were observed by Gedam *et al*. (1998) in bitter gourd and by Gondappalavar (2000) in tomato. The number of pods and seed yield $plant^{-1}$ was increased in mustard and okra by foliar spray of GA_3 @ 50-75 ppm (Akter *et al.,* 2007; Marie *et al*., 2007). Moreover, Hoque and Haque (2002) reported that foliar application of GA_3 @ 100 ppm resulted into more number of pods $plant^{-1}$, seed yield $plant^{-1}$, 1000 seed weight and seed yield ha^{-1} of Mungbean. In addition, highest seed germination percentage and seedling vigor were recorded from chilli plants treated with 10 ppm NAA (Sultana *et al*., 2006).

Conclusion

Among the different treatments 200 ppm GA_3 + 100 ppm NAA and 200 ppm GA_3 + 200 ppm NAA were the best for vegetative growth, reproductive growth, seed yield and quality characters of Okra. This report signifies the role of combined application of GA_3 and NAA at high concentration (200 ppm + 200 ppm) in improving okra seed yield and quality. This is the first year study which is to be needed further for more confirmation.

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GERMINATION AND SEEDLING PERFORMANCE OF CASHEW NUT AS INFLUENCED BY CHEMICAL SCARIFICATION

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Abstract

A laboratory experiment was conducted at the Seed Technology Division, BARI, Gazipur, Bangladesh during 2021-2022 to find out a suitable chemical scarification agent for germination and seedling performance of cashew nut. Hydropriming and vinegar (25% and 50%) were used as chemical scarification and the seeds were soaked for 0h, 24h, 48h, 72h and 96 h using Completely Randomized Design with three replications. The results of this research showed that the germination percentage of cashew nut increased due to the application of priming in different durations. According to the obtained results, treatment for water with 72 h soaking duration was the most effective treatment for improvement of cashew nut seed germination.

Introduction

Anacardium occidentale L (Cashew) belongs to the family Anacardiaceae. The tree is a native of tropical America, from Mexico and West Indies to Brazil and Peru (James, 1983). Part of the problems associated with its cultivation is successful seedling establishment due to dormancy associated with the seeds. Therefore, it is needed to find ways of breaking the seed dormancy and make planting stock available to farmers. Dormancy in nature serves to protect the seeds from inconsistent weather conditions. It also helps to prevent germination occurring during seed handling (Agbola, 1991). A physiologically sound seed may remain quiescent after exposure to all favorable conditions necessary for germination due to dormancy (Kozlowski, 1971). Dormancy could be either physical or chemical in nature. Physical dormancy is caused by hard seed coats or pericarps with cutinized layers which are impermeable to water, gases and light, while chemical dormancy may be caused by inhibitory chemicals present in the fruit and seed covering (Fasidi and Olufinboba, 1975, Fasidi *et al.*, 1979). Both conditions may however occur simultaneously. Seed with immature embryos may also fail to germinate (Nikolaeva, 1980).

According to Bajehbaj (2010) that chemical scarification of seed is an efficient method for increasing seed vigor and synchronization of germination, and in addition the growth of seedlings of many crops under stressful conditions. Heydecker and Coolbear (1977) stated that one of the long known main merits of priming treatments is to increase germination and emergence rate. The advantage of chemical scarification of seed is reducing the germination time and improving emergence in field and laboratory conditions. However, few detailed studies have been reported on the performance of osmotically treated seeds under field conditions. Chemical scarification of aged seeds of okra resulted in good germination and establishment in the field trials (Sanjaykumar *et al.*, 1996). There are a lot of benefits derived from chemical scarification particularly in all crops which included; faster emergence, more and uniform stands, less need to re-sow, more vigorous plants, drought tolerance, earlier flowering, earlier harvest maturity and higher seed yield (Chavan *et al.*, 2014; Harris *et al.*, 2001 and Assefa, 2008.). One of chemical scarification material used in seed germination is vinegar.

Evans and Blazich (1914) stated that vinegar is safer and can be used for species that do have an extremely hard seed coat; the technique is the same as with sulfuric acid. According to Tóbiás, *et.al*, (2007), vinegar types seem to be environmental friendly, cheap, and perspective dressing materials in ecological seed treatment. Acetic acid, in vinegar, is one of the most anciently used preservatives. Acetic acid is still examined in other countries as seed treating material, but it was applied only against fungi in arable cultures. Other examinations are also developed new adequate methods for seed treatment in ecological vegetable production, for example: natural compounds (Tinivella *et al*., 2004), plant extracts (Hartman *et al*., 1995), essential oils, and natural acids), antagonistic microorganisms, physical treatments (aerated steam treatment, hot water treatment (Roberts *et al*., 2006). Vinegar also changes pH, so the new environment is not suitable for bacteria. Acetic acid is a natural substance with low oral toxicity to humans, birds, and others who have contact with it (Borgen, 2001).

Hence, this study was conducted to determine the germination of the seeds of cashew nut under different treatments with the aim of breaking the dormancy, and to determine the most appropriate chemical scarification treatment in order to improve germination for easy propagation. This effort would go a long way in encouraging the plantation culture of cashew that is lacking, in the area under study.

Materials and methods

The experiment was laid out at the research laboratory of Seed Technology Division, BARI, Joydebpur, Gazipur, Bangladesh during 2021-2022 in a two factor Complete Randomized Design (CRD) and each treatment was replicated 3 times. The variety of cashew nut was M-23, collected from LA Agro Limited, Bandarban, Bangladesh.

Factor A: Chemical scarification: Water, 25% vinegar and 50% vinegar.

Factor B: Soaking duration: 0 h, 24 h, 48 h, 72 h and 96 h.

All the seeds of cashew nut were disinfected with ethanol 70% for three minutes and rinsed three times with distilled/sterilized water, before treatments. Six beakers, cleaned with a 10% bleach solution and distilled water, was labeled with their corresponding vinegar concentration. The first beaker was filled with 100 mL of 100% vinegar. A pipette was next used to transfer 50 mL of the 100% solution to the second beaker (labeled 50%). Additionally, 50 mL of distilled water was added to the second beaker, and it was gently swirled. Likewise, 25 ml of the 100% solution was transferred to the third beaker (labeled 25%). It was diluted with 75 mL of distilled water and swirled.

Seed germination was conducted using soil media at room temperature (25^0C). Seeds were soaked in water, and 25%, and 50% vinegar solution for 24 h, 48 h, 72 h and 96 h. Initial weight of seed was measured and weight was taken after 24 h, 48 h, 72 h and 96 h soaking. The difference between initial weight and weight after soaking for 24 h, 48 h, 72 h and 96 h provides the amount of absorbed water.

Ten seeds with three replications were used and expressed in percentage. Germinated seeds were counted daily for 30 days.

The percentage of survival of seedlings were estimated at the end of 60 days by using the following formula

$$\text{Survival rate (\%)} = \frac{\text{Total number of emerged seedlings} - \text{Total number dead seedlings}}{Total\ number\ of\ emerged\ seedlings}\ x\ 100$$

Data analysis

The data collected on the effect soaking duration and types of priming on germination and related parameters were subjected to two-way analysis of variance (ANOVA) using open-source R software. Separation of significant means was carried out using the Least Significant Difference (LSD).

Results and Discussion

Interactive effect of soaking duration and chemical scarification on germination characteristics of *Cashew nut* seeds

The germination capacity of one seed, based on a binary answer (germinated/non germinated), is one qualitative attribute of the germination process generally converted in a quantitative attribute, commonly in percentage.

The results of (Figure 1) showed that there are differences (at 5% level) between effective treatments on germination characteristics and the different treatments resulted in significant differences among germination properties.

The results of this research showed that the germination percentage of cashew nut increased due to the application of chemical scarification in different duration. According to the obtained results, treatment for water with 72 h soaking duration was the most effective treatment for improvement of seed germination (73%) which was statistically non-identical with all other treatments. Germination percentage was increased up to 72 h soaking duration then it stared declined for water. For 25% vinegar solution germination increased rapidly up to 48 hours and then declined. For 50% vinegar solution germination occurs only in 24 hour soaking duration. Results indicated that vinegar had a negative effect on germination of cashew nut.

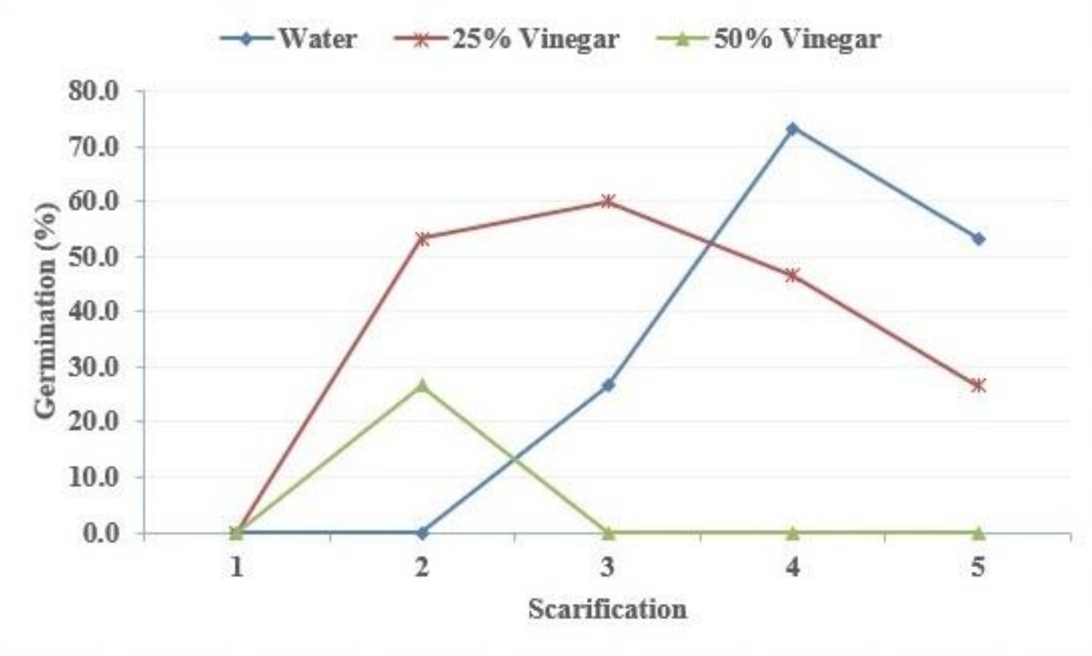


Fig.1: Interaction effect of scarification types over time (1=0 h, 2=24 h, 3=48h, 4=72h and 5= 96 h) on germination

Results for zero hour soaking duration of water, 25% vinegar and 50% vinegar reflect not having any combination of these treatments.

From table 1a, maximum value for the survivability was recorded in 25% vinegar for 24 h and 48 h priming which was statistically identical with all other germinated treatments. Survivability rate was around 80% and above in every germinated treatment which indicates that treatments did not affects survivability.

From table 1b, the highest number of leaves (11.00) was recorded in hydration and priming with 25% vinegar for 72 h soaking duration and the minimum (7.00) was recorded in hydration for 96 h and 25% vinegar for 48 h.

From Table 1c, the highest leaf length (6.93 cm) was recorded in hydration for 72 h soaking duration which was statistically identical with hydration for 96 h soaking duration and the lowest leaf length (4.23 cm) was recorded in 25% vinegar treatment when it was soaked for 96 hours.

From Table 1d, the highest leaf (3.43 cm) diameter was recorded in 25% vinegar treatment for 24 h which was statistically identical with 48 h soaking duration and the lowest (2.67 cm) was recorded in 25% vinegar solution for 96 h which was statistically identical with hydration for 96h.

From Table 1e, the highest seedling length (17.00 cm) was recorded in hydration for 72 h soaking duration which was statistically identical with 25% vinegar for 24 h and 96 h, and also with 50% vinegar for 24 h. The results reveal that priming does not effect on seedling length directly.

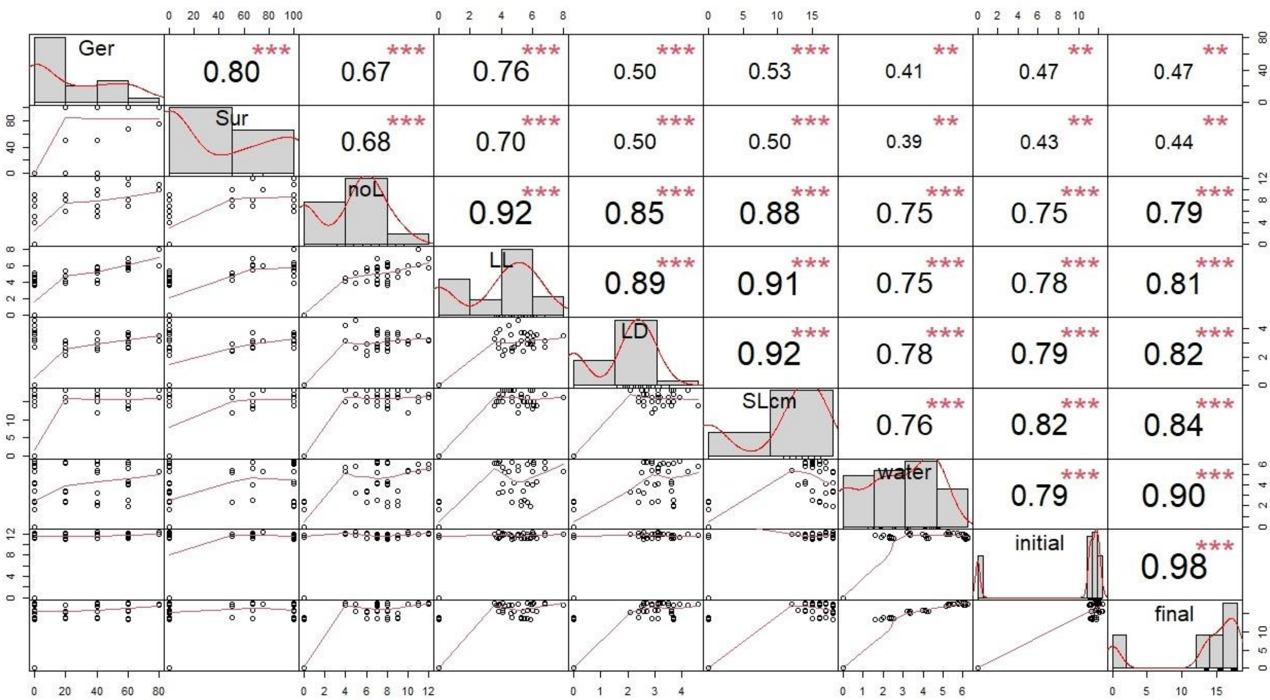
From table 1f, the results showed that maximum amount of water absorbed after soaking (6.17g, 5.79g and 6.11g respectively) was found when the seeds were soaked for 96 hours in all combinations namely, hydration, 25% and 50% vinegar solution. Water absorption rate was increased with the increasing of time.

Table 1a. Survivability (%)					
Chemical Scarification/ Soaking duration	**0h**	**24h**	**48h**	**72h**	**96h**
Water	0	0	0	80.67	78.00
25% Vinegar	0	89.00	89.00	83.33	83.33
50% Vinegar	0	83.00	0	0	0
CV (%)	41.14				
LSD (0.05)	26.83				
Table 1b. Number of leaves					
Water	0	0	0	11.00	7.00
25% Vinegar	0	7.00	8.00	11.00	8.00
50% Vinegar	0	9.00	0	0	0
CV (%)	11.37				
LSD (0.05)	1.08				
Table 1c. Leaf length (cm)					
Water	0	0	0	6.93	6.27
25% Vinegar	0	5.70	6.00	5.63	4.23
50% Vinegar	0	5.10	0	0	0
CV (%)	11.89				
LSD (0.05)	0.75				
Table 1d. Leaf diameter (cm)					
Water	0	0	0	3.23	2.73

25% Vinegar	0	3.43	3.40	3.20	2.67
50% Vinegar	0	3.07	0	0	0
CV (%)	15.44				
LSD (0.05)	0.59				
Table 1e. Seedling length (cm)					
Water	0	0	0	17.00	15.33
25% Vinegar	0	16.33	13.67	14.33	16.00
50% Vinegar	0	16.33	0	0	0
CV (%)	10.36				
LSD (0.05)	2				
Table 1f. Amount of water absorbed after soaking (g)					
Water	0	2.12	3.28	5.34	6.17
25% Vinegar	0	2.25	4.12	5.73	5.79
50% Vinegar	0	2.26	3.90	5.60	6.11
CV (%)	7.71				
LSD (0.05)	0.45				

Analysis of Correlation Matrix

The phenotypic correlation analysis is being used to explore a linear relationship between various traits, which was visualized in the correlation matrix (Figure 1). In this analysis, Germination (Ger) displayed a significant positive correlation with all parameters. Most of the parameters exhibited a strong positive correlation with other parameters. Germination and Survivability showed a moderate positive significant correlation with leaf diameter (LD), seedling length (SL) and amount of water absorbed during the period of soaking. Leaf length (LL) and leaf diameter (LD) displayed highest positive correlation with seedling length (SL).



*****Ger-Germination, Sur-Survivability, noL-Number of leaves, LL-Leaf length, LD-Leaf diameter, SL-Seedling length, Water-Amount of water absorbed during soaking, Initial-Initial seed weight, Final-Final seed weight

Conclusion

Hydration for 72 hours gave the highest seed germination (73%) and it was 27% higher over control.

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IMPROVING FIELD EMERGENCE PERFORMANCE OF SOYBEAN BY SAND MATRIX PRIMING

M. S. RAHMAN, U. KULSUM, A. HOSSAIN, P. C. SARKER, AND M. A. H. S. JAHAN

Abstract

A priming method called sand matrix priming was developed using sand as a priming solid matrix. The effect of sand matrix priming on improving the field emergence performance of soybean was investigated during 2020-21 and 2021-22 in the field of Oilseed Research Center, and in the laboratory of Seed Technology Division, BARI. The ratio of water: seed: sand was 1:2:2 on volume basis. Seeds were uniformly embedded in the wet sand and incubated at 25ºC for 24 hr, 48 hr, 72 hr, and 96 hr in darkness using Completely Randomized Design with three replications. Sand matrix priming for 24 hr incubation improves the emergence and yield of soybean. The relative possibility of emergence and yield was increased by 123% and 112%, respectively in 2020-21 and 120% and 118% respectively in 2021-22.

Introduction

Sand matrix priming (SMP) is a pre-sowing controlled seed hydration treatment in which seeds are mixed with sand carrier with low matric potential that allows them to imbibe water and go through the first stage of germination but does not permit radical protrusion through the seed coat. After sand matrix priming, the seeds are dried back to enable normal handling, storage, and planting (Mehta *et al.*, 2013). The key processes involved in sand matrix priming are the early onset of RNA, protein synthesis, and polyribosome formation. The activities of many enzymes involved in the mobilization of storage reserves are triggered. During sand matrix priming, the water content of the seed increases by 35 to 40 percent of its weight, enough to activate the biochemical events, advancing seed germination processes without radical emergence. The products of these changes persist the following desiccation and are available on re-imbibition of water during seed sowing, enabling the completion of seed germination rapidly, leading to a uniform crop stand and synchronized flowering/fruiting. Under invigoration, sand matrix priming improves metabolic repair processes in deteriorated seeds occur before the onset of the seed germination process (Varier *et al*., 2010).

It is a treatment at pre-sowing, leading to a physiological condition that makes it more useful for the seed to germinate. SMP also implies a simple procedure that hydrates seed partially in a controlled environment followed by seed drying, so that processes of germination start without a radical appearance (Paparella *et al.*, 2015). This simple pre-sowing process can enhance the emergence of radicle, pace of germination, seedling vigor, and uniform establishment by changing various physiological and metabolic activities (Eisvand *et al*., 2011). Therefore, the optimization of the priming technique and priming duration for a specific crop is an area worth exploring to improve crop establishment and productivity in a wide range of environmental conditions. Keeping in view the above facts, the present investigation was undertaken to study the effect of sand matrix priming on germination, growth, and yield of soybean.

Materials and methods

Seed materials

Seed material (BARI Soybean-6) was collected from Oilseed Research Center (ORC), Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

For priming sand material was used. Fresh sand passing through a sieve with a mesh size of 0.8 mm was sterilized at 180ºC for 1 hr. After that the sand was cooled, sterile water was added to make the ratio of water: seed: sand 1:2:2 on volume basis. Seeds were uniformly embedded in the wet sand and incubated at 25ºC for 24h, 48h, 72h, and 96h in darkness. The ratio of water volume, seed volume and sand volume were determined by trial and error method. Then, seeds were cleaned, air-dried at room temperature at 25ºC for 4 hr.

Field emergence test

The field emergence test was conducted using a randomized complete block design on three replicates of 100 seeds for each treatment. The plant and row spacing was 5 cm × 5 cm. Seeds were sown in soil 5 cm deep when the average temperature was 22.5ºC and the average relative water content was 72% at the sowing season (January) in 2021 and 2022. The number of emerged seedlings higher than 2 cm was recorded every day until no further emergence till 21 days after sowing.

Seedling characteristics, yield attributes and yield

Data on seedling height, number of leaves and leaf area were measured at 21 days after sowing.

The observations on days to 50 percent emergence, total emergence (%), plant height 21 at days after sowing (cm), days to first female flower appearance, node at which first female flower appear (number), days to first picking, harvest duration (days), fruit length (cm), fruit weight (g), number of fruits per plant, pod per plant, seeds per plant and hundred seed weight (g), fruit yield per plant (kg), fruit yield per plot (kg) and fruit yield per hectare (kg) were taken on five randomly selected plants from each replication.

Data analysis

The data were subjected to analysis of variance (ANOVA) using STAT-10 software. Least Significant difference (LSD) was used to separate and compare treatment means at a 5% probability level. Correlation analysis was computed to generate information about the association of yield and other parameters.

Results and discussion

The highest field emergence (93% and 85%) were recorded in T1 (24h) treatment in both 2021 and 2022, respectively which were statistically identical with T_2 (48 hr) treatment. The lowest emergence (67% and 21%) was recorded in T_4 (96 hr) treatment, it might be due to the sprouting of seeds during the period of priming. The highest leaf area (31.66 and 30.79) and the number of leaves (24 and 23) were recorded in T_1 (24 hr) treatment and the lowest were in T_4 (96 hr) treatment. The highest shoot length (12.3 and 12.7) were recorded in T_3 (72 hr) treatment, root length (2.9 and 3.9) in T_1 treatment, and dry matter (1.05 and 1.03) of seedling were recorded in T_1 (24 hr) and T_4 treatment in 2021 and 2022 respectively. The highest relative possibility of emergence (123 and 115) were obtained from T_1 (24 hr) treatment and T_4 (96 hr) treatment showed negative relative possibility (Table 1).

The present study showed that sand priming technology can improve the field emergence performance of soybean. Hu *et al.* (2005) reported that sand priming improved germination percentage, germination index, seedling height, root length, number of root and root dry weight, and so on. In this study, we found that the field emergence performance was decreased with the increase of priming time (24 hr, 48 hr, 72 hr, and 96 hr).

Table 1. Emergence and seedling characteristics

Treatment	Field Emergence (%)			Rel. Pos of Field emergence			Leaf area (mm)			No. of leaves		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean
Control (o hr)	77	71	74	100	100	100	25.77	29.9	27.83	21	22	22
24 hr	93	85	89	**123**	**120**	121	31.66	30.79	31.22	24	23	24
48 hr	89	82	85.5	115	**115**	115	30.88	30.1	30.49	23	23	23
72hr	82	66	74	116	**93**	104	27.44	29.3	28.37	23	22	23
96 hr	67	21	44	97	**30**	63	23.22	31.87	27.54	20	22	21
LSD (0.05)	5.02	6.97					0.292	NS		2.6	NS	
CV (%)	3.25	4.21					3.99			8.28		

(Rel. Pos.> Relative possibility)

Table 1. Continued...

Treatment	Shoot length (cm)			Root length (cm)			Dry matter (g)		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean
Control (o hr)	10.8	11.2	11.0	2.2	3.2	2.7	0.85	0.91	0.88
24 hr	11.9	11.8	11.85	2.9	3.7	3.3	1.05	0.98	**1.15**
48 hr	11.9	11.1	11.5	2.8	3.9	3.3	0.98	0.92	0.95
72hr	12.3	12.3	12.3	2.5	3.1	2.8	0.99	0.96	0.97
96 hr	11.0	12.7	11.35	2.8	3.0	2.9	0.83	1.03	0.93
LSD (0.05)	0.9	1.1		NS	NS		0.2	0.34	
CV (%)	5.86	4.98		18.21			12.35	9.87	

(Rel. Pos.> Relative possibility)

Priming had a significant effect was recorded in all the field parameters under study, except plant height and pod length (Table 2).

Days to flowering and days to maturity ranged from 61-63 and 58-60; and 104-107 and 108-110, respectively in 2021 and 2022. In the case of 24 hours, sand matrix priming of BARI Soybean-6 produced the highest pods per plant (66 and 65) and the lowest in 96 hours priming (53 and 51) which leads to an increase in total yield. 1000 seed weight (112.8 g and 104g) were also highest in 24 hours seed priming. The maximum yield of BARI Soybean-6 was recorded in 24 hours seed priming (1988 kg per ha and 1954 kg per ha) which is 12% 18% higher compared to the non-primed control (Table 2).

Sand matrix priming for 24 hr reduces 3 days to mature seeds without affecting 1000 seed weight and yield in both two tears. The number of internodes has a great influence on the end product. A higher number of internodes produce a higher number of pods and ultimately produce a higher yield.

Table 2. Mean field performance of yield contributing characters of soybean during Rabi, 2020-21 and 2021-22

Treatment	**Days to Flowering**			**Days to Maturity**			**Plant height (cm)**		
	2020-21	**2021-22**	**Mean**	**2020-21**	**2021-22**	**Mean**	**2020-21**	**2021-22**	**Mean**
Control (0 hr)	63	60	62	106	110	108	43	46.8	44.5
T_1 (24 hr)	61	58	60	104	108	106	47	45.6	**46.0**
T_2 (48 hr)	61	59	60	105	109	107	46	46.6	**46.0**
T_3 (72 hr)	62	59	61	107	109	108	43	51.0	47.0
T_4 (96 hr)	63	60	62	107	110	109	42	43.4	42.5
LSD (0.05)	1.1	0.8		1.3	1.6		Ns	1.4	
CV (%)	0.9	3.7		0.7	0.60		6.5	12.69	

Table 2. Continued...

Treatment	**Pods/plant (no.)**			**Pod length (cm)**		
	2020-21	**2021-22**	**Mean**	**2020-21**	**2021-22**	**Mean**
Control (0 hr)	59	61	60	3.7	3.9	3.8
T_1 (24 hr)	66	65	65	3.7	3.9	3.8
T_2 (48 hr)	57	58	57	3.7	3.8	3.7
T_3 (72 hr)	59	53	56	3.6	3.4	3.5
T_4 (96 hr)	53	51	52	3.7	3.2	3.4
LSD (0.05)	7.6	5.9		Ns	Ns	
CV (%)	6.9	9.83		5.2	7.04	

Table 2. Continued...

Treatment	**1000 seed weight (g)**			**Yield (kg/ha)**			**Rel. Pos. of yield**		
	2020-21	**2021-22**	**Mean**	**2020-21**	**2021-22**	**Mean**	**2020-21**	**2021-22**	**Mean**
Control (0 hr)	98.3	89	93.5	1770	1629	1700	100	100	100
T_1 (24 hr)	112.8	104	108	1988	1919	1954	**112**	118	115
T_2 (48 hr)	100.3	98	99	1942	1802	1872	**110**	111	111
T_3 (72 hr)	97.8	96	96.5	1656	1343	1500	94	82	88
T_4 (96 hr)	108.7	110	109	1642	1272	1457	93	78	85
LSD (0.05)	11.7	8.6		106.3	98.4				
CV (%)	6.1	3.9		4.2	7.8				

Conclusion

Sand matrix priming for 24 hour showed higher field emergence performance (22% over control) of soybean as well as yield contributing characters like pods/plant, 1000 seed weight and seed yield (15% over control).

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Acknowledgement

This work was supported by the fund of SACP (BARI component) project to complete this work and also for further collaboration.

EFFECT OF DIFFERENT SEED DRYING METHODS ON SEED QUALITY OF SWEET PEPPER

M. S. RAHMAN, P. C. SARKER, S. MIAH, M. A. HOSSAIN, M. ISLAM AND M. A. H. S. JAHAN

Abstract

An experiment was conducted in the laboratory of Seed Technology Division, and Farm Machinery and Postharvest Engineering Division, BARI to find out the influence of drying methods for sweet pepper using Completely Randomize Design with 3 replications. The treatments were fan drying, sun drying, solar cabinet drying and drying with drying beads. The results indicated that solar cabinet drying and drying with drying beads were more suitable for drying of sweet pepper considering seed quality parameters and reduction of germination percentage during storage.

Introduction

Drying is one of the essential unit operations performed to increase the shelf life of agricultural / horticultural produce and it is one of the most practical methods of preserving food and the quality of horticultural produce. If the drying process is not completed fast enough, growth of microorganisms will take place as a result of the high relative humidity (Desai *et al*., 2002). This often leads to severe deterioration of the quality of the product. Traditionally, the food products are dried by spreading in thin layer in open sun. Though this method is economical and simple, it has the draw backs like - no control over the rate of drying, non-uniform drying, and chance of deterioration due to exposure of products against rain, dust, storm, birds, rodents, insects and pests resulting in poor quality of dried products.

Seed moisture plays major role in determining the longevity of seed in several vegetables, particularly in sweet pepper. Most of the vegetable seeds can withstand drying to extend their storage life with low moisture content. All kinds of drying methods will not suit equally well under given set of conditions in retaining viability and vigour of seeds. After extraction of seeds from the fruits, seed moisture content varies generally from 40 to 45 per cent. It has to be reduced to safer level of 8 to 9 per cent by drying to preserve the quality of seed during storage (Rajkumar, 2013). Sweet pepper (*Capsicum annuum* L.) is a highly perishable crop after harvest in a ripened condition at moisture content of 310 % (d.b.) as against its safe moisture level of 8% (d.b.) Chandy (2002). It has been found that the higher temperatures resulted in reduced drying time and an increase in the effective moisture diffusivity (Di Scala and Crapiste, 2008). However, using high temperatures for drying produces a low quality of chillies, with losses of volatile compounds, nutrients and color (Kaleemullah and Kailappan, 2006). The present in work is conducted with the specific objective to find out the influence of different drying methods on seed quality of sweet pepper seeds.

Materials and Methods

An experiment was conducted in the Seed Technology Division, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. Fruits of BARI Misti Morich-2 variety were obtained from Seed Technology Division. The seeds were collected manually from fully ripe sweet pepper fruits and then dried by different dying methods. Collected seeds were subjected to different drying methods with three replications. The treatments details

T_1 – Fan drying (room temperature)
T_2 – Sun drying
T_3 – Solar cabinet drying (temperature was fixed at 42^0C)
T_4 – Drying beads

The seed quality parameters such as moisture content (%) and germination percentage were accessed by adapting ISTA procedure (ISTA, 2005). Hundred seeds each in each treatment were germinated in laboratory condition for germination test. While evaluating the number of normal seedlings at the time of final count, the seedling length of 5 randomly selected seedlings were measured. Seed vigour index is calculated by multiplying germination (%) and seedling length (cm). The seed lot showing the higher seed vigour index is considered to be more vigorous. The vigour index (VI) was calculated by adopting Abdul-Baki and Anderson (1973). The plant shoot length, root length, seedling dry weight and field emergence were observed as per standard methods.

Results and Discussion

The results of seed quality parameters such as Germination, vigour index, root length, shoot length, seedling dry weight, electrical conductivity and moisture content due to drying methods are presented in table 1 and 2. Capsicum seed attains physiological and functional maturity at high seed moisture content of 39-40% (w.b). Therefore sooner the seed is extracted, cleaned and dried, seed will be better quality. While, the rate of moisture migration from center to surface of the seed is influenced by temperature, pericarp thickness, chemical composition of seed and seed coat permeability. The rate of moisture removal from the surface of seed is influenced by degree of surface saturation, relative humidity and temperature of drying air. If evaporation from the seed surface occurs too rapidly it can damage the embryo, therefore seed should be dried carefully to arrest stress damage due to heat

(Philpot, 1976). In contrast, if moisture elimination takes place too slowly it may favour invasion of pathogens (Harrington, 1972). Among the drying methods, maximum time (79h) to reach at 9.0±0.5% moisture content was recorded in fan drying and the minimum time (4.0 h) was recorded in Solar cabinet dryer. The drying time ranges from 4 h to 79 h. Drying procedure continued till to reach at 9.0±0.5% MC and it varied from 8.51-9.46%. The initial germination was recorded just after drying of seeds before storage. The highest initial germination (90%) was recorded in drying beads (T_4) which was statistically identical with the treatment of solar cabinet (T_3) and the lowest was recorded in T_1 treatment. The difference of range from maximum to minimum was very tiny. The final germination was recorded after outlet from the storage for 6 month. The highest germination (81%) after outlet from the storage was recorded in T_4 treatments which were statistically identical with T_3 treatment and the lowest (75%) was recorded in T_1 treatment.

In the present study, the mechanical drying (solar cabinet drying) and sun drying reduced seed moisture content to 8.79 and 8.51 per cent respectively in relatively shorter period. While, in fan drying moisture content reduced to 9.46 per cent over a longer period. Germination was also affected by drying methods. The highest germination reduction was recorded in T_1 treatment and the lowest was recorded in T_3 and T_4 treatments. There was a difference in initial moisture content of T_1 and T_4 treatments. T_1 treatment had 0.39% more moisture than T_4 treatment; it might be a cause of reduction of viability of seeds in storage. As a result, the final germination percentage of seed varied from T_1 treatment to T_4 treatment. There is a chance of damaging of seeds in direct sun light namely stress damage of heat. As because of this, having lower moisture content before storage the initial germination percentage was lowest and after storage the germination percentage did not gave the maximum values for germination.

Table 1. Influence of different drying methods on pre and post storage germination

Treatment	**Time to reach at 9.0±0.5% MC (hour)**	**Moisture**	**Initial germination (Pre storage; %)**	**Final germination (Post storage; %)**	**Reduction of germination (%)**
Fan drying	79	9.46	89	75	14
Sun drying	13	8.51	87	77	10
Solar cabinet dryer	4	8.79	89	80	9
Drying beads	28	9.07	90	81	9
CV (%)	5.24	2.26	1.3	2.76	-
LSD (0.05)	3.07	0.38	2.17	4.0674	-

According to the results, root length and vigor index were varied significantly due to drying methods. Root length, shoot length and SVI I were recorded highest in T_4 treatment. The lowest root length (6.33) was recorded in T_1 treatment which also gave the lowest (1005) Seed Vigor Index. Low electrical conductivity (1.39 ds/m) of seed leachate values were recorded in T_4 treatment which indicates that seeds were less injured when dried in controlled condition like drying beads. The results of shoot length, dry weight and electrical conductivity did not vary significantly among the treatments. Shoot length ranges from 6.33 to 7.52 cm, dry weight ranges from 16.33 to 18.67 and electrical conductivity ranges from 1.39 to 2.19 ds/m.

Table 2. Influence of different drying methods on seedling quality parameters

Treatment (s)	Root length (cm)	Shoot length (cm)	SVI I	Dry weight (mg)	Electrical conductivity (ds/m)
Fan drying	6.33	7.00	1005	17.33	2.19
Sun drying	8.00	6.33	1103	17.67	1.98
Solar cabinet dryer	8.67	6.66	1227	18.67	1.59
Drying beads	8.67	7.33	1291	17.33	1.39
CV (%)	2.32	7.52	18	0.88	- -
LSD (0.05)	0.9414	NS	163.76	NS	

Conclusion

Considering the results of above study, it may be suggested that solar cabinet dryer and drying beads are more preferable methods of seed drying of sweet pepper in consideration with seed quality parameters like germination, SVI I and loss of viability during storage period.

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GERMINATION AND SEEDLING PERFORMANCE OF WATERMELON AS INFLUENCED BY SEED PRIMING

M. ISLAM, R. KARIM, M. S. RAHMAN AND M. A. H. S. JAHAN

Abstract

An experiment was conducted in the laboratory of Seed Technology Division, BARI, Gazipur during 2021 to know the effect of seed priming in watermelon to overcome germination problem. Seeds of BARI Tormuj-1 were subjected to priming with 1%, 2% and 3% of KNO_3 and $CaCl_{2;}$ hydroponic solution and fresh water for 24 hours and no priming as control using Completely Randomized Design with three replications. 1% KNO_3 & $CaCl_2$ gave higher germination (89.33% & 88.00%) than the other treatments. Higher germination speed was recorded from seed priming with 1% KNO_3 solution. Maximum root length (5.60 cm), shoot length (5.74cm), length of seedling (11.34cm), seedling fresh weight (0.862g), dry weight (0.080), vigor index (5.74) and emergence index (75.66%) was obtained from seed priming with better quality of seedling 1% $CaCl_2$ solution. Minimum germination and poor quality seedling was obtained from 3% $CaCl_2$ where minimum emergence was found in control treatment. Therefore, priming of watermelon seed with 1% $CaCl_2$ would increase germination and give better quality seedling

Introduction

Seed priming is a pre-sowing treatment that involves exposure of seeds to low external water potential that limits hydration. Seed priming is a controlled hydration treatment in which seeds are allowed to imbibe before radical protrusion (Bradford, 1986) and improves the germination rate, uniformity of germination, and sometimes greater total germination percentage (Basra *et al*., 2006 a, 2006b, Farooq *et al*., 2006). The most important priming treatments are osmopriming, halopriming and hydro priming. Mechanical weakening of the seed coat structure such as scarification, seed coat nicking, and seed coat lateral splitting has been reported to successfully enhanced germination performance of triploid watermelon seed (Duval and Ne Smith, 1998; Grange and Leskovar, 2000). However, some drawback effects such as embryo injury and time involved are the negative effects usually associated with these treatments. Priming with potassium nitrate (KNO_3) solution has been shown to have beneficial effects on germination and growth rate of a wide range of vegetable crops under stressful environments, as in eggplant (Nascimento & Lima, 2008), tomato (Ebrahimi *et al*., 2014), and pepper (Batista, 2015). Therefore, researchers are needed to detect a practical and easily handling method to improve the germination performance of triploid seeds aiming to promote triploid watermelon production. Considering the above perspective, the present study was done to overcome germination problem in watermelon.

Materials and Methods

The research work was executed in the Laboratory of Seed Technology Division. The seeds were soaked in aerated 1, 2 and 3% solutions of each KNO_3, $CaCl_2$, hydroponic solution, fresh water for 24 h. The ratio of seed weight to solution volume was 1:5 (g/mL) (Farooq *et al.*, 2006).

Composition of the hydroponic solution-(Stock A+ Stock B+ Stock C)

Stock A: N -244.5 ppm, K -2.43 %, P -1.52 %, B -28.12 ppm , Mo -24.76 ppm.

Stock B: N- 120.27 ppm, Ca- 0.89 %, Fe- 0.11 %.

Stock C: Mg- 0.46 %, S-1.01 %, Mn- 190.67 ppm, Cu- 10.57 ppm, Zn- 31.24 ppm.

After priming, seeds were given three surface washings with distilled water and re-dried to original weight with forced air under shade at 27±3 °C. A portion of seeds were subjected to germination test in the laboratory and rest of seed were sown in plastic seed growing tray filled with garden soil and placed in an open place accomplished with adequate sunlight and air. The number of emerged seeds was recorded at 14 days after sowing. The following data were recorded in the study.

Germination percentage: Seed germination test was conducted in the Seed Technology laboratory of BARI using three layered moistened blotter paper on Petri dishes. Hundred seeds were placed on each Petri dish and kept at 25^{0}C temperature for fourteen days for germination. It was replicated 4 times for germination test. The first and final count was taken on 4^{th} and 14^{th} day of the test respectively. Germination percentage was calculated using the following formula:

$$\text{Germination (\%)} = \frac{\text{Normal seedlings germinated}}{\text{Seeds kept for germination}} \times 100$$

Germination speed: Speed of germination was computed by recording daily observations on 100 seeds sown in sand medium until the final count day (14 days). The speed of germination was calculated as total number of seeds emerged on day basis, and the mean was calculated as suggested by Copeland (1976).

$$GS = \left(\frac{\text{No. of germinated seeds at first count}}{\text{Days of first count}} + \text{- - -} + \frac{\text{No. of germinated seeds at final count}}{\text{Days of final count}}\right)$$

Seedling length: 5 seedlings were drawn randomly from the petri dish and radical length, plumule length of each seedling was measured using a measuring scale in centimeter. Average length of seedling was calculated from radical and plumule length.

Seedling fresh weight (g): Five normal seedlings were randomly selected on 14th day and fresh weight of seedlings was measured by an electronic weighing balance and expressed in gram.

Seedling dry weight (g): For dry weight determination, the 5 normal seedlings were randomly selected on 14th day and dried in an oven at 71ºC for 72 hrs. Then cooled and weighed in an electronic weighing balance and expressed in gram.

Seedling vigor index: Vigor index was calculated on the basis of mean seedling length by adopting the formula (Adbdul-Baki and Anderson 1973).

Vigor index = Germination (%) × Seedling length (cm)

Emergence percentage: The number of emerged seeds was recorded at 14 days after sowing seed.

Statistical Analysis

The collected data on different parameters were analyzed statistically by analysis of variance (ANOVA) using R command program. The significance of the difference among the means was calculated by LSD test (Least Significance Difference).

Results & Discussion

Germination percentage

Maximum germination was found 89.33% from the treatment 1% KNO_3 that was statistically similar to the treatment of 1% $CaCl_2$ and minimum 44% was observed in 3% $CaCl_2$ treatment. Similarly, Korkmaz *et. al.* (2004) found seeds primed in KNO_3 solution increased germination up to 69%, Farooq *et al*. (2007) found osmopriming in KNO_3 solutions improved the germination rate and uniformity, Armin *et. al*. (2010) found 17.87% higher germination in watermelon compared to non-primed seed.

Table 1. Seed priming effect on germination and length of seedling

Treatments	Germination (%)	Germination Speed	Root length of seedling (cm)	Shoot length of seedling (cm)	Seedling length (cm)
KNO_3 -1%	89.33	6.093	3.81	5.30	9.12
KNO_3- 2%	80.00	5.403	4.62	3.80	8.42
KNO_3- 3%	82.66	3.773	5.14	3.49	8.64
$CaCl_2$ - 1%	88.00	5.400	5.60	5.74	11.34
$CaCl_2$ - 2%	54.66	3.453	4.46	4.57	9.03
$CaCl_2$ - 3%	44.00	2.806	3.47	3.64	7.12
Hydroponic Solution	84.00	5.806	5.33	3.48	8.82
Fresh water	64.66	4.376	4.87	5.45	10.32
Control	85.33	4.276	5.05	4.46	9.52
Lsd (0.05)	1.47	0.66	0.42	0.25	0.56
CV(%)	1.15	8.41	5.72	3.34	3.61

Germination speed

Germination speed was found higher in primed seed in 1% KNO_3 solution than the other treatments and lower in 3% KNO_3 solution. Seed primed with 2% KNO_3, 1% $CaCl_2$ and hydroponic solution showed statistically similar result in case of germination speed.

Seedling length

This positive effect of priming was clearly reflected in subsequent root and shoot length. Maximum (5.6 cm) root length and (5.74 cm) shoot length was obtained from treatment 1% $CaCl_2$ where minimum was found in 3% KNO_3 solution. 5.33 cm root length was obtained from hydroponic solution that was statistically similar to 1% $CaCl_2$. Total length of seedling was found higher in 1% $CaCl_2$ than the other treatments. 10.327 cm long seedling was obtained from fresh water soaking treatment that was comparatively higher than other treatments.

Dry weight of seedlings

Maximum dry weight of seedlings was found in treatment of 1% $CaCl_2$ that was statistically similar with the treatment 1% KNO_3 and hydroponic solution. Minimum seedlings dry weight was found in seed priming with 3% KNO_3 solution.

Seedling vigor index

Vigor Index of seedling was found higher in seed when primed with 1% $CaCl_2$ solution and lower in case of seed priming with 3% KNO_3 solution. Osmopriming with high concentration of KNO_3 may have some toxic effects as reported by Basra *et al.*, (2005) and Farooq *et al.*, (2006a) in rice.

Emergence Index

Emergence Index of seed was found maximum (62.66) when seed primed with 1% $CaCl_2$ solution that was statistically similar with seed priming with 2% $CaCl_2$ and hydroponic solution. Minimum emergence of seedlings was observed in control treatment. Osmopriming with KNO_3 and $CaCl_2$ (at low concentration) also improved the emergence percentage that might be due to overcoming some seed dormancy and /or improving embryonic development.

Table 2. Seed priming effect on seedling fresh weight, dry weight, vigor and emergence index

Treatments	Fresh weight of seedlings (g)	Dry weight of seedlings (g)	Vigor Index	Emergence Index
KNO_3-1%	0.725	0.079	814.67	62.66
KNO_3- 2%	0.737	0.068	673.67	74.66
KNO_3- 3%	0.669	0.066	714.00	70.66
$CaCl_2$ - 1%	0.862	0.080	998.00	75.66
$CaCl_2$ - 2%	0.683	0.072	493.33	64.00
$CaCl_2$ - 3%	0.521	0.071	313.33	62.66
Hydroponic Solution	0.831	0.080	740.67	75.33
Farmer Practice	0.842	0.067	668.00	68.00
Control	0.839	0.067	812.33	62.00
Lsd (0.05)	0.065	0.0071	46.160	3.43
CV(%)	5.14	5.72	3.89	2.92

Conclusion

The present study revealed that seed priming with 1% $CaCl_2$ solution gave better result in case of germination, germination speed, seedling quality, vigor index and emergence index. This was the first year result. For confirmation of the result, the experiment should be repeated in next year.

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SEED PRODUCTION OF BARI HYBRID MISTIKUMRA-1

S. A. BAGUM

Abstract

The field experiment was carried out during 2021-22 in *Rabi* season at Seed Technology Division, BARI, Gazipur to increase the quality hybrid seeds stock of BARI hybrid mistikumra-1 for demonstration and distribution. The seed of parental lines of BARI hybrid mistikumra-1 was collected from Olericulture Division, Horticulture Research Center, BARI, Gazipur. The seedlings were raised in controlled conditions and 30 days old seedlings were transplanted one seedling per hill at the spacing of 3.0 m x 1m. Planting ratio was 3:1 i.e. 3 female and 1 male. During sowing time of male plant was sowed 10 days after females for synchronization of flowering. Finally, 3.0 kg quality hybrid mistikumra-1 seed was harvest and kept in safe store for distribution.

Introduction

Pumpkin (*Cucurbita moschata* Poir.), is an important Cucurbitaceae family member and is grown extensively during rabi and kharif season in Bangladesh. It is locally known as “Mistikumra”. The pumpkin is a diploid (2n=40), self-compatible, monoecious annual vegetable crop. The area of winter pumpkin is 17409, ha and production is 206000 metric tons and the area of summer pumpkin is 11336 ha and production is 114000 tons during 2018-19 (BBS, 2020). It is a good source of carotene, pectin, mineral salts, vitamins and other substances that are beneficial to health (Jun *et al*., 2014).

The trend of hybrid seed usage in vegetable is increasing day by day in Bangladesh. Availability of cost-effective mechanism/method to produce large-scale F_1 seeds utilizing selected parental lines is an important factor, which ultimately determines the commercial viability of the hybrid varieties. In vegetables, hybrid seeds can be developed through manual emasculation (in case of hermaphrodite crops) followed by manual pollination of emasculated flowers or pistilate flowers (in case of monoecious crops with separate staminate and pistilate flowers) & seed production of commercial hybrids (large quantity of seeds for cultivation) based on such methods is economically feasible only in cucurbits and few other vegetables, in which a large number of F1 seeds are obtained from one manually pollinated crossed fruits.

Hybrid varieties play a vital role in increasing vegetable production due to their high yield potential, early maturing, superior quality, disease and pest resistance attributes. Techniques of hybrid seed production in cucurbits through hand emasculation and hand pollination, hand emasculation and pollination by insect, use of genetic male sterility system, use of gynoecious sex form and modification of sex expression.

Seed is pre-requisite to popularize the selected promising hybrids to the farmers and growers. For conducting demonstrations and distribution large amount of hybrid seed is needed. Therefore, the program is undertaken to increase the seed stock of BARI hybrid mistikumra-1 for demonstration and distribution.

Materials and Methods

The field experiment was carried out during 2021-22 *rabi* at Seed Technology Division, BARI, Gazipur-1701. The seed of parental lines of BARI hybrid mistikumra-1 was obtained from the of Olericulture Division, Horticulture Research Center, BARI, Gazipur. The seedlings were raised in controlled conditions and 30 days old seedlings were transplanted one seedling per hill at the spacing of 3.0 m x 1m. Planting ratio was 3:1 was applied i.e. 3 female and 1 male. During sowing time of male plant was sowed 10 days after females for synchronization of flowering.

Hand pollination method was followed for hybrid seed production; the male flowers in female or seed parent were pinched regularly before the anthesis. The female flowers likely to be opened next day, were tied with James clips during evening (5-7 p.m.). On the same day, the male bud in the pollen parent was also tied with James clips. On the next day the male buds were collected and the anthers were rubbed gently over all the three stigmatic lobes. The female flower was again tied with the James clips and label was placed over the peduncle of pollinated female flower. The pollination was performed in the morning between 6-8 a.m. continuously for one-month duration.

Plant spacing was 2x2 m and unit plot size was 3 x 20 m. The recommended doses of manure and fertilizers such as 5 ton/ha cow dung, 100 kg N, 48 kg P, 80 kg K, 28 kg S, 3 kg Zn and 2.1 kg/ha B in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid were applied in the experimental field (FRG, 2018). The full doses of cow dung, TSP, MP, gypsum, zinc sulphate and boric acid were applied during pit preparation before one week of transplanting. The urea was applied in the four installments as top dressing at 15, 35, 55 and 75 days after transplanting. Normal cultivation techniques and intercultural operations were followed to have a good crop. Pheromone trap was used for insect control. All the intercultural operations such as irrigation, weeding, insect control etc. were done as and when necessary.

The observations on days to first male flowering, number of fruits per plant, seed yield per fruits (g), seed yield per plant (g), fruit weight (kg), fruit diameter (cm), number of seed, total seed (kg), 100 seeds weight (g), seed length (mm), seed wide (mm), seed thickness (mm), 100 seed volume (cc), percent germination (%), root length (cm), shoot length (cm), seedling dry weight (g), Root Shoot Ratio, Vigour Index I and Vigour Index II were recorded.

Table 1. Fruits characteristics of male and female plant and seed quality of BARI hybrid mistikumra-1 sweet gourd

Traits	Male Parent		Female Parent	
	Mean	**SE (±)**	**Mean**	**SE (±)**
Days to first male flowering	82.00	2.45	66.00	3.74
Fruit weight (kg)	2.26	0.42	1.90	0.20
Fruit diameter (cm)	62.61	4.34	52.96	4.22
Number of seed per fruits	424.00	64.21	365.67	93.09
Total seed (nos.)	53.31	15.28	37.55	5.49
100 seeds weight (g)	14.07	3.03	12.05	0.98
Seed length (mm)	17.19	2.86	15.60	3.46
Seed wide (mm)	7.92	1.78	7.69	2.32
Seed thickness (mm)	3.41	1.37	2.67	2.47
100 Seed volume (cc)	19.80	1.85	18.40	1.24
Percent germination (%)	53.33	16.65	93.33	8.33
Root length (cm)	11.07	3.64	9.47	2.47
Shoot length (cm)	12.93	2.21	17.37	0.21
Seedling dry weight (g)	380.00	40.00	430.00	62.00
Root Shoot Ratio	0.86	0.07	0.55	0.09
Vigour Index I	689.56	45.00	1621.14	17.00
Vigour Index II	20265.40	66.00	40131.90	51.00

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ASSESSMENT OF SEED QUALITY OF SOYBEAN THROUGH ACCELERATED AGING METHOD

S. A. BAGUM and M. A. H. S. JAHAN

Abstract

The experiment was conducted to evaluate the effects of duration of seed aging on soybean seeds quality characteristics on soybean varieties/lines. The experiment was laid out in Split plot completely randomized design with 4 replications. Seeds were subjected to accelerated aging treatment for, 24, 48, 72 and 96 hours at 45 ±1°C and 90% relative humidity. These artificially aged seeds were compared to control (Unaged seeds) for evaluation of seed quality parameters. The percentage germinated was significantly affected by accelerated aging treatments. Accelerated aging (AA) reduced seedling length, seed vigor index, dry weight, in addition to lowering germination percentage. From probit analysis, it can be concluded that the BARI Soybean-4 and 5 can be stored 6-8 months in store with 80% germination. Finally, the findings demonstrated that accelerated aging reduced the viability of soybean seeds.

Introduction

The soybean (*Glycine max*) is a species of legume native to East Asia, widely grown for its edible bean which has numerous uses. Soybeans are the main grains produced, ranking fourth in global production volume and first among the oil "major oilseeds," participating in the global agricultural economy. Soybean is one of the most important sources of protein and gaining popularity in Bangladesh. Now a day its oil is very popular as cooking purposes in the country. The extraction of soybean oil from the seed is not yet possible by the traditional method. So, most of the soybean produced in the country is used mainly in the feed industries. The soybean can also be used to prepare the quality food items like soyadal, soyakhechuri, soyamisty, soyapolao, soyamilk, soya cake, soya biscuits, and soya bread etc. Soybean seed contains 42-45% protein and 20-22% edible oil. Recently the crop has gained popularity for its meal used in an important ingredient of poultry and fish feed as a source of protein. Introduction of this temperate crop to sub-tropical climatic conditions like Bangladesh made it more vulnerable to problems like seed storage duration, poor growth rate due to changed photoperiod, various biotic and abiotic stresses, etc.

The evaluation of the physiological potential of seeds is an essential component of any quality control program, as it provides information for the detection and problem solving during the production process, as well as on seed performance. As the official procedure for evaluating the ability seeds to produce normal seedlings under ideal conditions, the germination test is conducted in the laboratory under favorable conditions of substrate, moisture and temperature. As a result, this test usually overestimates the physiological potential of seed lots, thus creating a need for improved testing techniques regarding seed vigor to provide consistent results in a short time.

Vigor tests have been used to identify differences in the performance of seed lots, which may occur during storage or after seeding, highlighting lots with greater capacity to yield adequate stands under a wide range of environmental conditions, usually unfavorable, thus, providing complementary information to that provided by the germination test.

The accelerated aging test is one of the most commonly used procedures for the evaluation of seed vigor and has shown high correlation with the seedling emergence of several vegetable species in the field. This test is based on the simulation of adverse environmental conditions such as high temperatures and high relative humidity, which are listed as the main factors responsible for seed deterioration, wherein temperature and time of exposure will vary on their effects according to the different species. Seed quality as measured by its vigor and viability plays a major role in establishment of seedling as well as higher crop yield. Accelerated ageing is effective for creating ageing of seeds. Seed deterioration is enhanced by high temperature and relative humidity during storage. The accelerated test is also useful in predicting relative storability of seed.

The objective of this work was to study certain changes associated with loss of viability during accelerated ageing of soybean and to predict duration soybean seed storability in storage.

Materials and Methods

The work was conducted at the Laboratory of Seed Technology Division, BARI, Gazipur-1701 during of 2021-22. The experiment comprised of nine soybean genotypes including four BARI released soybean varieties (BARI Soybean-5, BARI Soybean-4, BARI Soybean-6, Sohag, p-7-E, USDA-15, Goo-382, BINA soybean-4 and Vietkhai) in main plot and four ageing time treatments with control viz. (i) T_1 = Control (0 hour), (ii) T_2 = 24 hours, (iii) T_3 = 48 hours, (iv) T_4 = 72 hours and (v) T_5 = 96 hours in sub-plot. The experiment was laid out in a split plot CRD design with three replications.

For accelerated ageing, the seeds were kept in ageing chamber at 45 ± 1^0C and nearly 90% relative humidity for duration of 0, 24, 48,72 and 96 hours. After accelerated ageing, seeds were dried in the sun and the percentage survival of the seeds was determined by standard germination test at 30^0C. The procedure of ageing technique was used as per Bagum *et al.* (2005)

Data recorded

Germination percentage (%)
Seed germination tests were carried out according to ISTA (1985) methods and performed with four replications. The germination test was conducted using sand method of germination and 25 seeds per replication were sown on sterilized sand. Distilled water was added to each beaker every alternate day while inside the germinator to keep uniform moisture content of paper towels. No light was provided during germination, as light is not necessary for germination of pea seeds (ISTA, 1985). Seeds were considered germinated when the emerging radical was at least 2 mm long (Amador et.al, 2002). Final count was made on eighth (8th) day. The germination percentage was calculated by counting the total number of seeds germinated from each replication at final count.

Maximum Root Length (cm)
The seedling root length of only normal seedlings was measured in cm at 8th day after planting. Means of seedling root length of ten normal seedlings were then calculated in cm per seedling (ISTA, 1985).

Maximum Shoot Length (cm)
Only normal seedlings were measured for seedling shoot length in cm. Means of seedling shoot length of ten normal seedlings were then calculated in cm per seedling.

Dry Seedling Weight (mg)
Ten seedlings from each replicate of every treatment were placed in paper bags and transferred to an oven, then dried at 75°C for 72 hours. These were then weighed on automatic digital balance for obtaining seedling dry weight in milligrams (mg). The readings were then averaged.
Vigor Index I and Vigor Index II

The germination percentage obtained in the germination test was used to calculate vigor index. The vigor index was calculated adopting the method of Abdul Baki and Anderson (1973).

Vigor Index I = Germination percentage x average seedling length

Vigor Index II = Germination percentage x seedling dry weight in milligrams

Statistical analysis
Statistical analysis was carried out by one-way ANOVA using STAR (version 1.1 2013) to evaluate the significant differences among means of all tested parameters at 5% level of significant. Six (3+3) nonorthogonal contrasts were performed (T: Control vs 24 hours, T: Control vs 48 hours, T: Control vs 72 hours and T:V:: Control vs 24 hours, T:V::Control vs 48 hours and T:V:: Control vs 72 hours). Further statistical validity of the differences among treatment means were estimated using the Least Significance Difference (LSD) method. To determine the degree of association between the assessed characters, for each pair of characteristics, the Pearson coefficient correlation was estimated at the 5% significance level by the t test, with the assistance of R statistical software (R, 2022). Viability was modelled using the probit transformation within the generalized linear modelling procedure in R. From this, p^{20}, p^{50} and p^{80} were calculated for all of the 45°C treatments were examined (Ellis and Roberts, 1980).

Results and Discussion

Effect of accelerated ageing time on seed quality traits of soybean

The effect of different accelerated ageing treatments (T) showed highly significant variation on all the seed quality traits of soybean (Table 1). For the contrasts that involve the PG, MSL, MRL, RSR, SDW and VI-I, VI-II the following accelerated ageing contrasts were highly significant: T: Control vs 24 hours, T: Control vs 48 hours, T: Control vs 72 hours and T: Control vs 96 hours which presents a negative effect for this accelerated ageing time in soybean (Table 1). Maximum GP (96 %), MSL (23.6 cm), SDW (166 mg), VI I (2759) and VI II (14940) was observed with T_0 treatment (Control) and highest MRL (14.8 cm), RSR (1.0) was observed with T_{96} treatment which was significantly differed with others level of time (Fig. 1-7), respectively. Minimum GP (1 %), MSL (6.0 cm), VI I (21.45) and VI II (59.00) was observed with T_{96} treatment and lowest MRL (3.0 cm), RSR (0.39) was observed with T_0 treatment which was significantly differed with others level of time (Fig. 1-7), respectively. Regardless of soybean variety differences, PG, MSL, VI I and VI II decreased and MRL and RSR increased progressively up to 96 hours accelerated aging time, respectively.

Effect of soybean cultivars on seed quality traits of soybean

The maximum seed quality parameters viz. GP (88.00 %), MSL (16.23 cm), MRL (11.92 cm), SDW (127 mg), VI I (8574) was observed in BARI Soybean-4 which was statistically identical with BARI Soybean-5 (Fig 8-14). The minimum seed quality parameters; GP (31%) was found from Goo-382, MSL (7.20 cm) found from BINA soybean-4 (Fig. 8-14). Seed quality parameters were an inherent character and varied with cultivars and environmental conditions. In this research, seed quality parameters were varied due to cultivars, accelerated ageing time and the combined effect of growing condition. The results obtained from the present study were also conformity with the findings of Bagum *et al*., (2005) in chilli. The differences in seed quality parameter due to various cultivars might be due to varied genetic makeup of the cultivar and interaction between cultivar and environment.

Table 1. Analysis of variance of the tested seed quality traits of soybean during 2021-22

Source of variation	df	Mean sum of squares			
		PG	MRL	MSL	RSR
Genotypes (V)	8	4796**	39.20**	72.39**	0.175**
Error (a)	18	16	0.25	0.94	0.004
Time (T)	4	5492**	40.01**	182.35**	0.037**
T: Control vs 24 h	1	642**	86.18**	335.04**	0.011**
T: Control vs 48 h	1	448**	0.02^{ns}	0.33^{ns}	0.068**
T: Control vs 72 h	1	501**	10.69**	38.58**	0.004**
T: Control vs 96 h	1	20378**	63.16**	355.43**	0.064**
T:V	32	674**	21.02**	40.07**	0.109**
T:V:: Control vs 24 h	8	424**	31.61**	63.57**	0.102**
T:V::Control vs 48 h	8	335**	11.00**	36.87**	0.044**
T:V:: Control vs 72 h	8	1136**	16.23**	25.07**	0.085**
T:V:: Control vs 96 h	8	800**	25.26**	34.79**	0.207**
Error (b)	72	5	0.16	0.35	0.001

H=hours, ns P > 0.05; * P <= 0.05; ** P <= 0.01

Table 1. Analysis of variance of the tested seed quality traits of soybean during 2021-22 (contd.)

Source of variation	df	Mean sum of squares		
		SDW	VI-I	VI-II
Genotypes (V)	8	4796**	39.20**	72.39**
Error (a)	18	16	0.25^{ns}	0.94^{ns}
Time (T)	4	5492**	40.01**	182.35**
T: Control vs 24 h	1	642**	86.18**	335.04**
T: Control vs 48 h	1	448**	0.02	0.33
T: Control vs 72 h	1	501**	10.69**	38.58**
T: Control vs 96 h	1	20378**	63.16**	355.43**
T:V	32	674**	21.02**	40.07**
T:V:: Control vs 24 h	8	424**	31.61**	63.57**
T:V::Control vs 48 h	8	335**	11.00**	36.87**
T:V:: Control vs 72 h	8	1136**	16.23**	25.07**
T:V:: Control vs 96 h	8	800**	25.26**	34.79**
Error (b)	72	5	0.16	0.35

h=hours, ns P > 0.05; * P <= 0.05; ** P <= 0.01

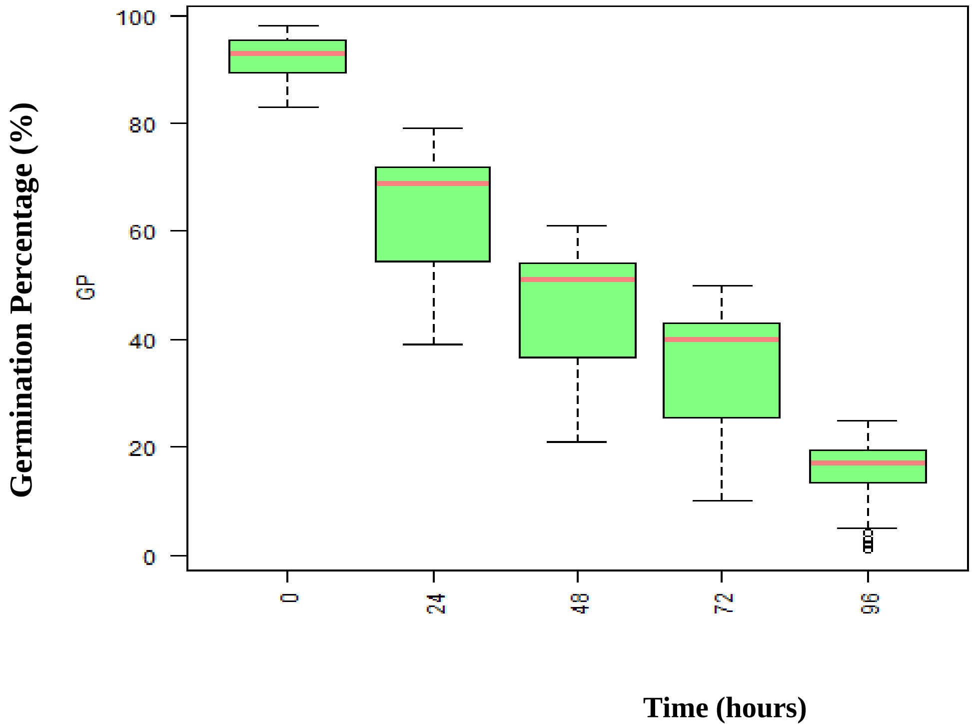


Fig. 1: Effect of Accelerated Aging time on germination percentage (%) of soybean seed during Accelerated Aging (AA). The box plot's edges depict the upper and lower quintiles, as well as the median, which is depicted in the box's centre. Individuals who do not fit inside the rank of whisker are indicated by a circle.

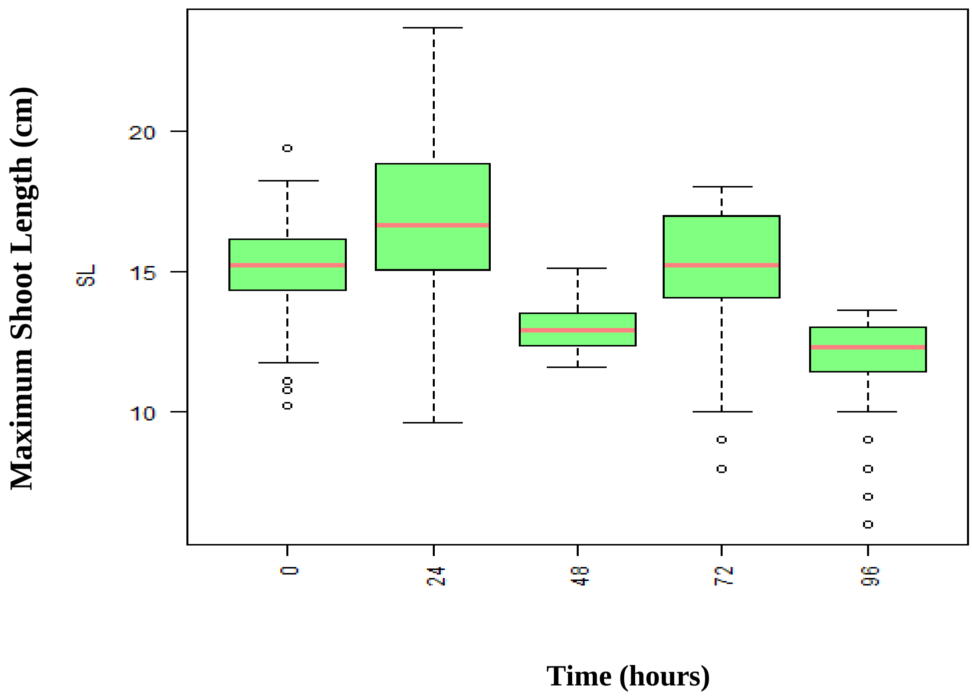


Fig. 2: Effect of Accelerated Aging time on Maximum Shoot Length (cm) of soybean seedling during Accelerated Aging

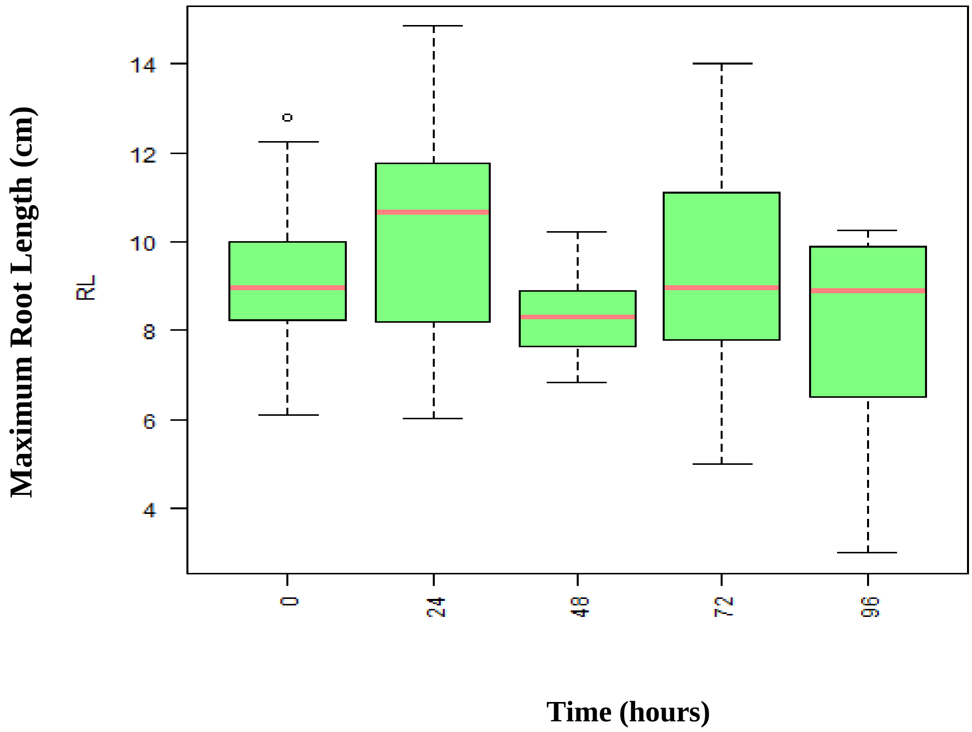


Fig. 3: Effect of Accelerated Aging time on Maximum Root Length (cm) of soybean seedling during Accelerated Aging

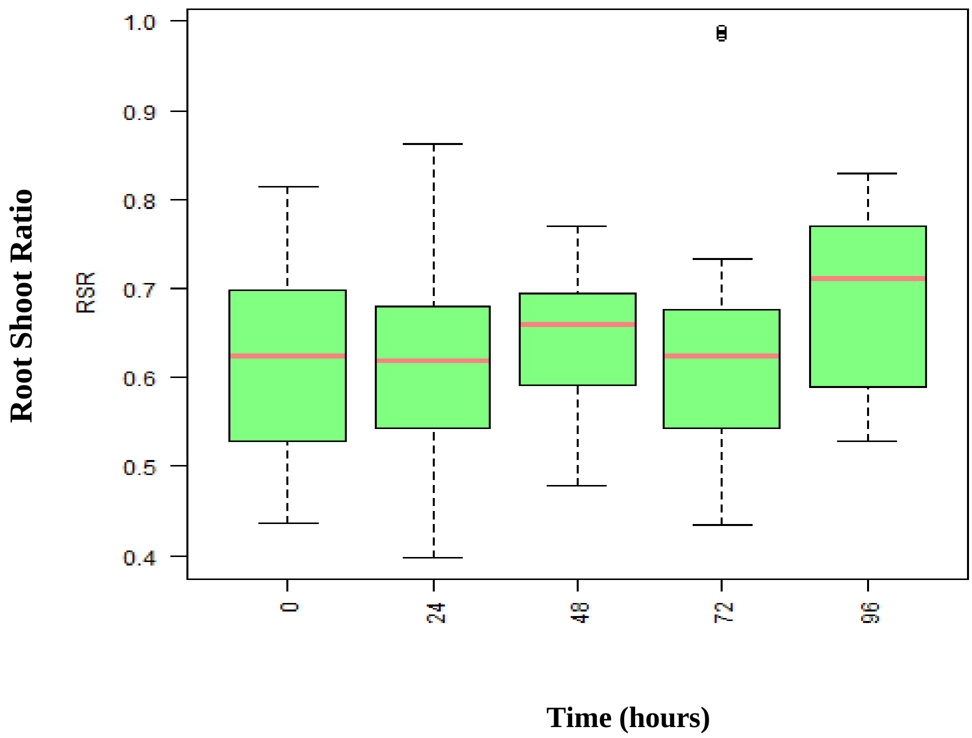
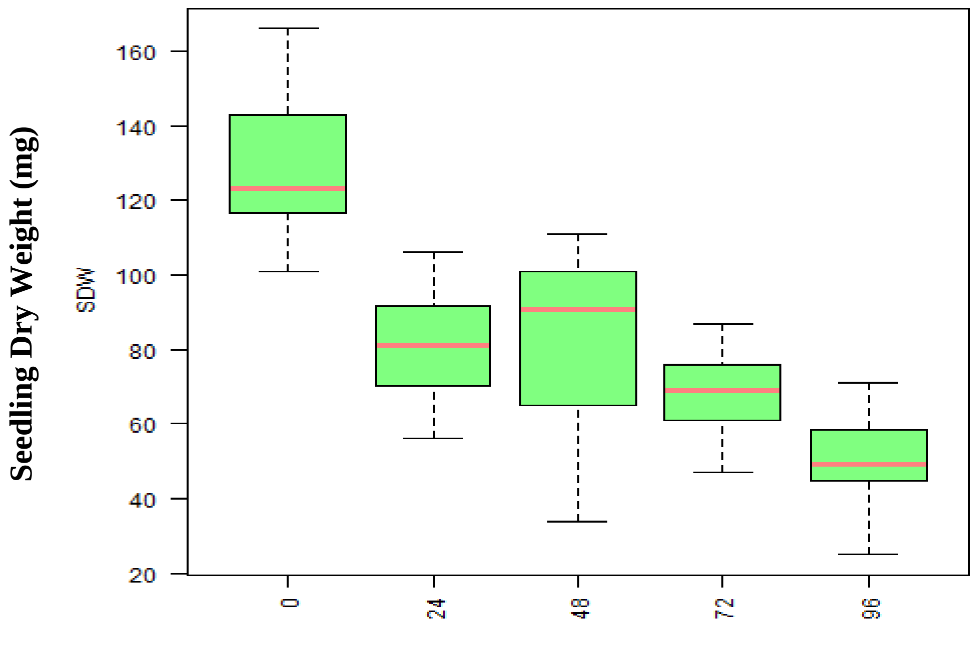
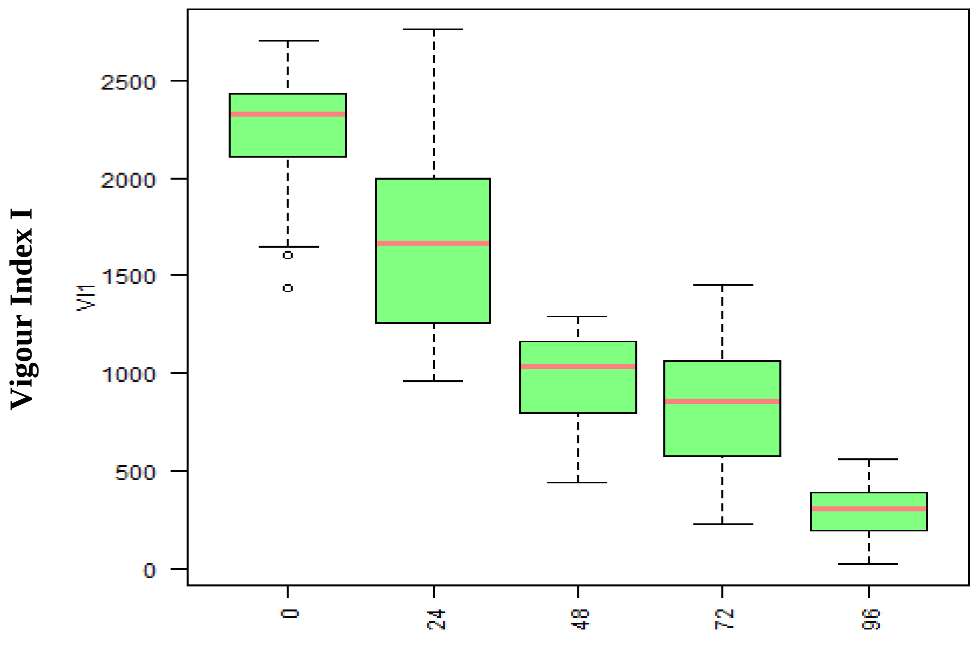


Fig. 4: Effect of Accelerated Aging time on Root Shoot Ratio of soybean seedling during Accelerated Aging



Time (hours)

Fig. 5: Effect of Accelerated Aging time on Seedling Dry Weight (mg) of soybean seedling during Accelerated Aging



Time (hours)

Fig. 6: Effect of Accelerated Aging time on Vigour Index I of soybean seedling during

Accelerated Aging

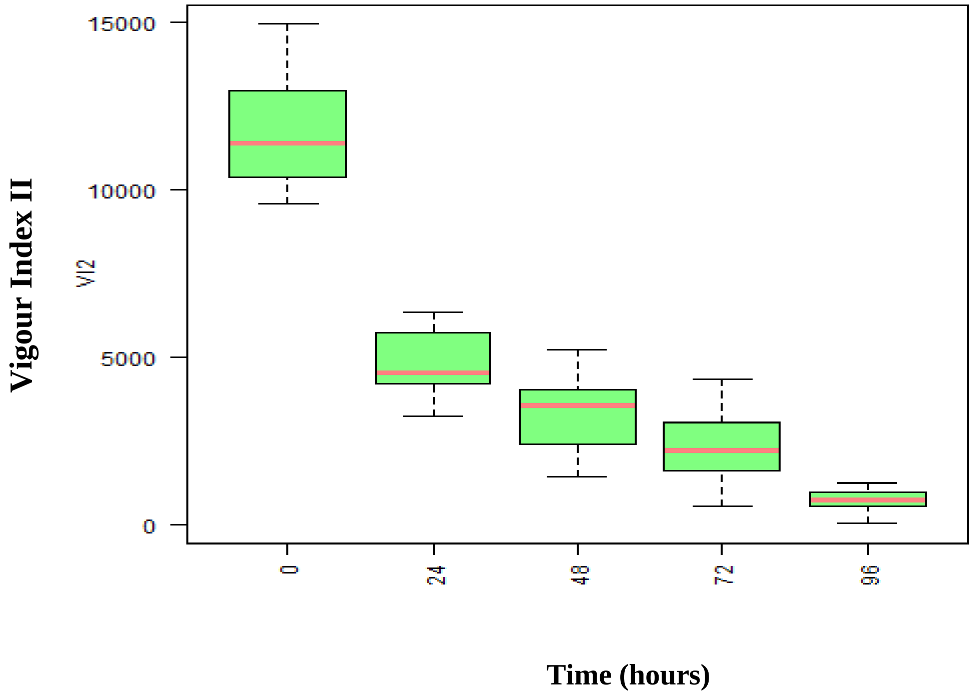


Fig. 7: Effect of Accelerated Aging time on Vigour Index II of soybean seedling during Accelerated Aging

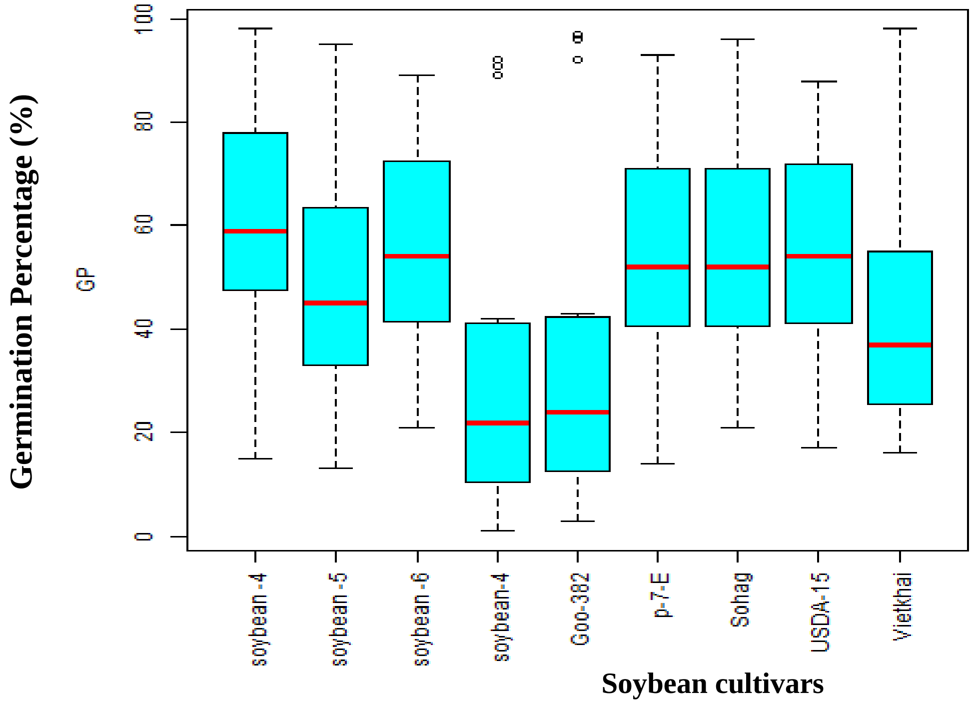


Fig. 8: Effect of soybean cultivars on germination percentage (%) of soybean seed during Accelerated Aging

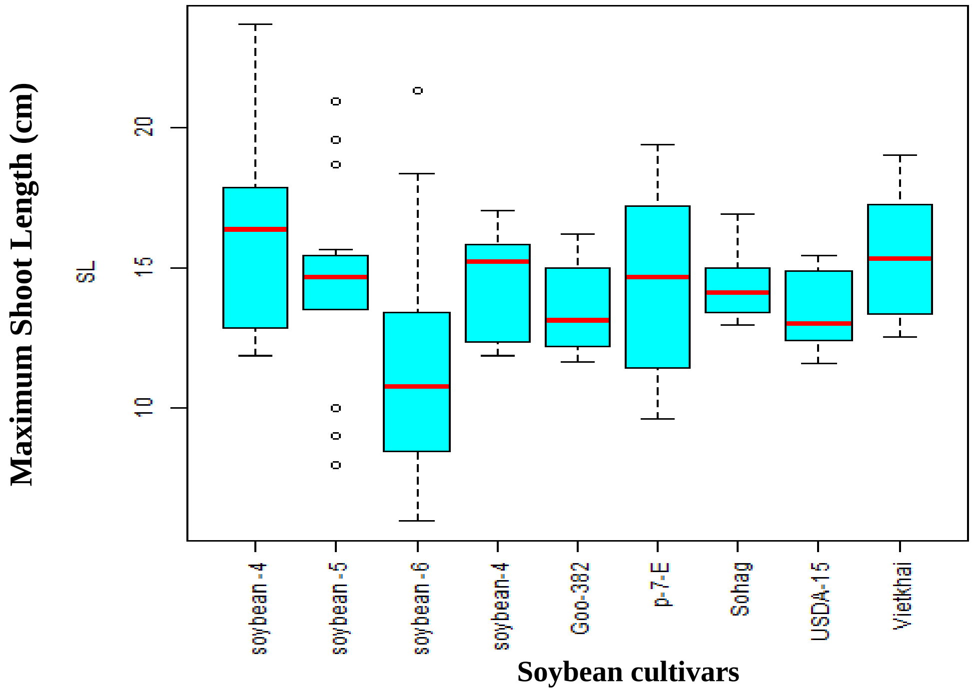


Fig. 9: Effect of soybean cultivars on Maximum Shoot Length (cm) of soybean seedling during Accelerated Aging

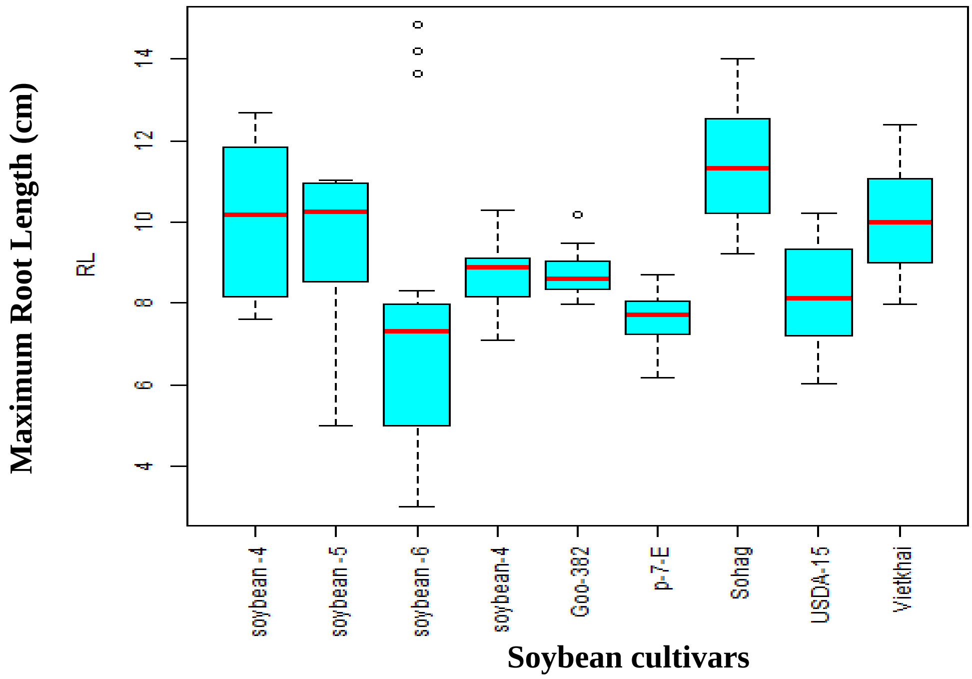


Fig. 10: Effect of soybean cultivars on Maximum Root Length (cm) of soybean seedling during Accelerated Aging

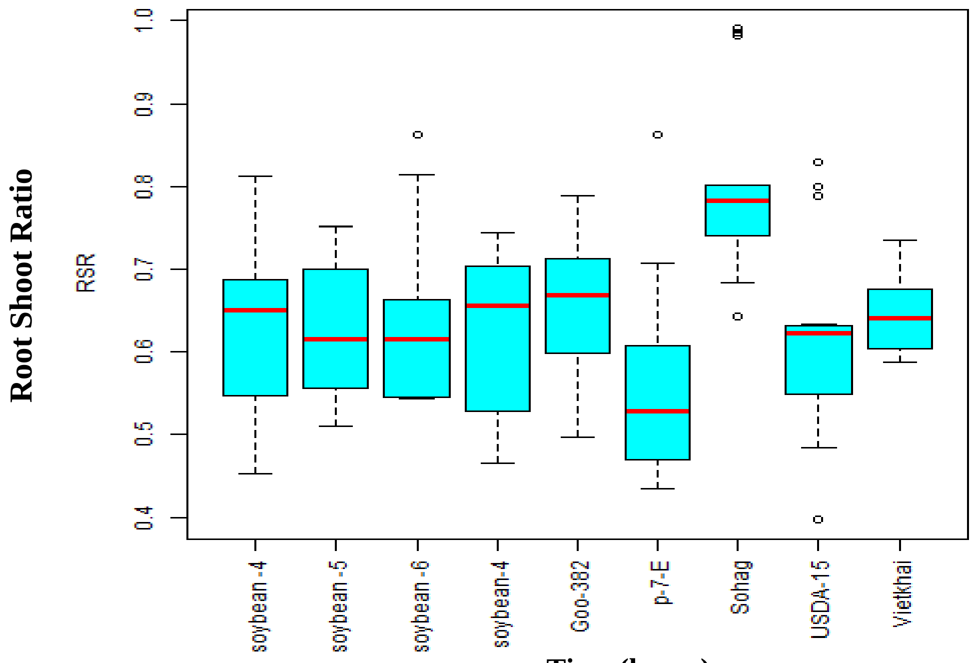


Fig. 11: Effect of soybean cultivars on Root Shoot Ratio of soybean seedling during Accelerated Aging

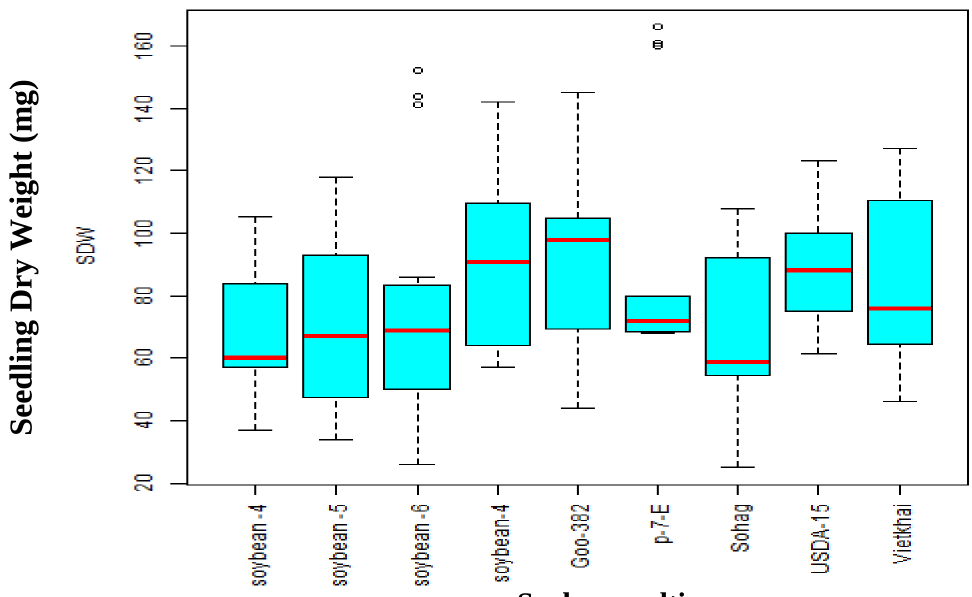


Fig. 12: Effect of soybean cultivars on Seedling Dry Weight (mg) of soybean seedling during Accelerated Aging

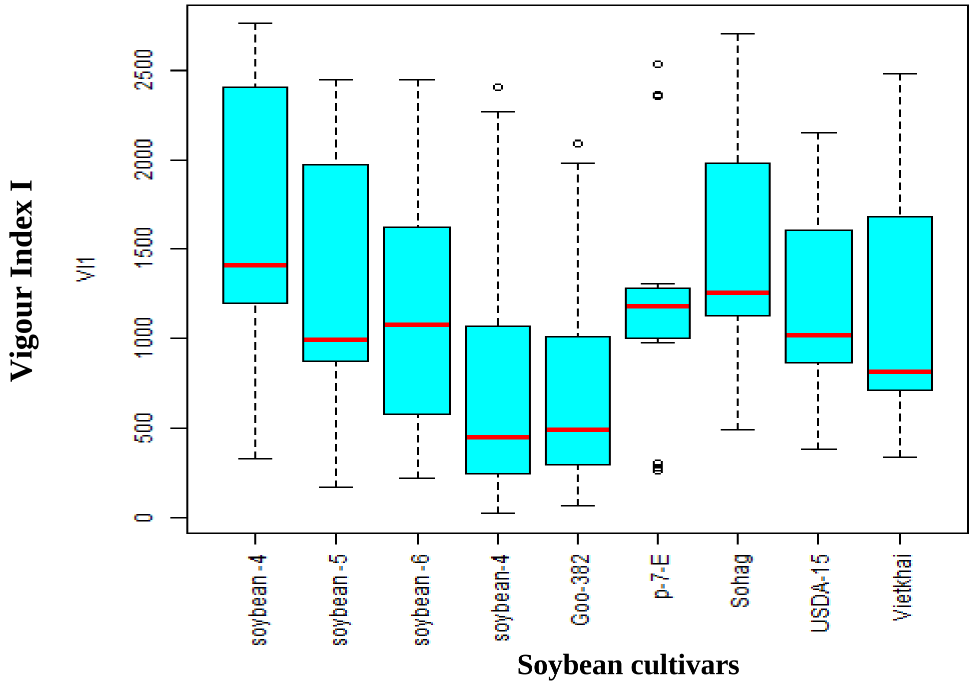


Fig. 13: Effect of soybean cultivars on Vigour Index I of soybean seedling during Accelerated Aging

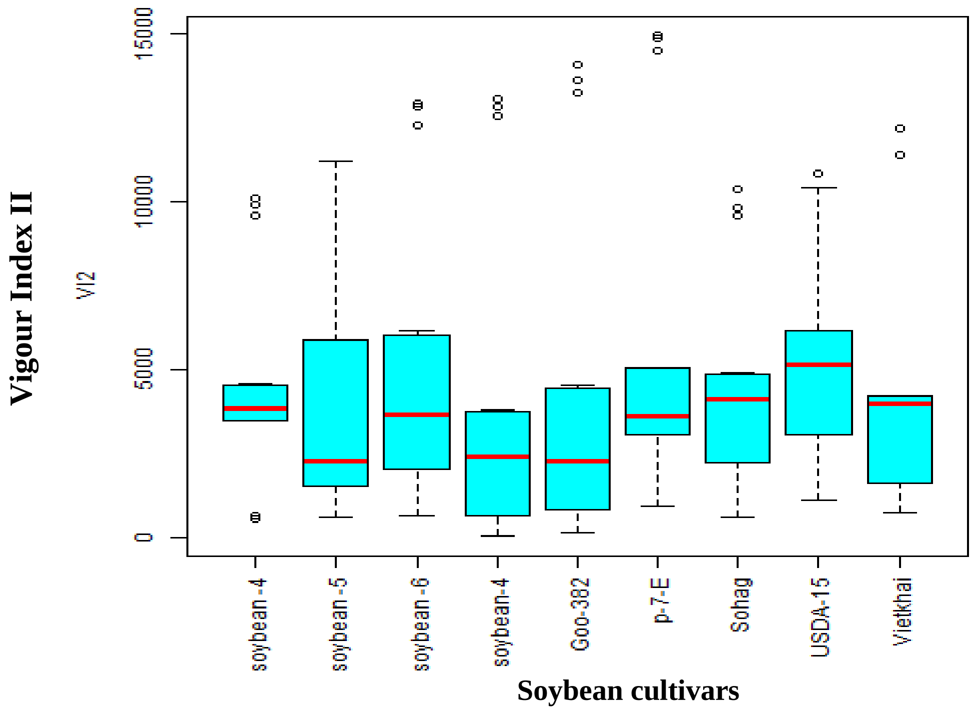


Fig. 14: Effect of soybean cultivars on Vigour Index II of soybean seedling during Accelerated Aging

Table 2. Interaction effect of accelerated ageing time and soybean cultivars on germination percentage

AA / Genotypes	Accelerated ageing time (hours)				
	Control	24 h	48h	72 h	96 h
BARI Soybean -5	96 a	77 A	59 a	48 A	17 bc
BARI Soybean -4	94 b	63 C	45 c	34 C	15 c
BARI Soybean -6	87 d	71 B	53 b	42 B	23 a
Sohag	91 c	40 E	22 e	11 E	2 d
p-7-E	95 ab	42 E	24 e	13 E	4 d
USDA-15	91 c	70 B	52 b	41 B	15 c
Goo-382	95 ab	70 B	52 b	41 B	22 a
BINA soybean-4	86 d	71 B	53 b	42 B	19 b
Vietkhai	96 a	55 D	37 d	26 D	17 bc

Interaction effect of accelerated ageing (AA) time and soybean cultivars on seed quality traits of soybean

The interaction effect of accelerated ageing time and soybean cultivars on germination percentage was statistically significant (Table 1). For the contrasts that involve the PG, the following interaction contrasts highly significant: T:V:: Control vs 24 hours, T:V::Control vs 48 hours, T:V:: Control vs 72 hours and T:V:: Control vs 96 hours which presents a negative effect for this accelerated ageing time in soybean (Table 1). Highest PG (96%) was found from BARI Soybean-5 and Vietkhai which was identical with BARI Soybean-4 (Table 2) in control treatment. After 24 hours AA, maximum PG (77%) was observed form BARI soybean-5 which significantly differed from other varieties/lines. Highest MRL (12.13 cm) was found Goo-382 which was significantly different form BARI soybean -4 and minimum (7.25 cm) MRL was observed from BARI Soybean-6 (Table 3), SDW (644 mg) was obtained from, VI I (3231) was found from soybean which was identical with BARI Soybean-4, BARI Soybean-6 (Table 6) and BARI Soybean-4. VI II (56193) was observed in BARI Soybean-4 which was statistically differed from other genotypes (Table 8).

Table 3. Interaction effect of accelerated ageing time and soybean cultivars on maximum root length (cm)

AA / Genotypes	Accelerated ageing time (hours)				
	Control	24 h	48h	72 h	96 h
BARI Soybean -5	7.90 fg	12.22 B	8.22 cd	11.75 b	9.83 a
BARI Soybean -4	10.46 b	10.64 de	8.65 bc	10.97 c	5.00 e
BARI Soybean -6	7.25 g	14.23 A	7.40 e	5.00 g	4.00 f
Sohag	8.93 de	10.26 E	8.41 cd	7.31 f	8.94 B
p-7-E	8.58 def	8.13 F	8.25 cd	9.00 d	9.66 A
USDA-15	8.25 ef	7.70 F	7.78 de	7.87 ef	6.73 D
Goo-382	12.13 a	11.26 cd	9.89 a	13.91 a	10.11 A
BINA soybean-4	9.23 cd	6.87 G	7.07 e	8.16 e	9.79 A
Vietkhai	9.83 bc	11.74 bc	9.22 ab	10.79 c	8.04 C

Table 4. **Interaction effect of accelerated ageing time and soybean cultivars on maximum shoot length (cm)**

AA / Genotypes	Accelerated ageing time (hours)									
	Control		24 h		48h		72 h		96 h	
BARI Soybean -5	16.4	b	21.8	A	12.4	cd	17.6	a	12.9	ab
BARI Soybean -4	14.7	c	19.7	B	13.8	ab	15.3	bc	9.0	d
BARI Soybean -6	10.7	e	18.9	B	13.1	bcd	9.0	e	7.0	e
Sohag	16.5	b	15.7	C	12.3	d	15.4	b	12.1	bc
p-7-E	12.4	d	15.5	C	11.9	d	15.0	bc	13.0	ab
USDA-15	18.3	a	10.4	D	14.6	a	17.1	a	11.6	c
Goo-382	15.3	bc	15.9	C	13.6	abc	14.1	cd	13.1	ab
BINA soybean-4	14.9	c	15.1	C	12.4	d	13.0	d	12.2	bc
Vietkhai	15.2	c	18.5	B	12.9	bcd	17.1	a	13.3	a

Table 5. **Interaction effect of accelerated ageing time and soybean cultivars on root shoot ratio**

AA / Genotypes	Accelerated ageing time (hours)									
	Control		24 h		48h		72 h		96 h	
BARI Soybean -5	0.48	de	0.56	D	0.66	ab	0.67	bc	0.76	a
BARI Soybean -4	0.71	b	0.54	D	0.63	bc	0.72	b	0.57	b
BARI Soybean -6	0.68	bc	0.76	A	0.57	cd	0.57	d	0.57	b
Sohag	0.54	d	0.65	Bc	0.68	ab	0.47	e	0.74	a
p-7-E	0.69	b	0.52	De	0.69	ab	0.60	cd	0.74	a
USDA-15	0.45	e	0.75	A	0.53	d	0.46	e	0.58	b
Goo-382	0.79	a	0.72	Ab	0.73	a	0.99	a	0.77	a
BINA soybean-4	0.62	c	0.46	E	0.57	cd	0.63	cd	0.81	a
Vietkhai	0.65	bc	0.63	C	0.72	a	0.63	cd	0.60	b

Table 6. **Interaction effect of accelerated ageing time and soybean cultivars on seedling dry weight (mg)**

AA / Genotypes	Accelerated ageing time (hours)									
	Control		24 h		48h		72 h		96 h	
BARI Soybean -5	103	d	58	e	59	e	83	a	39	e
BARI Soybean -4	118	c	93	b	36	f	67	b	49	c
BARI Soybean -6	146	b	82	c	68	d	49	c	35	e
Sohag	141	b	89	b	108	a	65	b	58	b
p-7-E	144	b	104	a	97	bc	69	b	49	c
USDA-15	162	a	71	d	69	d	77	a	69	a
Goo-382	105	d	59	e	90	c	55	c	41	de
BINA soybean-4	122	c	87	bc	98	b	77	a	64	ab
Vietkhai	121	c	75	d	110	a	65	b	47	cd

Table 7. Interaction effect of accelerated ageing time and soybean cultivars on vigour index I

AA / Genotypes	Accelerated ageing time (hours)				
	Control	**24 h**	**48h**	**72 h**	**96 h**
BARI Soybean -5	2344 b	2633 A	1225 a	1420 a	379 bc
BARI Soybean -4	2357 b	1903 C	1002 c	883 d	206 ef
BARI Soybean -6	1562 d	2363 B	1091 bc	592 f	257 de
Sohag	2307 b	1048 F	462 e	257 g	49 g
p-7-E	1996 c	993 F	484 e	312 g	91 fg
USDA-15	2417 b	1271 E	1172 ab	1032 c	281 cde
Goo-382	2608 a	1908 C	1230 a	1158 b	519 a
BINA soybean-4	2069 c	1551 D	1022 c	880 d	409 ab
Vietkhai	2412 b	1656 D	811 d	717 e	357 bcd

Table 8. Interaction effect of accelerated ageing time and soybean cultivars on vigour index II

AA / Genotypes	Accelerated ageing time (hours)				
	Control	**24 h**	**48h**	**72 h**	**96 h**
BARI Soybean -5	9880 g	4485 C	3520 d	3993 a	643 c
BARI Soybean -4	11021 e	5807 A	1610 f	2247 c	720 bc
BARI Soybean -6	12668 c	5875 A	3605 d	2071 c	797 bc
Sohag	12815 c	3606 E	2407 e	745 e	135 d
p-7-E	13648 b	4383 Cd	2320 e	902 e	193 d
USDA-15	14770 a	4996 B	3593 d	3197 b	1065 ab
Goo-382	9930 g	4142 Cd	4729 b	2290 c	896 abc
BINA soybean-4	10436 f	6121 A	5155 a	3203 b	1196 A
Vietkhai	11657 d	4101 D	4021 c	1677 d	789 bc

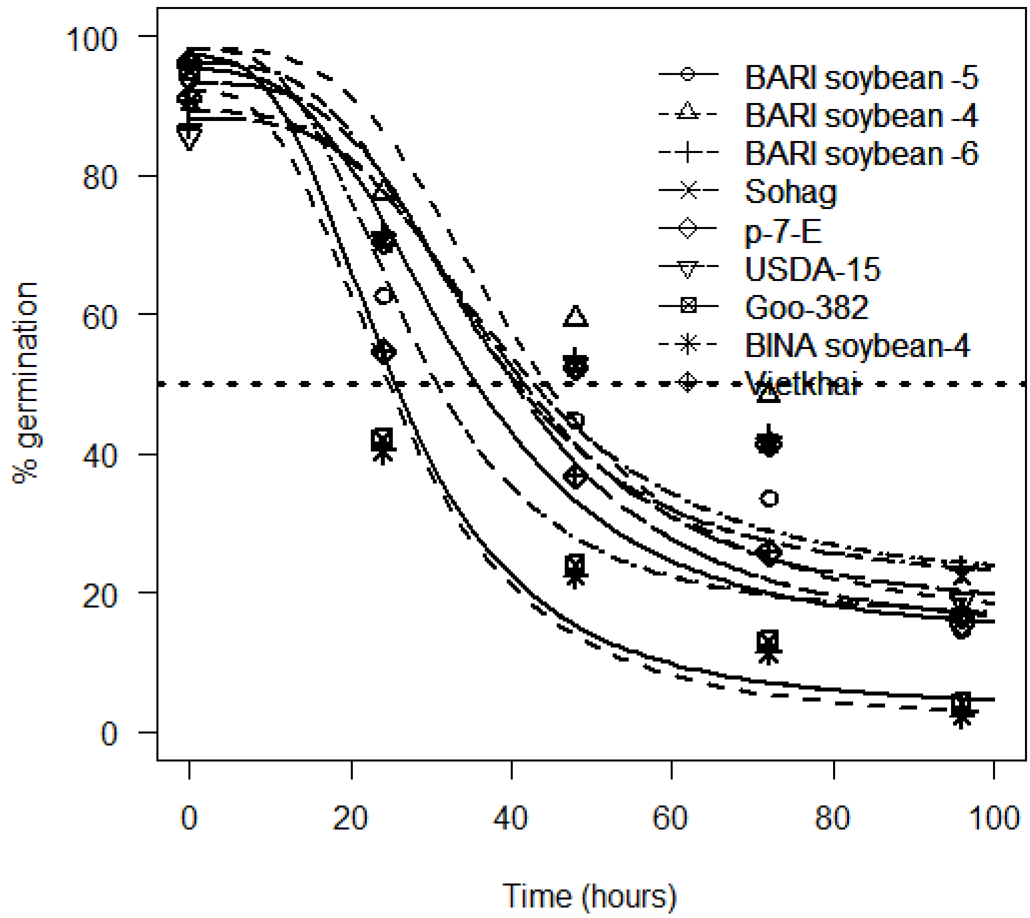


Fig. 8. Plot of viability (% germination) against accelerated ageing (AA) duration (hours) for different soybean genotypes by probit analysis.

Table. 9. Calculated longevity parameters (intercept, slope) in accordance with the longevity equation n ¼ Ki 2(1/ σ) p including the time for the level of germination to fall to 50% (P50)

Genotypes	Probit parameters			95% Confidence limits		P50 (hour)
	Intercept (K_i)	Slope (-1/σ)	SE (slope)	Lower bound	Upper bound	
BARI Soybean -5	96	0.74	0.08	0.01	0.17	3802
BARI Soybean -4	94	1.20	0.09	0.02	0.20	288
BARI Soybean -6	87	1.04	0.07	-0.03	0.08	631
Sohag	91	0.84	0.09	-0.04	0.08	636
p-7-E	95	1.03	0.08	0.05	0.25	466
USDA-15	91	1.17	0.07	0.03	0.20	527
Goo-382	95	0.62	0.54	0.04	0.23	3013
BINA soybean-4	86	0.65	0.19	-0.02	0.09	2673
Vietkhai	96	0.69	0.31	0.02	0.14	1905

Conclusion

The present study revealed that the results indicated that the BARI Soybean-5 observed significantly higher on seed quality parameter such as germination percentage (96%), seedling root length (11.4 cm), seedling shoot length (16.4 cm), seedling dry weight (103 mg), seedling vigour index I (3244) and seedling vigour index II (9880) were recorded from BARI Soybean-5 followed by BARI Soybean-4. From probit analysis, it can be concluded that the BARI Soybean-4 and 5 can storage 6-8 months in store with 80% germination.

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EFFECT OF STORAGE CONDITIONS AND SEED TREATMENTS ON SEED VIABILITY OF SOYBEAN

M. A. HOSSAIN, P. C. SARKER, S. A. BEGUM, A. N. M KARIM, M. ISLAM, S. RAHMAN AND M. A. H. S. JAHAN

Abstract

The experiment was carried out at the laboratory of Seed Technology Division, BARI, Gazipur during 2021-2022 to know the impact of different storage conditions and seed treatments on seed viability of soybean. The treatment consisted of two storage conditions (C) viz., C_1 (Ambient temperature) and C_2 (Cold storage at $15^oC \pm 2^oC$), and five seed treatments (S) viz., S_1= Control, S_2 = Carbendazim @ 2g/kg seed, S_3 = Mancozeb @ 2g/kg seed, S_4 = Neem leaf powder @ 10g/kg seed, and S_5 = Neem oil@5ml/kg seed. The experiment was carried out using Completely Randomized Design (Factorial) repeated three times. The results revealed that storage condition (C) and seed treatments (S) exhibited significant differences almost for the all the traits for germination and seedling parameters after 9 months of storage. The results of soybean seed stored in two different storage conditions showed that on an average, the seed stored under cold storage ($15^oC \pm 2^oC$) noted higher values for all the traits studied except seed moisture content after 9 months of storage. Among the seed treatments, after 9 months of seed storage, significantly higher values were recorded by all the seed treatments over the control. Soybean seed may be stored under cold storage ($15^oC \pm 2^oC$) condition with seed treatment of Mancozeb @ 2g/kg seed or Carbendazim @ 2g /kg seed or Neem Oil@5ml/kg seed for a period of 9 months without deterioration in germination and seedling vigour. Most of the interactions effects were found significant ($P<0.05$) for all the traits studied.

Introduction

Soybean (*Glycine max* (L.) Merr) is an important oilseed crop, is listed as poor storer. It loses viability rapidly under warm and humid storage conditions. One of the major constraints in soybean cultivation is the non-availability of high vigour seeds at the time of sowing. Now-a-days, the area and production of this crop is increasing gradually, but productivity remains almost constant (Mahesh Babu and Hunje, 2008). Poor seed germination is a major constraint for increasing the productivity of soybean.

High quality seed that provides adequate plant stand is the basis for profitable production and expansion of soybean crop. In order to increase the production of soybean, a source of high quality, disease free seed must be established and maintained. Loss of viability and vigour under high temperature and relative humidity conditions is a common phenomenon in many crop seeds but it is well marked in soybean. Under adverse conditions such as the temperature above 30°C and relative air humidity from 80 to 90 per cent, the variation in seed germination rate can be high. It seems that temperature, moisture and storage duration are the most important individual factors which affected the stored product quality and quantity (Sisman, 2005). Fabrizius *et al.* (1999) confirmed the possibility of predicting the actual germination rate of soybean seed during natural aging by applying the accelerated aging test, the main factors being the time of natural aging duration and degree of seed deterioration.

Many of synthetic chemicals look effective, but they are not readily degradable physically or biologically which yield more toxic residues. Hence, the feasible approach is the treatment of seeds with botanicals which are safe, economical, eco-friendly, cheap, easily locally available and non-harmful to seeds, animals and human beings. It will be of immense use to the farming community. Therefore, the experiment was carried out to know how the soybean seed can be stored by treating them with fungicides or botanicals under specific storage conditions for longer period with minimum qualitative and quantitative changes.

Materials and Methods

The experiment was conducted at the laboratory of Seed Technology Division, BARI, Gazipur from the December 2021 to May 2022, where in two kg of freshly harvested quality seed of soybean cv. BARI Soybean-6 having high germination percentage and low moisture content (below 8%) was taken for each repetition and for each combination of treatments. The treatment consisted of two storage conditions (C) viz., C_1 (Ambient temperature) and C_2 (Cold storage at 15^{o}C ± 2^{o}C), and five seed treatments (S) viz., S_1= Control, S_2 = Carbendazim @ 2g/kg seed, S_3 = Mancozeb @ 2g/kg seed, S_4 = Neem leaf powder @ 10g/kg seed, and S_5 = Neem Oil@5ml/kg seed. The experiment was carried out using Completely Randomized Design (Factorial) repeated three times. After proper mixing or smearing the seeds as per the treatments, seeds were packed in cloth bag and kept in laboratory under two different storage conditions. Observations were recorded at 90 days interval on germination (%), root length (cm), shoot length (cm), seedling dry weight (g), seed vigour index and seed moisture content (%).Germination test was carried out using paper towel technique as per the procedure given by ISTA (1999). Germinated seeds were counted on 8th day and 10 germinated seedlings were selected from each replication of the treatment for calculating the seedling vigour index. The seedling vigour index was calculated as per the formula suggested by Abdul-Baki and Anderson, 1973). The shoot and root length of each of the 10 seedlings were measured in centimeters. Seedling dry weight was measured of all the germinated seedlings after oven drying. Seed moisture content was deter-mined by oven dry method. The data were statistically analyzed by using statistical package Statistix 10 and mean separation was done by LSD.

Results and Discussion

The results presented in Table 1 revealed that storage condition (C) and seed treatments (S) exhibited significant differences for germination per cent under laboratory in soybean for almost all the dates of recording observations after 9 months of storage. The data of soybean seed stored under two storage conditions revealed that seed stored under cold storage (15^{o}C ± 2^{o}C) noted significantly higher germination (85.06%) after the period of 9 months of storage. Among the seed treatments, seed treated with Mancozeb @ 2g/kg of seed recorded the significantly highest germination percentage (87.33%) and it was at par with Carbendazim @ 2g /kg seed (81.33%) and Neem leaf powder @ 10 g / kg seed (79.33%) after 9 months of storage. The germination percentage also noted in control treatment was 79.33 per cent after 9 months of storage stored under ambient condition. An ISTA standard for germination is 70 per cent for soybean. Over all the treatment combinations, more than 80 per cent germination was recorded by the combination of seed treated with fungicide and stored in cold storage after 9 months of storage. These results are in accordance with the results of Gupta *et al.* (1976), who reported that soybean seeds are short lived as compared to maize, rice, wheat, etc.

Table 1. Effect of storage condition and various seed treatments on germination percentage in soybean

Treatments	Germination (%)		
	3 Month	6 Month	9 Month
Storage condition			
C_1	80.53	78.93	77.33
C_2	88.00	91.73	85.06
LSD (0.05)	4.16	4.42	4.25
Seed treatments			
S_1	80.66	82.00	79.33
S_2	86.66	86.00	81.33
S_3	90.66	90.66	87.33
S_4	82.00	84.00	78.66
S_5	81.33	84.00	79.33
LSD (0.05)	6.58	6.99	6.72
Interaction effect of storage condition and seed treatments			
C_1 X S_1	81.33	78.66	77.33
C_1 X S_2	81.33	80.00	78.66
C_1 X S_3	85.33	84.00	82.66
C_1 X S_4	76.00	74.66	73.33
C_1 X S_5	78.66	77.33	74.66
C_2 X S_1	80.00	85.33	81.33
C_2 X S_2	92.00	92.00	84.00
C_2 X S_3	96.00	97.33	92.00
C_2 X S_4	88.00	93.33	84.00
C_2 X S_5	84.00	90.00	84.00
$LSD_{(0.05)}$	9.31	9.89	9.51
CV (%)	6.45	6.76	6.83

In a column, values with same letter (s) do not differ significantly at 5% level of probability. Here, C_1 (Ambient temperature) and C_2 (Cold storage at 15°C± 2°C), and five seed treatments (S) viz., S_1= Control, S_2 = Carbendazim @ 2g/kg seed, S_3 = Mancozeb @ 2g/kg seed, S_4 = Neem leaf powder @ 10g/kg seed, and S_5 = Neem Oil@5ml/kg seed.

Table 2. Effect of storage condition and seed treatments on seedling root length in soybean

Treatments	Seedling length (cm)		
	3 Month	6 Month	9 Month
Storage condition			
C_1	12.80	11.24	8.98
C_2	14.37	14.85	11.74
LSD $_{(0.05)}$	0.76	0.60	0.58
Seed treatments			
S_1	12.98	12.41	9.66
S_2	13.69	13.36	10.41
S_3	15.53	14.78	11.75
S_4	12.91	12.30	10.31
S_5	12.81	12.36	9.66
LSD $_{(0.05)}$	1.21	0.95	0.92
Interaction effect of storage condition and seed treatments			
C_1 X S_1	11.23	10.13	10.63
C_1 X S_2	13.10	11.60	12.10
C_1 X S_3	14.83	13.13	9.86
C_1 X S_4	12.8	10.80	11.33
C_1 X S_5	11.96	10.53	11.63
C_2 X S_1	14.73	14.70	8.70
C_2 X S_2	14.28	15.13	8.73
C_2 X S_3	16.23	16.43	13.0
C_2 X S_4	12.96	13.80	9.30
C_2 X S_5	13.66	14.20	8.30
LSD $_{(0.05)}$	1.71	1.35	1.30
CV (%)	7.35	6.06	7.35

In a column, values with same letter (s) do not differ significantly at 5% level of probability. Here, C_1 (Ambient temperature) and C_2 (Cold storage at $15^oC\pm 2^oC$), and five seed treatments (S) viz., S_1= Control, S_2 = Carbendazim @ 2g/kg seed, S_3 = Mancozeb @ 2g/kg seed, S_4 = Neem leaf powder @ 10g/kg seed, and S_5 = Neem Oil@5ml/kg seed.

Table 3. **Effect of storage condition and various seed treatments on seedling shoot length in soybean**

Treatments	**Seedling shoot length (cm)**		
	3 Month	**6 Month**	**9 Month**
Storage condition			
C_1	27.03	24.42	25.67
C_2	31.20	17.06	13.00
LSD $_{(0.05)}$	2.55	2.22	1.58
Seed treatments			
S_1	28.54	20.08	18.18
S_2	28.72	21.18	18.31
S_3	27.70	19.40	18.23
S_4	28.35	21.01	19.36
S_5	32.28	24.51	22.58
LSD $_{(0.05)}$	4.03	3.51	2.50
Interaction effect of storage condition and seed treatments			
C_1 X S_1	25.32	23.56	23.53
C_1 X S_2	26.57	24.93	24.60
C_1 X S_3	25.45	24.13	24.76
C_1 X S_4	26.33	24.83	26.03
C_1 X S_5	31.50	29.63	29.43
C_2 X S_1	31.76	16.60	12.83
C_2 X S_2	30.86	17.43	12.03
C_2 X S_3	29.95	14.66	11.70
C_2 X S_4	30.36	17.20	12.70
C_2 X S_5	33.06	19.40	15.73
LSD $_{(0.05)}$	5.70	4.96	3.53
CV (%)	11.43	13.64	10.67

In a column, values with same letter (s) do not differ significantly at 5% level of probability. Here, C_1 (Ambient temperature) and C_2 (Cold storage at $15^oC \pm 2^oC$), and five seed treatments (S) viz., S_1= Control, S_2 = Carbendazim @ 2g/kg seed, S_3 = Mancozeb @ 2g/kg seed, S_4 = Neem leaf powder @ 10g/kg seed, and S_5 = Neem Oil@5ml/kg seed.

Table 4. Effect of storage condition and various seed treatments on seedling dry weight in soybean

Treatments	Seedling dry weight (g)		
	3 Month	**6 Month**	**9 Month**
Storage condition			
C_1	0.104	0.105	0.108
C_2	0.105	0.097	0.099
LSD $_{(0.05)}$	NS	4.76	8.88
Seed treatments			
S_1	0.909	0.093	0.096
S_2	0.120	0.114	0.120
S_3	0.097	0.096	0.090
S_4	0.107	0.103	0.108
S_5	0.098	0.101	0.102
LSD $_{(0.05)}$	0.012	7.53	0.01
Interaction effect of storage condition and seed treatments			
C_1 X S_1	0.091	0.093	0.095
C_1 X S_2	0.122	0.123	0.125
C_1 X S_3	0.096	0.096	0.099
C_1 X S_4	0.110	0.112	0.115
C_1 X S_5	0.102	0.103	0.107
C_2 X S_1	0.089	0.093	0.098
C_2 X S_2	0.119	0.106	0.116
C_2 X S_3	0.099	0.096	0.080
C_2 X S_4	0.104	0.094	0.102
C_2 X S_5	0.095	0.098	0.098
LSD $_{(0.05)}$	0.018	0.010	0.01
CV (%)	10.32	6.11	11.16

In a column, values with same letter (s) do not differ significantly at 5% level of probability. Here, C_1 (Ambient temperature) and C_2 (Cold storage at 15^{o}C± 2^{o}C), and five seed treatments (S) viz., S_1= Control, S_2 = Carbendazim @ 2g/kg seed, S_3 = Mancozeb @ 2g/kg seed, S_4 = Neem leaf powder @ 10g/kg seed, and S_5 = Neem Oil@5ml/kg seed.

Table 5. Effects of storage condition and various seed treatments on seed vigor index in soybean

Treatments	**Seedling vigor index**		
	3 Month	**6 Month**	**9 Month**
Storage condition			
C_1	8392.3	8379.7	8345.9
C_2	8977.3	8422.9	8962.7
LSD $_{(0.05)}$	NS	NS	538.2
Seed treatments			
S_1	7270	7711.3	7658.7
S_2	8863	8500.7	8672.0
S_3	10429	9758.7	9904.0
S_4	8841	7878.7	8563.3
S_5	8021	8157.3	8473.3
LSD $_{(0.05)}$	1226.1	1429.2	851.06
Interaction effect of storage condition and seed treatments			
C_1 X S_1	7432	7386.7	7346.7
C_1 X S_2	8217	8226.7	8136.0
C_1 X S_3	9927	9825.3	9893.3
C_1 X S_4	8351	8457.3	8353.3
C_1 X S_5	8035	8002.7	8000
C_2 X S_1	7108	8036	7970
C_2 X S_2	9509	8774.7	9208
C_2 X S_3	10931	9692	9914.7
C_2 X S_4	9331	7300	8773.3
C_2 X S_5	8008	8312.0	8946.7
LSD $_{(0.05)}$	1733.9	2021.2	1203.6
CV (%)	11.64	14.03	8.11

In a column, values with same letter (s) do not differ significantly at 5% level of probability C_1 (Ambient temperature) and C_2 (Cold storage at $15^oC \pm 2^oC$), and five seed treatments (S) viz., S_1= Control, S_2 = Carbendazim @ 2g/kg seed, S_3 = Mancozeb @ 2g/kg seed, S_4 = Neem leaf powder @ 10g/kg seed, and S_5 = Neem Oil@5ml/kg seed.

Table 6. **Effect of storage condition and various seed treatments on seed moisture in soybean**

Treatments	Seed moisture (%)		
	3 Month	**6 Month**	**9 Month**
Storage condition			
C_1	10.85	11.56	11.49
C_2	10.40	9.85	9.92
LSD $_{(0.05)}$	NS	0.88	0.56
Seed treatments			
S_1	10.69	10.70	10.99
S_2	10.21	10.47	10.71
S_3	10.44	10.39	10.48
S_4	11.61	11.81	10.41
S_5	10.16	10.18	10.94
LSD $_{(0.05)}$	1.31	1.40	NS
Interaction effect of storage condition and seed treatments			
C_1 X S_1	10.92	9.87	11.77
C_1 X S_2	10.56	9.84	11.43
C_1 X S_3	10.46	9.18	11.51
C_1 X S_4	11.56	10.80	11.08
C_1 X S_5	10.73	9.56	11.66
C_2 X S_1	10.46	11.52	10.21
C_2 X S_2	9.86	11.09	9.99
C_2 X S_3	10.43	11.59	9.46
C_2 X S_4	11.66	12.82	9.74
C_2 X S_5	9.60	10.80	10.23
LSD $_{(0.05)}$	1.85	1.98	1.27
CV (%)	10.62	10.78	6.93

In a column, values with same letter (s) do not differ significantly at 5% level of probability C_1 (Ambient temperature) and C_2 (Cold storage at 15^{o}C± 2^{o}C), and five seed treatments (S) viz., S_1= Control, S_2 = Carbendazim @ 2g/kg seed, S_3 = Mancozeb @ 2g/kg seed, S_4 = Neem leaf powder @ 10g/kg seed, and S_5 = Neem Oil@5ml/kg seed.

The results presented in Table 2 revealed that storage condition (C) and seed treatments (S) exhibited significant differences for seedling root length in soybean after 9 months of storage. The data of soybean seed stored under two storage conditions revealed that seed stored under cold storage (15^{o}C± 2^{o}C) noted significantly higher seedling root length (11.74 cm) after the period of 9 months of storage. Among the seed treatments, seed treated with Mancozeb @ 2g/kg of seed recorded the significantly highest seedling root length (11.75 cm) after 9 months of storage. Over all the treatment combinations, C_2 X S_3 recorded the highest value for root length (13.0 cm).

The results presented in Table 3 revealed that storage condition (C) and seed treatments (S) exhibited significant differences for seedling shoot length in soybean after 9 months of storage. The data of soybean seed stored in two storage conditions revealed that seed stored under ambient condition noted significantly higher seedling shoot length (25.67 cm) after the period of 9 months of storage. Among the seed treatments, seed treated with Neem Oil@5ml/kg seed recorded the significantly highest seedling shoot length (22.58 cm) after 9 months of storage. Over all the treatment combinations, C_1 X S_5 recorded the highest value for root length (29.43 cm) after 9 months of storage.

The results presented in Table 4 revealed that storage condition (C) and seed treatments (S) exhibited significant differences for seedling dry weight in soybean after 9 months of storage. Among the seed treatments, seed treated with Carbendazim @ 2g/kg seed recorded the significantly highest seedling dry weight (0.120 g) after 9 months of storage. Over all the treatment combinations, C_1 X S_2 recorded the highest value for seedling dry weight (0.125g).

The results presented in Table 5 revealed that storage condition (C) and seed treatments (S) exhibited significant differences for seed vigour index in soybean for most of the dates. The data of soybean seed stored under two storage conditions showed that seed stored under cold storage (15^{o}C± 2^{o}C) noted significantly higher vigor index (8962.7) after the period of 9 months of storage. Among the seed treatments, seed treated with Mancozeb @ 2g/kg of seed recorded the significantly highest seed vigour index (9904.0) and it was at par with Carbendazim @ 2g/kg seed (8672.0 and Neem Oil@5ml/kg seed (8563.3) after 9 months of storage. Seed vigour index noted in control treatment was 7711.3 after 9 months of storage. Over all the treatment combinations, C_2 X S_3 recorded the highest value for seed vigour index (9914.7) after 9 months of storage.

The results presented in Table 6 revealed that storage condition (C) and seed treatments (S) exhibited significant differences for seed moisture content after 9 month of storage, however, The data of soybean seed among the seed treatments showed non-significant difference with respect to seed moisture after 9 months of storage. The results of soybean seed stored in two storage conditions showed that on an average, the seed stored in ambient storage condition manifested significantly higher seed moisture content. Over all the treatment combinations, C_1 X S_1 recorded the highest value for seed moisture (11.77) after 9 months of storage.

The variation in germination percentage of soybean seed decreased with increase storage period which might be due to the deleterious effects of moisture which resulted from the storage materials and perhaps environmental conditions. This agrees with Tame (2011) who reported that germination percentage of soybean seed decreased with increase in storage period. Arif *et al*. (2006) recorded that highest germination percentages in soybean were in seed stored at 4ºC than room temperature. Kandil *et al*. (2013) observed maxi-mum seed germination parameters in soybean, when the seeds of Giza 111 cultivar stored under refrigerator conditions (10 ± 1ºC) in cloth bags for 3 months.

Conclusion

It can be concluded that soybean seed may be stored under cold storage (15^{o}C ± 2^{o}C) condition with seed treatment of Mancozeb @ 2g/kg seed or Carbendazim @ 2g /kg seed or Neem Oil@5ml/kg seed for a period of 9 months without deterioration in germination and seedling vigour.

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EFFECT OF FUNGICIDES AND PLANT EXTRACTS ON PREVALENCE OF SEED BORNE FUNGI AND QUALITY OF CAPSICUM SEED IN STORAGE

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Abstract

The present study was conducted in the Laboratory of Seed Technology Division as well as Plant Pathology Laboratory, Bangladesh Agricultural Research Institute, Gazipur during 2020-2021 using Completely Randomized Design with three replications to evaluate the effect of seed treatment with different plant extracts and chemical fungicides on the prevalence of seed borne pathogens and maintaining quality of capsicum seed in storage. The following fungicides and plant extracts were used for the experiment viz. Autostin 50 WP (Carbendazim) and Dithane M-45 (Mancozeb) @ 2.2 g/kg, Rovral (Iprodione) @ 2.0 g/kg, Provax-200 WP (Carboxin) @ 3.0 g/kg, Garlic extract @ 1:1 w/v, Garlic extract @ 1:2 w/v , Neem leaf extract @ 1:1 w/v, Neem leaf extract @ 1:2 w/v, Zinger rhizome extract @ 1:1, Zinger rhizome extract @ 1:2 w/v just before storage (Number should be included in the treatment, design, replication). Prevalence of seed-borne pathogens, percent seeds germination, speed of germination and vigor index were evaluated for data parameters just before storage (0 day), 75 and 150 days after storage. The pathogens namely *Alternaria* sp., *Aspergillus* sp., *Fusarium* sp., *Carvularia* sp., *Colletotrichum* sp., *Penicillium* sp. and *Rhizopus* sp. were identified from the treated seeds during different storage periods respectively. The identified pathogens were exclusively fungi; no bacteria and virus diseases were observed. The untreated control showed highest disease incidence for all the pathogens identified throughout the storage period. There is no disease observed in T_4 treatment that is Provax-200 (Carboxin) @ 3.0g/kg throughout the storage period correspondingly. The lowest disease incidence was found in $T_{5=}$ Garlic extract @ 1:1 w/v and $T_{10=}$ Zinger rhizome extract @ 1:2 w/v treatments. Capsicum seed treated with Zinger rhizome extract @ 1:1 w/v up to 150 days of storage showed significantly higher germination rate, speed of germination, seedling dry weight and vigor index over control and others treatment.

Introduction

Bell pepper (*Capsicum annuum* L.) is an important spice-cum vegetable crop grown under various agro climatic conditions in Bangladesh and worldwide. Loss in vigor and viability as well as disease is a major problem in storage of capsicum seed. There are so many factors like loss of seed vigor and viability, low germination and pathogens prevalence which may impair seed health status and quality during storage (Justice and Bass, 1979; Ahmed, 1982 and Asalmol *et al.*, 2001). Pathogens propagated by seeds cause significant losses in seed yield and quality, resulting in low germinability and even damage to seedlings (Sarika *et al*, 2019). Fungal pathogens like *Aspergillus niger, A. flavus, Fusarium oxysporum, Alternaria solani* and *Penicillium* sp. are responsible for capsicum seed infection. These pathogens are frequently transmitted through seeds (Fakir, 1998). *Aspergillus* sp. *Penicillium* sp. and *Fusarium* sp. can cause losses of quality of capsicum seeds in storage. Ahmed and Hossain (1985) stated that the fungus can affect seed germination and seedling growth. Seed-borne fungi adversely affect seeds in storage. They bring down germinability, discolor the seeds, enhance biochemical changes, and accumulate toxins, and results in loss of weight (Neergaard, 1979). Thus, management of pathogens infection in seeds during storage is one of the crucial factors to maintain proper germination, vigor and health status of seeds. Among recommended practices, seed treatment probably the cheapest and easiest method of plant disease control. Treatment of seeds with chemicals has been proved to be effective in reducing seed-borne infection (Dubey and Singh, 2005; Barua *et al.*, 2007). Application of fungicides effectively inhibits *F.oxysporum* and *A. niger* and contributes to higher seed germination and vigor index (Behrani *et al*., 2015, Patra, 2017, Saranya *et al*., 2017). Prestorage seed treatment may reduce the prevalence of seed-borne pathogens and protect seeds from the invasion of mainly fungi in storage condition.

The present research work has therefore been undertaken to evaluate the effect of seed treatment with chemical fungicides and botanical agents on prevalence of major seed borne fungi, seed germination rate, seedling health, and seedling vigor index of capsicum during storage.

Materials and Methods

The research work was executed in the Laboratory of Seed Technology Divisions well as Plant Pathology Laboratory, BARI during October 2020- June 2021. The experiment was laid out in Complete Randomized Design (CRD) having 11 treatments with control and each treatment was replicated 4 times. Seeds of BARI capsicum-1 were subjected to seed treatments with fungicides namely Autostin 50 WP (Carbendazim) @ 2.2 g/kg (T_1), Dithane M-45 (Mancozeb) @ 2.2 g/kg (T_2), Rovral (Iprodione) @ 2.0 g/kg(T_3), Provax-200WP (Carboxin) @ 3.0 g/kg of seeds(T_4), and botanicals viz.Garlic extract @ 1:1 w/v (T_5), Garlic extract @ 1:2 w/v (T_6), Neem leaf extract @ 1:1 w/v (T_7), Neem leaf extract @ 1:2 w/v (T_8), Zinger rhizome extract @ 1:1(T_9), Zinger rhizome extract @ 1:2 w/v (T_{10}) and untreated control (T_{11}). For getting 1:1 (w/v) ratio, 100 ml of distilled water was added with 100 g plant parts. For getting 1:2 (w/v) ratio, 200 ml of distilled water was added with 100 g plant parts. Seeds were treated with fungicides and plant extracts above mentioned as well as distilled water for unsprayed control 1 hour respectively. Each treatment consisted of twenty grams of capsicum seed. All the treated seeds were dried back to original moisture content at room temperature. The treated seeds were then kept in storage and seed health status, germination rate and vigor index were tested according to standard methods (ISTA, 1996) just before storage (0), 75 and 150 days after storage.

Seed health test: Seed health test of capsicum seeds was carried out by standard blotter method (ISTA, 1996). In this method, three layers of blotter papers (Whatman No. 1) were soaked in sterilized distilled water and placed on the bottom of the 9 cm diameter Pyrex glass Petri dish. Four hundred seeds from each treatment were taken randomly and then placed on the moist blotter paper at the rate of 25 seeds per plate. The experiment was laid out following Completely Randomized Design (CRD) with four replications. The Petri dishes with seeds were then incubated at 25 ± 2^{o} C temperature in 12/12 hours alternating cycles of light and darkness for seven to ten days. After incubation, the seeds were examined under stereo-microscope for the presence of seed-borne pathogens and identified by observing their growth characters. In case of confusion, temporary slide was prepared and examined under a compound microscope and identified pathogens using appropriate keys of Mathur and Kongsdal (2003). Results were expressed in percentage of seeds infected by the pathogens.

Germination percentage: Seed germination test was conducted in the Seed Technology laboratory of BARI using three layered moistened blotter paper on Petri dishes. Hundred seeds were placed on each Petri dish and kept at 25^{0}C temperature for fourteen days for germination. 4 replications were used for germination test. The first and final count was taken on 4th and 14th day of the test respectively. Germination percentage was worked out using the following formula:

$$\text{Germination (\%)} = \frac{\text{Normal seedlings germinated}}{\text{Seeds kept for germination}} \times 100$$

Germination speed: Speed of germination was computed by recording daily observations on 100 seeds sown in sand medium until the final count day (14 days). The speed of germination was calculated as total number of seeds emerged on day basis, and the mean was calculated as suggested by Copeland (1976).

$$GS = \left(\frac{\text{No. of germinated seeds at first count}}{\text{Days of first count}} + - - - + \frac{\text{No. of germinated seeds at final count}}{\text{Days of final count}}\right)$$

Seedling vigor index: For calculating seedling vigor index the 10 normal seedlings were randomly selected on 14th day of germination test and seedling were dried in an oven at 71ºC for 72 hrs using. Then cooled and weighed in an electronic weighing balance and expressed in mg. Vigor index was calculated on the basis of mean seedling dry weight by adopting the formula (Adbdul-Baki and Anderson, 1973).

$$\text{Vigor index} = \text{Germination (\%)} \times \text{Seedling dry weight (mg)}$$

Statistical Analysis

The collected data on different parameters were analyzed statistically by analysis of variance (ANOVA) using R command program. The significance of the difference among the means was calculated by LSD test (Least Significance Difference).

Results & Discussion

Prevalence of seed- borne fungi:

All the capsicum seeds sample were infected with different levels of infection except T_4 (Table 1).There are seven different fungi viz. *Alternaria sp., Aspergillus sp., Fusarium sp., Carvularia sp., Colletotrichum sp., Penicillium sp. and Rhizopus sp.* were identified from the seeds placed in blotter method in laboratory conditions. The fungal pathogens prevalence in seeds increased with the increase in storage time. The prevalence of pathogens was minimal just after treatment (0 DAS) with different fungicides and botanical agents. The untreated control showed highest disease incidence for all the observed pathogens in an upward trend with irrespective of storage period. The lowest disease incidence was found in T_5 and T_{10} treatments with only one pathogen that is *Colletotrichum sp*. The treatment T_5 and T_{10} showed statistically identical results throughout the storage period. There is no pathogen infection was observed in T_4 treatment that is treated with Provax-200 (Carboxin) @ 3.0g/kg during the storage time.

Table 1. Effect of different treatments on percent disease incidence of different pathogens at 0, 75 and 150 DAS period

Treatments	Isolated pathogens	Disease incidence (%)		
		0 DAS	75 DAS	150 DAS
Autostin 50 WP @ 2.2 g/kg	*Alternaria sp.*	-	2.15	5.33
	Carvularia sp	-	3	4
	Fusarium sp	-	3.55	5. 57
Dithane M-45 @ 2.2 g/kg	*Colletotrichum sp.*	1.25	3.45	7.10
	Fusarium sp.	-	4	6.50
Rovral @ 2.0 g/kg		-	2	5
	Alternaria sp.	-	3	7
	Colletotrichum sp.	-	4	9
Provax 200 WP @ 3.0 g/kg	-	-	-	-
Garlic extract @ 1:1 w/v	*Colletotrichum sp.*	-	1.25	2.75
Garlic extract @ 1:2 w/v	*Penicillium sp.*	-	2.0	4.0
	Rhizopus sp	-	2.0	5.0
	Aspergillus sp.	1.55	3.10	9.15
Neem leaf extract @ 1:1 w/v	*Colletotrichum sp.*	-	2.0	5.1
	Aspergillus sp.	1.33	2	4.25
Neem leaf extract @ 1:2 w/v	*Alternaria sp.*	-	2	5
	Colletotrichum sp.	1.00	2.50	6.50
Zinger rhizome extract @ 1:1 w/v	*Alternaria sp.*	-	2.15	5.0
	Rhizopus sp.	-	1.50	2.0
	Fusarium sp.	1.25	1.50	2.75
Zinger rhizome extract @ 1:2 w/v	*Colletotrichum sp.*	-	1.50	2.25
Control	*Alternaria sp.*	1.50	4.25	7.25
	Penicillium sp.	1.25	3.0	5.0

	Fusarium sp.	1.75	3.75	7.50
	Colletotrichum sp.	1.50	4.0	9.15
	Aspergillus sp.	1.50	3.2	8.0

Seed germination:

At the time of storage, the average initial germination of capsicum seeds was 84.00%. The treated seeds after 75 days of storage showed significant difference in germination that ranged from 55.00 to 81.25% (Table 2). Maximum 81.25% seed germination was recorded in seed treated with Zinger rhizome extract @ 1:1 w/v. Seed treated with Neem leaf extract @1:2 w/v showed 76.25% germination that was statistically similar to seed treatment with Rovral. The lowest germination (55%) was recorded from the untreated control. In case of 150 DAS (Table 2), considerably different results in germination rate was observed among the treatments. The higher germination was recorded that is 80.50% in seed treated with Zinger rhizome extract @ 1:1 w/v followed by Neem leaf extract (74.50%)@1:2 w/v while minimum germination was found in control (50.50%).

Table 2. Effect of seed treatment on germination of capsicum seeds at different storage period

Treatments	**Germination (%)**		
	Initial	**75 days**	**150 days**
Autostin 50 WP @ 2.2 g/kg	84.00	70.25	69.50
Dithane M-45 @ 2.2 g/kg		64.50	64.75
Rovral @ 2.0 g/kg		74.00	69.50
Provax 200 WP @ 3.0 g/kg		65.00	63.50
Garlic extract @ 1:1 w/v		66.00	64.00
Garlic extract @ 1:2 w/v		64.25	62.00
Neem leaf extract @ 1:1 w/v		73.50	70.50
Neem leaf extract @ 1:2 w/v		76.25	74.50
Zinger rhizome extract @ 1:1 w/v		81.25	80.50
Zinger rhizome extract @ 1:2 w/v		63.50	61.50
Control		55.00	50.50
CV (%)		2.47	4.54
LSD (0.05)		2.7204	2.3592

Speed of germination:

Significant variation in germination speed of capsicum seed was observed in different storage period due to seed treatment with different fungicides and plant extracts **(**Table 3). Initial germination speed of capsicum seed was found 8.657that reduced to 4.124 in untreated control after 75 DAS. Maximum speed of germination (7.625) was found in the seed treated with Zinger rhizome extract @ 1:1 w/v that was statistically similar to seed treatment with Rovral (7.014) and Provax 200 WP (7.180). After 150 DAS germination speed of capsicum was significantly reduced to 3.478 in untreated control. Significantly higher speed of germination (6.619) was found in the seed treated with Zinger rhizome extract @ 1:1 w/v that was also statistically similar to seed treatment with Rovral (6.600) and Provax 200 WP (6.365).

Table 3.Effect of seed treatment on germination speed at different storage period

Treatments	Germination speed		
	Initial	75 days	150 Days
Autostin 50 WP @ 2.2 g/kg	8.657	5.490	5.227
Dithane M-45 @ 2.2 g/kg		4.937	4.262
Rovral @ 2.0 g/kg		7.014	6.600
Provax 200 WP @ 3.0 g/kg		7.180	6.365
Garlic extract @ 1:1 w/v		6.085	5.339
Garlic extract @ 1:2 w/v		6.267	5.62
Neem leaf extract @ 1:1 w/v		6.123	5.525
Neem leaf extract @ 1:2 w/v		6.035	5.042
Zinger rhizome extract @ 1:1 w/v		7.625	6.619
Zinger rhizome extract @ 1:2 w/v		6.392	5.465
Control		4.124	3.478
CV (%)		10.72	11.22
LSD (0.05)		0.9430	0.8740

Effect of seed treatment on dry weight of seedling:

At the time of storage, mean dry weight of 10 seedlings was 36 mg that decreased with the increase of storage period. After 75 days of storage it ranged from 29.25mg to 36.25 mg (Table 4). Maximum dry weight of seedling was found 36.25 mg from seed treatment with zinger rhizome extract @1:1 w/v followed by 35.50 mg from Neem leaf extract @ 1:2 w/v that was statistically similar to Zinger rhizome extract @ 1:2 w/v (35.50 mg) and Neem leaf extract @ 1:1 w/v (35.00 mg). During 150 days of storage period seedling dry weight ranged from 27.00mg to 35.50 mg. Statistically similar result was found in case of seedling dry weight from Neem leaf extract @ 1:2 w/v (34.25 mg), Zinger rhizome extract @ 1:1 (35.50 mg) and Zinger rhizome extract @ 1:2 w/v (33.50mg) where minimum was recorded in control that is 27.00.

Table 4. Effect of seed treatment on seedling dry weight at different storage period

Treatments	Seedling dry weight (mg/10 seedlings)		
	Initial	75 days	150 days
Autostin 50 WP @ 2.2 g/kg	36.00	32.50	30.75
Dithane M-45 @ 2.2 g/kg		33.75	31.00
Rovral @ 2.0 g/kg		33.00	30.75
Provax 200 WP @ 3.0 g/kg		33.25	32.25
Garlic extract @ 1:1 w/v		31.50	29.75
Garlic extract @ 1:2 w/v		31.25	31.00
Neem leaf extract @ 1:1 w/v		35.00	32.75
Neem leaf extract @ 1:2 w/v		35.50	34.25

Zinger rhizome extract @ 1:1 w/v		36.25	35.50
Zinger rhizome extract @ 1:2 w/v		35.50	33.50
Control		29.25	27.00
CV (%)		3.76	4.68
LSD (0.05)		1.8015	2.1323

Initial vigor index of capsicum seed was found 3025 before storing of seeds (Table 5). After 75 days of storage, vigor index was found 2945 from Zinger rhizome extract @ 1:1w/v treated seeds whereas lowest vigor index value that is 1610was found in untreated control. In case of 150 days of storage, vigor index was decreased to 2858 in Zinger rhizome extract @ 1:1 w/v treated seeds that was significantly higher than the other treatments. Lower value of seed vigor index was observed in control that is 1362.

Table 5. Effect of seed treatment on vigor index of capsicum seed at different storage period

Treatments	**Seedling vigor index**		
	Initial	**75 days**	**150 days**
Autostin 50 WP @ 2.2 g/kg	3025	2284	2138
Dithane M-45 @ 2.2 g/kg		2179	2009
Rovral @ 2.0 g/kg		2442	2137
Provax 200 WP @ 3.0 g/kg		2162	2047
Garlic extract @ 1:1 w/v		2080	1904
Garlic extract @ 1:2 w/v		2007	1920
Neem leaf extract @ 1:1 w/v		2572	2308
Neem leaf extract @ 1:2 w/v		2707	2551
Zinger rhizome extract @ 1:1 w/v		2945	2858
Zinger rhizome extract @ 1:2 w/v		2253	2057
Control		1610	1362
CV (%)		5.05	4.66
LSD (0.05)		166.58	142.04

Provax-200, Rovral, Dithane M-45 and Autostin 50 WP as well as plant extracts were found effective in controlling seed-borne pathogens of capsicum seeds, and improved germination and vigor index to a considerable extend. The treatment T_4= Provax-200 (Carboxin) @ 3.0g/kg ; T_5= Garlic extract @ 1:1 w/v; T_9= Zinger rhizome extract @ 1:1 w/v and T_{10}= Zinger rhizome extract @ 1:2 w/v showed promising result in case of pathogens reduction, germination rate, speed of germination, seedling dry weight and vigor index throughout the storage period of capsicum seed. Various authors also reported that fungicides and plant extracts application significantly reduced seed-borne infection and increased the percent germination and vigor index (Akgul *et al*., 2011; Rohtas, 2014; Saranya *et al*., 2017) of capsicum seed. Efficacy of Autostin 50 WP, Rovral 50 WP and Provax-200 was reported against *F. oxysporum* and *Aspergillus* sp. Seed treatment with fungicides also increased the germination rate of soybean (Chaity et al., 2011). Fungicides like Carbendazim, Thiophanate-methyl, Benomyl, Prochloraz and Tebuconazole showed inhibiting effects against *F. oxysporum* and their application increased the emergence of seedlings (Song *et al*. 2004; Ozer and Koycu, 2004; Rajput *et al*., 2006; Chandel and Deepika, 2010). Plant extract is a promising alternative for pathogens control associated with seeds, reducing costs and impacts to the environment (Silva *et al*., 2019). Plant extracts act directly or indirectly on pathogens growth in the seed due to their bioactive compounds. In the present study; all the botanicals especially T_9= Zinger rhizome extract @ 1:1 w/v and T_9= Zinger rhizome extract @ 1:2 w/v significantly reduced seed borne fungal pathogens of capsicum, simultaneously enhanced the growth parameters of capsicum seedling. The similar results in reducing percent seed borne fungal pathogens, increasing percent germination and enhancing growth characters of vegetable seedling were also found by the reports of Islam *et al*., (2006); Hossain *et al.* (2005); Howlader (2003); Rahman *et al*., (1999); Rahman *et.al.*, (2012); Khan(1999).

Conclusion

Seed treatment with different plant extracts and fungicides greatly contributed to seed health status and quality of capsicum seed during storage period. It is revealed from the present experiment that Provax-200 (Carboxin) @ 3.0g/kg is the most effective fungicides which reduced seed-borne pathogen infection in capsicum seed during storage. Therefore, pre-storage seed treatments with Provax-200 (Carboxin) @ 3.0g/kg is suggested as effective fungicide to control seed borne fungi whereas zinger rhizome extract@ 1:1 w/v is good for germination rate and vigor index and quality of capsicum seeds.

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Technology Developed during 2021-22

One technology developed from Seed Technology Division, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during 2021-22. The technology was-**"Production of better quality seed of Onion through Gibberellic Acid treated mother bulb".**

Description of technologies

Sl. no.	Topic		Description
1.	Technology name	:	Production of better-quality seed onion through Gibberellic Acid
2.	Technology characteristics	:	❑ Onion bulb soaked with 300 ppm of GA_3 before 48 hours sowing would give higher seed yield with better seed quality of BARI Piaj-1 ❑ Average seed yield would be 780-790 kg/ha which is increased 15-20 % yield than normal average seed yield. ❑ Seed germination: 90-95 %. ❑ Number of umbel per plant would be 6-7. ❑ Farmers will be benefited by maximizing quality seed production
3.	Suitability	:	All over the Bangladesh.
4.	Application information	:	Variety: BARI Piaj-1 Sowing time: October-November Bulb seed rate: 3000-5000 kg/ha Spacing: 20 x 15 cm Fertilizer dose: Urea: 250 kg/ha, TSP: 275 kg/ha, MoP: 150 kg/ha, gypsum: 110 kg/ha, zinc oxide:3 kg/ha, Boric acid: 5 kg/ha and Cowdung 5-10 ton/ha. Fertilizer application method: Entire amount of Cowdung, TSP, Gypsum, Zinc, Boron, one third of Urea and half of MoP, would be applied during land preparation. The remaining two third of and half of MoP will be top dressed in two equal splits at 25 and 50 days respectively after bulb or directly seed sowing. Weeding at 2-3 times or more and Irrigation should be done at 8-10 times. Irrigation should be stopped before one month of harvesting when onion bulbs are matured Water logging should be avoided. Insect control: Whenever it will be necessary Harvest time : 150-170 DAS
5.	Yield/achievement from the technology	:	Seed yield will be increased up to 15-20%

Quality seed production and distribution during 2021-22

Seed is the basic input of crop production. Quality seed plays an important role for increasing crop production of the country. Seed Technology Division of BARI is generally producing some amount of breeder and truthfully labeled seed to meet up demand of BADC, Seed Company, researchers and farmers of the country. In 2021-22, this division produced 23 (twenty three) kilogram breeder seeds of onion (BARI Piaj-1), 125 kg seed of garden pea (BARI Motorshuti-3: Breeder seed-37 kg and TLS-88 kg), 19 kg TLS seed of mungbean (BARI Mung-6) and 03 kg of BARI Sheem-6 and BARI Sheem-7 were produced in Gazipur location by this division. Therefore, a total of 170 kg (One hundred and seventy kilogram) seed of BARI mandate crop was produced during 2021-22. On the other hand, 154 kg seed of onion, garden pea, and French bean were supplied to BADC, DAE, advanced farmers, researchers and University students.

Table 1. Quality Seed Production & Distribution during 2021-22

S.I	Crop	Variety	Seed	Production (kg)	Distribution (kg)
1.	Onion	BARI Piaj-1	Breeder	23	13
			TLS	-	-
2.	Garden pea	BARI Motorshuti-3	Breeder	37	17
			TLS	88	104
3.	Mung bean	BARI Mung-6	Breeder	-	-
			TLS	19	-
4.	Country bean	BARI Sheem-6, 7	Breeder	-	-
			TLS	3	
05	French bean	BARI Jharsheem-2	Breeder	-	20
			TLS	-	
			Total	170	154

TECHNOLOGY DEMONSTRATION DURING 2021-22

Technology Demonstration

1. **Production of groundnut seed at Jamalpur**

The production program of BARI groundnut variety was conducted in two locations of Jamalpur Sadar, Jamalpur during the Rabi 2021-22. One is Nao-bhangar Char and other is Charbelgacha, Gutail, Islampur of Jamalpur Sadar, Jamalpur. BARI Chinabadam-9 was grown in two farmer's field having 66 decimal land areas. Crop was fertilized with 12-32-43-54-2 kg ha-1 N-P-K-S-B, respectively. Half of nitrogen and full amount of P, K, S and B were applied at the time of final land preparation in the form of urea, triple super phosphate, muriate of potash, gypsum and boric acid, respectively. Remaining N were top dressed at 45 days after sowing (DAS) before flowering stage. The plant spacing was 30 cm x 15 cm. Intercultural operation, pests and other crop management practices were done as and when necessary. Nirto @ 2 ml/Litre water was sprayed to control insects. The seeds were sown in 10 November, 2021 at Nao-bhangar Char and 15 October, 2021 at Charbelgacha, Gutail, Islampur of Jamalpur Sadar, Jamalpur. The crop was harvested during 20-30 April, 2021. Pod yield of BARI Chinabadam-9 ranged 1.85-1.90 t/ha.

Farmers' Opinion: BARI Chinabadam-9 gave higher pod yield than the existing surrounding local cultivar. They also chose the variety for its larger pod size, less disease infestation and attractive seed coat color. The farmers also opined that they would store the seed of BARI Chinabadam-9 and will grow in the next year.

2. Production of garden pea seed

The production program of BARI garden pea variety was conducted in three locations of Sherpur Sadar, Sherpur during the Rabi2021-22. BARI Motorshuti-3 was grown in farmer's field having 20 decimal land area. The crop was fertilized with 100-150-100 kg ha^{-1} Urea-TSP-MoP, respectively. Half of urea and MoP and full amount of TSP were applied at the time of final land preparation. Remaining urea and TSP were top dressed at 20 and 45 days after sowing (DAS). The plant spacing was 10 cm x 15 cm. Intercultural operation, pests and other crop management practices were done as and when necessary. The seeds were sown during 22-23 November, 2021 and the crop was harvested during 25-31 March, 2021. Pod yield of BARI Motorshuti-3 ranged 1.30-1.40 t/ha.

Farmers' Opinion: BARI Motorshuti-3 gave higher pod yield than the existing surrounding local cultivar. They also choose the variety for its larger pod size, less disease infestation and attractive seed coat color. The farmers also opined that they would store the seed of BARI Motorshuti-3 and will grow in the next year.

FARMERS' TRAINING DURING 2021-22

Seed Technology Division of BARI is engaged to disseminate seed production, processing and storage technologies of BARI mandate crops among large number of farmers aiming at availability of quality seed to the farmers of Bangladesh (Table-1). In 2021-22, farmers trainings were conducted on ''Improved Production and Storage Technologies of Onion / garden pea / Bt Brinjal / Groundnut''. A total of 150 farmers were trained in five batches in five locations of Bangladesh. Farmers would be benefitted by knowing the seed production technologies of onion. So that farmers would able to grow onion seed and onion seed would be available to farmers' level

Table 1. Farmer's Training conducted by Seed Technology Division of BARI during 2020-21

Sl. no.	Topic	Location	Date	Farmer (no.)
01.	Farmers training on " Imporved seed production technologies of Garden pea, Bt Brinjal and Onion"	RSRS, Magura	31.03.22	30
02.	Farmers training on " Imporved seed production technologies of Groundnut"	RARS, Jamalpur	27.03.22	30
03.	Farmers training on " Imporved seed production technologies of Garden pea"	OFRD, Sherpur	24.01.22	30
04.	Farmers training on " Imporved seed production technologies of Garden pea, Bt Brinjal and Onion"	BARI, Gazipur	24.03.22	30
05.	Farmers training on " Imporved seed production technologies of Garden pea, Bt Brinjal and Onion"	ARS, Rajbari, Dinajpur	23.02.22	30
	Total			150

FIELD DAYS DURING 2021-22

Farmers' field day is a re-known process of technology dissemination among large number of farmers within a short time. Two field days were conducted on Demonstration on Garden pea and Groundnut seed production technologies at Sherpur Sadar, Sherpur and RARS, Jamalpur at 24 January, 2022 and 27 March 2022, respectively. At First field day, sixty farmers were participated. Dr. Md. Shamsur Rahman, CSO, OFRD, BARI, Sherpur was present as Chief Guest. At second field day, sixty farmers were participated in the farmer's field at Naobangar char, Jamalpur sadar, Jamalpur. Dr. Md. Manjural Kader, CSO, RARS, BARI, Jamalpur was present as chief guest and chaired by Dr. Md. Abu Hena Sorwar Jahan, CSO, Seed Technology Division, BARI. Farmers learned a lot about groundnut and garden pea seed production technologies from these field days. Farmers opined that more farmers will produce groundnut and garden pea seed in next season as these seed production is more profitable. Therefore, Groundnut and garden pea seed availability will increase more onion production in these areas.

WORKSHOP DURING 2021-22

Seed Technology Division, BARI, Joydebpur, Gazipur conducted 01 (one) workshop during 2021-22 (Table 01). In total, 80 (Eighty) Scientists of BARI were participated in the workshop.

Table 01. Workshop conducted by Seed Technology Division, BARI, Gazipur during 2020-21

Sl. no.	Workshop title	Venue	Date	Participant no.
01.	Workshop on Internal Research Review 2020-21 and Program Planning 2021-22	Seed Technology Division, BARI (Zoom platform)	22.08.2021	80

PUBLICATIONS DURING 2021-22

Sl. no.	Type	Number	Name	Type	Publication date
01.	Annual Report	01	Annual Research Report 2020-2021 and Annual Research programme 2021-22	Report	September 2021
02.	Booklet	01	Quality seed production technologies of French bean	Booklet	June 2022

SCIENTIFIC PUBLICATIONS DURING 2021-2022

A. N. M. A. Karim, U. K. Sarker, A. K. Hasan, N. Islam, M. R. Uddin. October 2021. Selection of Drought Tolerant High Yielding Chickpea Genotypes based on Field Performance and Genetic Variation in Bangladesh. *Legume Research- An International Journal*, 44(10): 1131-1137.

ANNUAL PERFORMANCE AGREEMENT (APA) REPORT 2021-22

Table 1. Annual Performance Agreement (APA) in 2021-22 of Seed Technology Division, BARI, Gazipur

Performance Indicators	**Unit**	**Target 2021-22**	**Achievement 2021-22**	**Target 2022-23**
1.1.4 Developed other technologies	Number	1	1	1
1.2.1 Trained person/farmer	Man-hour	900	900	180
1.2.3 Established demonstration	Number	5	5	1
1.2.4 Seminar/Workshop	Number	1	1	1
1.2.5 Field day/ Rally	Number	2	2	1
1.3.3 Annual Research Report	Number	1	1	1
1.3.4 Report, bulletin, leaflet, booklet, newsletter etc. publish	Number	1	1	1
2.1.1 Production of Breeder seed	M. Ton	0.060	0.060	0.030
2.1.2 Production of Truthfully Labeled Seed	M. Ton	0.110	0.110	0.070
2.1.4 Distributed Breeder seed	M. Ton	0.060	0.050	0.040
2.1.5 Distributed Truthfully Labeled Seed	M. Ton	0.110	0.104	0.060
5.2.1 Human Resource Development	Man-hour	240	240	120

Rapporteur's report of internal research review and program planning workshop 2022

Organizer: Seed Technology Division, BARI **Date:** 01 August 2022

Venue: BARI, Gazipur (Zoom Platform)

Chairman: Dr. Md. Khairul Bashar, Ex-Director Research, BRRI and Country Manager, Harvest Plus Bangladesh

Expert Member(s):

1. Dr. Solaiman Ali Fakir, Professor, Department of Crop Botany, BAU
2. Dr. M. Moynul Haque, Professor, Department of Agronomy, BSMRAU

Key note speaker: Dr. Md. Abu Hena Sorwar Jahan, CSO and Head, Seed Technology Division, BARI

Rapporteurs:

1. Md. Arafat Hossain, SSO, Seed Technology Division (STD), BARI, Gazipur
2. Md. Sadiqur Rahman, SO, Seed Technology Division (STD), BARI, Gazipur

- **Comments and suggestions on reports:**

Sl. No.	Comments and suggestions	Remarks
	From Participants	
1	Pictures of demonstration plots, farmer's training, field days, etc. should be discarded from the report.	Action was taken
2	Only books, review books, and scientific papers would be presented in the report.	Action was taken
	From Expert Members	
1	Treatment should be elaborately presented in the table instead of the treatment number.	Action was taken
2	BARC-2018 should be mentioned instead of FRG-2018	Action was taken
3	More reviews should be added in the introduction part.	Action was taken
4	Sub-head should be in a shorter format in the results and discussion part.	Action was taken
	From Chairman	
1	The report should be prepared according to different project basis like seed production management, seed storage management, etc.	Action was taken
2	APA list should be represented in English language in the report.	Action was taken

- **Comments and suggestions on proposed research programme:**

Sl.. No.	Title	Comments & Suggestion (s)	Remarks
01	Effect of flower stalk (scape) retention on seed yield and quality of onion	No comments	-
02	Effect of different mulch on seed yield and quality of sweet pepper	Cost analysis should be included.	Action will be taken
03	Assessment of seed quality of Rapeseed-Mustard through accelerated aging method	The objective should be revised according to the title	Action was taken
04	Effect of different weed management practices on yield and seed quality of groundnut	The Program should be done in collaboration with Agronomy Division, BARI	Action was taken
05	Effect of different threshing methods on seed quality of Mung bean	The Program should be done in collaboration with FMPE Division, BARI	Action was taken
06	Seed quality of Chilli as influenced by different drying methods	Number of treatments should be increased in artificial drying	Action was taken
07	Determination of harvest maturity and seed quality of okra as influenced by picking time of fruits	No comments	-
08	Develop a user friendly germinator assistant using Internet of Things	No comments	-
09	Seed quality status of soybean as influenced by packaging materials and time after outlet from the cool room	7 days interval should be maintained in treatment	Action was taken
10	Seed yield and quality of soybean as influenced by nutrient management	Soybean crop should be changed.	Action was taken
11	Quality seed production of mustard under different irrigation levels	The program should be done in collaboration with Oilseed Research Center, BARI	Action was taken

- **Overall comments and suggestions on improvement and future plan of Seed Technology Division:**

Sl. No.	Comments and suggestions	Remarks
01.	Seed Technology Division should take initiative to disseminate the seed of BARI-developed popular varieties through proper packaging and related technologies to the end users.	Action will be taken under supervision of Director Research, BARI and Director General, BARI
02.	Seed Technology Division should take initiative in seed production in collaboration with Horticulture Research Center, BARI	Action will be taken under supervision of Director HRC, Director Research, BARI and Director General, BARI

<u>**Rapporteur's report (Task force)**</u>

Comments and suggestions on programs of Crops, Soil and Water Management of Seed Technology Division presented at Taskforce-2022

Date: 08 September 2022 Venue: Seminar Room, BARI, Gazipur

Chaired by : Dr. Apurba Kanti Choudhury
Director, Planning and Evaluation, BARI, Gazipur.

Member- Director : Dr. Dilwar Ahmed Choudhury
Chief Scientific Officer, Agronomy Division, BARI, Gazipur

Rapporteur : Samim Ara Begum
Senior Scientific Officer, Seed Technology Division, BARI, Gazipur

Exp. no.	Name of the experiment	Comments from expert planes	Remarks
01.	Effect of flower stalk (scape) retention on seed yield and quality of onion	No comment	Ok
02.	Effect of different mulch on seed yield and quality of sweet pepper	No comment	Ok
03.	Assessment of seed quality of Rapeseed-Mustard through accelerated aging method	No comment	Ok
04.	Effect of different weed managements practices on yield and seed quality of groundnut	References should be added in rationale	Action was taken
05.	Effect of different threshing methods on seed quality of Mung bean	References should be added in rationale part	Action was taken
06	Seed quality of Chilli as influenced by different drying methods	Treatments should be re-arranged	Action was taken
07.	Determination of harvest maturity and seed quality of Okra as influenced by picking time of fruits	No comment	Ok
08.	Develop a user friendly germinator assistant using Internet of Things	No comment	Ok
09.	Seed quality status of soybean as influenced by packaging materials and	No comment	Ok

	time after outlet from the cool room		
10.	Seed yield and quality of soybean as influenced by nutrient management	No comment	Ok
11.	Effect of drying temperature and duration of drying on seed quality of watermelon	No comment	Ok
12.	Quality seed production of mustard under different irrigation levels	In treatment, irrigation as and when necessary should be replaced by rainfed or no irrigation	Action was taken

<u>Recommendations (BARC)</u>

Comments and suggestions on programs presented at annual review workshop on Crop Production Program of NARS Institutes, BARC-2022

Date: 24-25 August, 2022 Venue: Seminar Room, BARC, Dhaka

<u>Recommendations for Seed Technology Division</u>:

Sl. No.	Comments and suggestions	Remarks
01.	Promotion strategy should be undertaken regarding promising BARI hybrid Mistikumra-1	Seed Technology Division will disseminate promising BARI hybrid Mistikumra-1 through OFRD, BARI.
02.	Strengthen public private partnership on seed production.	A letter was given to Director General, BARI from Seed Technology Division seeking initiative regarding these matters.
03.	Emphasize on seed production and distribution program to accelerate dissemination process at farmer's level.	

Appendix-1: List of Scientific Officer, scientific Assistant and Office Staff

SI. No.	Name	Designation	Remarks
	Scientist		
1.	Dr. Md. Abu Hena Sorwar Jahan	CSO	
2.	Dr. Parimal Chandra Sarker	PSO	
3.	Shamim Ara Bagum	PSO	
4.	Abdul Hannan	SSO	
5.	A. N. Md. Anamul Karim	SSO	
6.	Remi Chakma	SSO	
7.	Md. Nazmul Islam	SSO	Deputation
8.	Md. Arafat Hossain	SSO	
9.	Md. Sadiqur Rahman	SO	
10.	Maria Islam	SO	
	Scientific Assistant		
1.	Md. Mofassel Hoque	SA	
2.	Aziz Miah	SA	
3.	Feruz Ahmed	SA	
	Office Staff		
1.	Md. Ruhul Amin	Office Assistant Cum Computer Operator	
2.	Md. Babul Hossain	Office Assistant Cum Computer Operator	
3.	Rokeya Begum	Office Attendant	