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Seed Germination and Seedling Vigour of Spine Gourd (*Momordica dioica* Roxb.) in Response to Different Physical and Chemical Treatments

Gargi Gautami Padhiary [a*], Gouri Shankar Sahu [a], Pradyumna Tripathy [a], Gyana Ranjan Rout [b] and Kailash Chandra Samal [c]

[a] Department of Vegetable Science, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India.
[b] Department of Molecular Biology and Biotechnology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India.
[c] Department of Molecular Biology and Biotechnology and Plant Physiology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out at Department of Vegetable Science, OUAT, Bhubaneswar during 2019-2021. Five to six months old stored spine gourd seeds were exposed to various physical (T_1: control, T_2: 48 hours soaking in water, T_3: hot water treatment for 20 minutes + 48 hourssoaking in water, T_4: scarification by sand paper + 48 hours soaking in water, T_5: removal

**Corresponding author: E-mail: nikigargi.15@gmail.com, niki.gargi15@gmail.com;*

of seed coat + 48 hours soaking in water) and chemical (C_1: GA_3 100 ppm, C_2: GA_3 200 ppm, C_3: KNO_3 1%, C_4: KNO_3 2%, C_5: Thiourea 1%, C_6: Thiourea 2% & C_7: Control) treatments. The experiment was laid out in factorial CRD design with 35 treatment combinations replicated twice. The seeds were sown in plastic trays containing cocopeat media. The effect of these treatments on percentage of germination, length of seedling, seedling dry weight, seedling vigour index- I and II were studied. It was concluded that among the physical treatments, T_5 (removal of seed coat + 48 hours soaking in water), among the chemical treatments, C_1 (GA_3 100 ppm) and between the interactions, T_5C_1 recorded highest germination percentage, seedling length, seedling dry weight, vigour index- I and vigour index – II. The lowest values were recorded in control. From the experimental results.it was observed that seed coat removed seeds soaked for 48 hours in water followed by treatment with GA_3 100 ppm recorded highest germination percentage and seedling vigour in spine gourd.

Keywords: Physical; chemical; germination; vigour index; spine gourd.

1. INTRODUCTION

Spine gourd (*Momordica dioica* Roxb.) belongs to family cucurbitaceae with chromosome number 2n=2x=28 [1] is native of Indo- Malayan region [2] and distributed in India, Bangladesh, China, Malaysia, Nepal, Myanmar, Pakistan, and Sri Lanka [3]. It is widely distributed in tropical and sub-tropical parts of India and adapted to different soil and climatic conditions [4]. It is an economically important vegetable with high food and medicinal value cultivated mainly for its fruits which is used as vegetable. This popular vegetable has high demand in market owing to its good nutritional, medicinal value, high keeping quality, ability to withstand long distance transportation, high market price and good export potential [5]. However, the potentiality of this crop is not fully exploited due to several limitations, one of them is presence of hard seed coat and dormancy of seeds. The seeds of spine gourd are shiny, small with hard seed coat. Freshly harvested seeds possess dormancy up to 4-6 months. The seeds germinate but at very low frequency which is a major hindrance in commercial cultivation of this crop. Germination is the sequence of events that initiate with the uptake of water and nutrients by the quiescent dry seed and ends with the elongation of the embryonic axis [6]. To overcome the problem in germination, the seeds may be given some physical and chemical treatments which will enhance the germination. Therefore, by using physical treatments and seed priming with chemicals, the problems of dormancy of seeds, delay in germination, lower germination percentage, less vigour seedlings can be solved.

2. MATERIALS AND METHODS

The research work was carried out in the experimental field of Department of Vegetable Science, OUAT, Bhubaneswar during 2019-20 and 2020-21. Five-six months old well matured stored spine gourd seeds were used for this investigation. The seeds were first given different physical treatments *i.e.*, T_1: control, T_2: 48 hours soaking in water, T_3: hot water treatment for 20 minutes + 48 hours soaking in water, T_4: scarification by sand paper + 48 hours soaking in water and T_5: removal of seed coat + 48 hours soaking in water. Then the seeds were soaked in different concentrations of chemicals (C_1: GA_3 100 ppm, C_2: GA_3 200 ppm, C_3: KNO_3 1%, C_4: KNO_3 2%, C_5: Thiourea 1%, C_6: Thiourea 2% & C_7: Control). The seeds are then sown in plastic trays filled with cocopeat. The experiment consisted of 35 treatment combinations with 2 replications. 100 seeds were sown in each tray. The trays were kept under poly house and watered regularly. The number of seeds germinated in each tray was recorded till 50 days after sowing to calculate the percentage of germination. Seedling length and dry weight (mg) were calculated by taking average of 5 seedlings 30 days after germination.

Germination percentage was calculated by following formula:

$$\text{Germination percentage} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds sown}} \times 100$$

Five seedlings were uprooted carefully 30 days after germination without any damage to the root system and the length was measured from the base of the root to the tip of the shoot and their mean was computed and expressed in centimeters.

The uprooted seedlings were kept in oven overnight at 100^0 F and next day their dry weight was taken and mean was expressed in mg.

Vigour index- I was calculated by adopting the following formula and expressed as number.

Vigour index – I = Germination percentage x Seedling length

Vigour index – II was calculated by adopting the following formula and expressed as number.

Vigour index – II = Germination percentage x Seedling dry weight

The data were subjected to statistical analysis as per CRD with factorial concept. The data in percentages were transformed to angular values for statistical analysis. Critical difference values were tabulated at 5 % probability where 'f 'test was significant.

3. RESULTS

3.1 Percentage of Germination

Percentage of germination of spine gourd seeds as affected by different physical, chemical treatments and their interactions are presented in Tables 1 and 2. The percentage of germination was significantly affected by physical and chemical treatments and their interactions during 2019-20, 2020-21 and in pooled analysis.

During 2019-20, significant difference was observed in germination percentage in case of physically treated seeds. Among the physical treatments, T_5 (seed coat removal + 48 hours soaking in water) recorded highest germination percentage (76.93) followed by T_4 (scarification + 48 hours soaking in water) *i.e.,* 69.36. The lowest germination percentage was observed in case of control (33.43). Among the chemical treatments, the seeds treated with GA_3 100 ppm (C_1) recorded highest germination percentage (65) followed by C_6 (58.60) and the lowest was recorded in control (37.50).Among the interaction between physical and chemical treatments, T_5C_1 recorded highest germination percentage (93.00) followed by T_5C_6 (85.00) and the lowest was observed in T_1C_7 (25.00).

During 2020-21, similar trend was observed and significant difference was noticed among the physically, chemically treated seeds and their interactions. T_5 (seed coat removal + 48 hours soaking in water) recorded highest germination percentage (76.79) followed by T_4 (scarification + 48 hours soaking) *i.e.,* 69.29 with lowest germination percentage in case of control (31.21) were recorded in case of physical treatments. Among the chemical treatments, the seeds treated with GA_3 100 ppm (C_1) recorded highest germination percentage (63.40) followed by C_6 (60.60) and the lowest was recorded in control (39.19). Among the interaction between physical and chemical treatments, T_5C_1 recorded highest germination percentage (88.50) followed by T_5C_6 (87) and the lowest was observed in T_1C_7 (22).

In case of pooled analysis, significant difference was observed in germination percentage in physically and chemically treated seeds and among their interactions. Among the physical treatments, T_5 (seed coat removal + 48 hours soaking in water) recorded highest germination percentage (76.86) followed by T_4 (scarification + 48 hours soaking in water) *i.e.,* 69.32. The lowest germination percentage was observed in case of control (32.32). Among the chemical treatments, the seeds treated with GA_3 100 ppm (C_1) recorded highest germination percentage (64.20) followed by C_6 (59.60) and the lowest in control (38.95). Among the interaction between physical and chemical treatments, T_5C_1 recorded highest germination percentage (90.75) followed by T_5C_6 (86.00) and the lowest was observed in T_1C_7 (23.50).

3.2 Seedling Length (cm)

The data presented in Tables 3 and 4 showed significant differences in seedling length during 2019-20,2020-21 and pooled analysis in case of physical and chemical treatments. However, the interaction effects were found non-significant.

During 2019-20, among the physical treatments, T_5 (seed coat removal + 48 hours soaking in water) recorded highest seedling length (33.65 cm) followed by T_4 (scarification + 48 hours soaking in water) *i.e.,* 30.69 cm. The lowest seedling length was observed in case of control (24.90 cm). Among the chemical treatments, the seeds treated with GA_3 100 ppm recorded highest seedling length (32.29 cm) and the lowest was recorded in control (23.07 cm).Among the interaction between physical and chemical treatments, T_5C_1 recorded highest seedling length (37.09 cm) followed by T_5C_2 (36.13 cm) and the lowest was observed in T_1C_7 (18.50 cm).

Table 1. Effect of different physical and chemical treatments on percentage of germination during 2019-20 & 2020-21

	2019-20						2020-21					
	T1	**T2**	**T3**	**T4**	**T5**	**MEAN**	**T1**	**T2**	**T3**	**T4**	**T5**	**Mean**
C1 (GA3 100 ppm)	41.50 (40.11)	48.50 (44.14)	61.50 (51.65)	80.50 (63.84)	93.00 (74.81)	65.00 (54.91)	39.00 (38.64)	43.00 (40.98)	63.50 (52.84)	83.00 (65.73)	88.50 (70.22)	63.40 (53.68)
C2 (GA3 200 ppm)	32.50 (34.74)	33.00 (35.04)	57.00 (49.03)	71.00 (57.45)	74.00 (59.36)	53.50 (47.12)	34.50 (35.96)	39.00 (38.64)	51.00 (45.57)	65.00 (53.75)	80.00 (63.46)	53.90 (47.48)
C3 (KNO3 1%)	30.00 (33.21)	31.50 (34.14)	49.50 (44.71)	62.00 (51.98)	85.50 (67.64)	51.70 (46.34)	27.00 (31.27)	29.00 (32.57)	46.50 (42.99)	69.50 (56.48)	81.00 (64.28)	50.60 (45.52)
C4 (KNO3 2%)	35.50 (36.56)	33.00 (35.05)	53.00 (46.72)	75.00 (60.00)	78.50 (62.39)	55.00 (48.15)	32.50 (34.74)	38.50 (38.35)	60.00 (50.79)	71.00 (57.43)	69.50 (56.51)	54.30 (47.56)
C5 (Thiourea 1%)	32.00 (34.45)	35.00 (36.25)	55.50 (48.16)	72.50 (58.37)	69.50 (56.48)	52.90 (46.74)	28.00 (31.93)	30.00 (33.21)	47.00 (43.28)	66.50 (54.66)	71.00 (57.42)	48.50 (44.10)
C6 (Thiourea 2%)	37.50 (37.76)	35.50 (36.57)	57.50 (49.31)	77.50 (61.68)	85.00 (67.26)	58.60 (50.52)	35.50 (36.57)	42.00 (40.40)	58.50 (49.90)	80.00 (63.46)	87.00 (68.92)	60.60 (51.85)
C7 (Control)	25.00 (30.00)	25.00 (29.98)	37.50 (37.74)	47.00 (43.28)	53.00 (46.72)	37.50 (37.54)	22.00 (27.95)	26.50 (30.98)	43.00 (40.97)	50.00 (45.00)	60.50 (51.07)	40.40 (39.19)
Mean	33.43 (35.26)	34.50 (35.88)	53.07 (46.76)	69.36 (56.66)	76.93 (62.09)	53.46 (47.33)	31.21 (33.87)	35.43 (36.45)	52.79 (46.62)	69.29 (56.65)	76.79 (61.70)	53.10 (47.05)
	T		**C**		**T × C**		**T**		**C**		**T × C**	
SEm (±)	0.498		0.589		1.318		0.578		0.684		1.529	
CD @ 5%	1.43		1.69		3.78		1.65		1.96		4.38	

** Numbers in parenthesis indicate the angular transformed values (T_1 – control, T_2 – 48 hours soaking in water, T_3 – hot water treatment for 20 minutes + 48 hours soaking in water, T_4 – scarification + 48 hours soaking in water, T_5 - removal of seed coat + 48 hours soaking in water)*

Table 2. Effect of different physical and chemical treatments on percentage of germination (Pooled)

	Pooled					
	T1	**T2**	**T3**	**T4**	**T5**	**Mean**
C1 (GA3 100 ppm)	40.25 (39.37)	45.75 (42.56)	62.50 (52.25)	81.75 (64.79)	90.75 (72.51)	64.20 (54.30)
C2 (GA3 200 ppm)	33.50 (35.35)	36.00 (36.84)	54.00 (47.30)	68.00 (55.60)	77.00 (61.41)	53.70 (47.30)
C3 (KNO3 1%)	28.50 (32.24)	30.25 (33.35)	48.00 (43.85)	65.75 (54.23)	83.25 (65.96)	51.15 (45.93)
C4 (KNO3 2%)	34.00 (35.65)	35.75 (36.70)	56.50 (48.75)	73.00 (58.72)	74.00 (59.45)	54.65 (47.85)
C5 (Thiourea 1%)	30.00 (33.19)	32.50 (34.73)	51.25 (45.72)	69.50 (56.52)	70.25 (56.95)	50.70 (45.42)
C6 (Thiourea 2%)	36.50 (37.16)	38.75 (38.48)	58.00 (49.61)	78.75 (62.57)	86.00 (68.09)	59.60 (51.18)
C7 (Control)	23.50 (28.97)	25.75 (30.48)	40.25 (39.36)	48.50 (44.14)	56.75 (48.90)	38.95 (38.37)
Mean	32.32 (34.56)	34.96 (36.16)	52.93 (46.69)	69.32 (56.65)	76.86 (61.90)	53.28 (47.19)
	T	**C**	**T x C**	**Y X T**	**Y X C**	**Y X T X C**
SEm (±)	0.381	0.451	1.009	0.539	0.638	1.427
CD @ 5%	1.07	1.27	2.84	NS	1.80	4.02

** Numbers in parenthesis indicate the angular transformed values*

(T_1 – control, T_2 – 48 hours soaking in water, T_3 – hot water treatment for 20 minutes + 48 hours soaking in water, T_4 – scarification + 48 hours soaking in water, T_5 - removal of seed coat + 48 hours soaking in water)

Table 3. Effect of different physical and chemical treatments on seedling length (cm) during 2019-20 & 2020-21

	2019-20						2020-21					
	T1	**T2**	**T3**	**T4**	**T5**	**Mean**	**T1**	**T2**	**T3**	**T4**	**T5**	**Mean**
C1 (GA3 100 ppm)	27.93	28.98	32.33	35.13	37.09	32.29	27.59	29.26	32.55	35.05	38.13	32.52
C2 (GA3 200 ppm)	26.02	27.55	29.23	31.44	36.13	30.07	25.61	26.47	29.59	32.44	34.99	29.82
C3 (KNO3 1%)	23.95	25.52	27.46	29.78	32.50	27.84	22.33	24.94	26.90	28.36	32.94	27.09
C4 (KNO3 2%)	25.98	27.41	29.91	30.19	34.14	29.53	26.32	26.96	28.87	31.39	32.62	29.23
C5 (Thiourea 1%)	24.27	26.44	27.95	29.63	35.30	28.72	23.95	25.52	27.71	30.27	32.39	27.97
C6 (Thiourea 2%)	27.62	28.56	30.54	33.27	32.44	30.49	26.42	27.74	31.18	32.55	36.59	30.90
C7 (Control)	18.50	20.24	23.22	25.40	27.98	23.07	20.12	21.12	22.56	24.84	27.72	23.27
Mean	24.90	26.39	28.66	30.69	33.65	28.86	24.62	26.00	28.48	30.70	33.63	28.69
	T		**C**		**T × C**		**T**		**C**		**T × C**	
SEm (±)	0.313		0.371		0.829		0.316		0.374		0.836	
CD @ 5%	0.90		1.06		NS		0.90		1.07		NS	

(T_1 – control, T_2 – 48 hours soaking in water, T_3 – hot water treatment for 20 minutes + 48 hours soaking in water, T_4 – scarification + 48 hours soaking in water, T_5 - removal of seed coat + 48 hours soaking in water)

During 2020-21, among the physical treatments, T_5 (seed coat removal + 48 hours soaking in water) recorded highest seedling length (33.63 cm) followed by T_4 (scarification + 48 hours soaking in water) *i.e.,* 30.70 cm. The lowest seedling length was observed in case of control (24.62 cm). Among the chemical treatments, the seeds treated with GA_3 100 ppm recorded highest seedling length (32.52 cm) and the lowest was recorded in control (23.27 cm).Among the interaction between physical and chemical treatments, T_5C_1 recorded highest seedling length (38.13 cm) followed by T_5C_6 (36.59 cm) and the lowest was observed in T_1C_7 (20.12 cm).

In case of pooled analysis over the years, among the physical treatments, T_5 (seed coat removal + 48 hours soaking in water) recorded highest seedling length (33.64 cm) followed by T_4 (scarification + 48 hours soaking in water) *i.e.,* 30.70 cm. The lowest seedling length was observed in case of control (24.76 cm). Among the chemical treatments, the seeds treated with GA_3 100 ppm recorded highest seedling length (32.40 cm) and the lowest was recorded in control (23.17 cm).Among the interaction between physical and chemical treatments, T_5C_1 recorded highest seedling length (37.61 cm) followed by T_5C_2 (35.56 cm) and the lowest was observed in T_1C_7 (19.31 cm).

3.3 Seedling Dry Weight (mg)

The data presented in Tables 5 and 6 showed significant differences in seedling dry weight during 2019-20, 2020-21 and pooled analysis in case of physical and chemical treatments. However, the interaction effects were found non-significant.

Among the physical treatments, T_5 (seed coat removal + 48 hours soaking in water) recorded highest seedling dry weight (553.66 mg) followed by T_4 (scarification + 48 hours soaking in water) *i.e.,* 530.83 mg during 2019-20. The lowest seedling dry weight was recorded in case of control (420.47 mg). Among the chemical treatments, the seeds treated with GA_3 100 ppm recorded highest seedling dry weight (530.52 mg) which was at per with Thiourea 2% (510.76 mg) and the lowest was recorded in control (483.80 mg).Among the interaction between physical and chemical treatments, T_5C_1 recorded highest seedling dry weight (601.40 mg) which was at per withT_5C_6 (592.90 mg) and the lowest was recorded in T_1C_7 (364.60 mg).

During 2020-21, T_5 (seed coat removal + 48 hours soaking in water) recorded highest seedling dry weight (550.71 mg) and lowest was recorded in case of control (421.99 mg). Among the chemical treatments, the seeds treated with GA_3 100 ppm recorded highest seedling dry weight (525.52 mg) which was at per with Thiourea 2% (518.58 mg) & GA_3 200 ppm (505.08 mg) and the lowest was recorded in control (437.80 mg).Among the interaction between physical and chemical treatments, T_5C_1 recorded highest seedling dry weight (583.10 mg) which was at per with T_5C_2 (575.50 mg),T_5C_6 9570.80mg),T_4C_1 (576.70 mg) and T4C6 (567.00 mg) and the lowest was recorded in T_1C_7 (376.20 mg).

In pooled analysis, among the physical treatments, T_5 (seed coat removal + 48 hours soaking in water) recorded highest seedling dry weight (552.19 mg) followed by T_4 (scarification + 48 hours soaking in water) *i.e.,* 530.14 mg. The lowest seedling dry weight was recorded in case of control (421.23 mg). Among the chemical treatments, the seeds treated with GA_3 100 ppm recorded highest seedling dry weight (528.02 mg) which was at per with Thiourea 2% (514.67 mg) and the lowest was recorded in control (434.72 mg).Among the interaction between physical and chemical treatments, T_5C_1 recorded highest seedling dry weight (592.25 mg) followed by T_5C_6 (581.85 mg) and the lowest was recorded in T_1C_7 (370.40 mg).

3.4 Vigour Index –I

The data presented in Tables 7 and 8 showed significant differences in seedling vigour index- I during 2019-20, 2020-21 and pooled analysis in case of physical and chemical treatments and their interactions.

During 2019-20, among the physical treatments, T_5 (seed coat removal + 48 hours soaking) recorded highest vigour index- I (2610.38) followed by T_4 (scarification + 48 hours soaking) *i.e.,* 2153.97. The lowest vigour index- I was recorded in case of control (845.45). Among the chemical treatments, the seeds treated with GA_3 100 ppm recorded highest vigour index-I (2165.45) and the lowest was recorded in control (903.01).Among the interaction between physical and chemical treatments, T_5C_1 recorded highest vigour index-I (3447.35) followed by T_5C_3 (2778.18) and the lowest was recorded in T_1C_7 (460.66).

Table 4. Effect of different physical and chemical treatments on mean seedling length (cm) (Pooled)

	Pooled					
	T1	**T2**	**T3**	**T4**	**T5**	**Mean**
C1 (GA3 100 ppm)	27.76	29.12	32.44	35.09	37.61	32.40
C2 (GA3 200 ppm)	25.82	27.01	29.41	31.94	35.56	29.95
C3 (KNO3 1%)	23.14	25.23	27.18	29.07	32.72	27.47
C4 (KNO3 2%)	26.15	27.19	29.39	30.79	33.38	29.38
C5 (Thiourea 1%)	24.11	25.98	27.83	29.95	33.85	28.34
C6 (Thiourea 2%)	27.02	28.15	30.86	32.91	34.52	30.69
C7 (Control)	19.31	20.68	22.89	25.12	27.85	23.17
Mean	24.76	26.19	28.57	30.70	33.64	28.77
	T	**C**	**T x C**	**Y X T**	**Y X C**	**Y X T X C**
SEm (±)	0.222	0.263	0.589	0.315	0.372	0.833
CD @ 5%	0.62	0.74	NS	NS	NS	NS

(T_1 – control, T_2 – 48 hours soaking in water, T_3 –hot water treatment for 20 minutes + 48 hours soaking in water, T_4 – scarification + 48 hours soaking in water, T_5 - removal of seed coat + 48 hours soaking in water)

Table 5. Effect of different physical and chemical treatments on seedling dry weight (mg) during 2019-20 & 2020-21

	2019-20						2020-21					
	T1	**T2**	**T3**	**T4**	**T5**	**Mean**	**T1**	**T2**	**T3**	**T4**	**T5**	**Mean**
C1 (GA3 100 ppm)	464.70	491.50	536.70	558.30	601.40	530.52	460.20	481.30	526.30	576.70	583.10	525.52
C2 (GA3 200 ppm)	416.20	448.30	488.50	550.70	562.30	493.20	430.80	466.50	516.10	536.50	575.50	505.08
C3 (KNO3 1%)	406.10	417.70	480.50	521.10	539.70	473.02	386.30	436.90	464.90	509.10	521.50	463.74
C4 (KNO3 2%)	441.30	469.50	480.10	525.70	561.00	495.52	428.50	433.20	508.70	536.30	552.30	491.80
C5 (Thiourea 1%)	410.90	445.10	493.60	528.50	534.50	482.52	415.80	434.70	468.10	517.20	549.70	477.10
C6 (Thiourea 2%)	439.50	463.90	508.20	549.30	592.90	510.76	456.10	478.50	520.50	567.00	570.80	518.58
C7 (Control)	364.60	381.30	446.30	482.20	483.80	431.64	376.20	397.10	450.30	463.30	502.10	437.80
Mean	420.47	445.33	490.56	530.83	553.66	488.17	421.99	446.89	493.56	529.44	550.71	488.52
	T		**C**		**T × C**		**T**		**C**		**T × C**	
SEm (±)	6.589		7.797		17.434		6.406		7.580		16.949	
CD @ 5%	18.91		22.38		NS		18.39		21.75		NS	

Table 6. Effect of different physical and chemical treatments on seedling dry weight (mg) (Pooled)

	Pooled					
	T1	**T2**	**T3**	**T4**	**T5**	**Mean**
C1 (GA3 100 ppm)	462.45	486.40	531.50	567.50	592.25	528.02
C2 (GA3 200 ppm)	423.50	457.40	502.30	543.60	568.90	499.14
C3 (KNO3 1%)	396.20	427.30	472.70	515.10	530.60	468.38
C4 (KNO3 2%)	434.90	451.35	494.40	531.00	556.65	493.66
C5 (Thiourea 1%)	413.35	439.90	480.85	522.85	542.10	479.81
C6 (Thiourea 2%)	447.80	471.20	514.35	558.15	581.85	514.67
C7 (Control)	370.40	389.20	448.30	472.75	492.95	434.72
Mean	421.23	446.11	492.06	530.14	552.19	488.34
	T	**C**	**T x C**	**Y X T**	**Y X C**	**Y X T X C**
SEm (±)	4.595	5.437	12.158	6.498	7.689	17.193
CD @ 5%	12.95	15.33	NS	NS	NS	NS

(T_1 – control, T_2 – 48 hours soaking in water, T_3 –hot water treatment for 20 minutes + 48 hours soaking in water, T_4 – scarification + 48 hours soaking in water, T_5 - removal of seed coat + 48 hours soaking in water)

During 2020-21, among the physical treatments, T_5 (seed coat removal + 48 hours soaking) recorded highest vigour index- I (2609.95) followed by T_4 (scarification + 48 hours soaking) *i.e.,* 2151.99. The lowest vigour index- I was recorded in case of control (780.28). Among the chemical treatments, the seeds treated with GA_3 100 ppm recorded highest vigour index-I (2136.73) and the lowest was recorded in control (976.74).Among the interaction between physical and chemical treatments, T_5C_1 recorded highest vigour index-I (3372.99) which was at per with T_5C_6 (3185.03) and the lowest was recorded in T_1C_7 (439.36).

In pooled analysis, among the physical treatments, T_5 (seed coat removal + 48 hours soaking) recorded highest vigour index- I (2610.16) followed by T_4 (scarification + 48 hours soaking) *i.e.,* 2152.98. The lowest vigour index- I was recorded in case of control (812.16). Among the chemical treatments, the seeds treated with GA_3 100 ppm recorded highest vigour index-I (2151.09) and the lowest was recorded in control (939.87).Among the interaction between physical and chemical treatments, T_5C_1 recorded highest vigour index-I (3410.17) followed by T_5C_6 (2971.66) and the lowest was recorded in T_1C_7 (450.01).

3.5 Vigour Index – II

The data presented in Tables 9 and 10 showed significant differences in seedling vigour index- II during 2019-20, 2020-21 and pooled analysis in case of physical and chemical treatments and their interactions.

Among the physical treatments, T_5 (seed coat removal + 48 hours soaking) recorded highest vigour index- II (42997.74) followed by T_4 (scarification + 48 hours soaking) *i.e.,* 37034.44 during 2019-20. The lowest vigour index- II was recorded in case of control (14195.50). Among the chemical treatments, the seeds treated with GA_3 100 ppm recorded highest vigour index-II (35413.94) and the lowest was recorded in control (16734.98).Among the interaction between physical and chemical treatments, T_5C_1 recorded highest vigour index-II (55966.60) followed by T_5C_6 (50351.10) and the lowest was recorded in T_1C_7 (9102.80).

During 2020-21, among the physical treatments, T_5 (seed coat removal + 48 hours soaking) recorded highest vigour index- II (42476.59) followed by T_4 (scarification + 48 hours soaking) *i.e.,* 37030.07. The lowest vigour index- II was recorded in case of control (13326.99). Among the chemical treatments, the seeds treated with GA_3 100 ppm recorded highest vigour index-II (34324.86) which was at per with Thiourea 2% (32338.40) and the lowest was recorded in control (18338.28).Among the interaction between physical and chemical treatments, T_5C_1 recorded highest vigour index-II (51632.10) which was at per with T_5C_6 (49616.80) and the lowest was recorded in T_1C_7 (8252.40).

In case pooled analysis, among the physical treatments, T_5 (seed coat removal + 48 hours soaking) recorded highest vigour index-II (42737.16) followed by T_4 (scarification+ 48 hours soaking) *i.e.,* 37032.26. The lowest vigour index- II was recorded in case of control (13761.24). Among the chemical treatments, the seeds treated with GA_3 100 ppm recorded highest vigour index-II (34869.40) and the lowest was recorded in control (17536.63). Among the interaction between physical and chemical treatments, T_5C_1 recorded highest vigour index-II (53799.35)which was at per with T_5C_6 (49983.95) and the lowest was recorded in T_1C_7 (8677.60).

4. DISCUSSION

One of the most common germination inhibitor is hard and water impermeable seed coat for which the seeds of some species cannot germinate under favourable climate conditions or germination occurs in a delayed manner even if their embryos develop. Majority of the cucurbits have hard and water impermeable seed coats, which inhibits seed germination and causes dormancy. Although hard seed coat is a structure which protects the embryo from mechanical effects, it has negative impact on germination. The main inhibition to water and oxygen penetration inside the spine gourd seeds is the presence of hard seed coat. In seeds which underwent no treatment, very less germination is reported, whereas other physical treatments significantly increased the germination percent. Removal of seed coat was found most effective in increasing germination followed by scarification by sand paper. Removal of hard seed coat and scrapping the seed coat with sand paper allowed penetration of water and oxygen. Similar results were also confirmed by Heidari al., [7], Pandey et al., [8] and Chaodumrikul et al. [9]. Hot water treatment followed by soaking also had a positive effect on germination rate. This treatment might have softened the hard and thick seed coat, as a result of which, germination rate might have increased due to water and oxygen penetration inside the seeds. Similar finding was also reported by Rincon et al. [10] who observed that soaking the seeds in hot water induced seed germination.

Table 7. Effect of different physical and chemical treatments on seedling Vigour index-I during 2019-20 & 2020-21

	2019-20						2020-21					
	T1	**T2**	**T3**	**T4**	**T5**	**Mean**	**T1**	**T2**	**T3**	**T4**	**T5**	**Mean**
C1 (GA3 100 ppm)	1159.00	1404.84	1988.61	2827.44	3447.35	2165.45	1076.51	1257.92	2067.45	2908.76	3372.99	2136.73
C2 (GA3 200 ppm)	844.75	905.64	1665.01	2228.70	2671.76	1663.17	882.77	1032.63	1507.77	2105.66	2796.82	1665.13
C3 (KNO3 1%)	718.50	804.42	1358.79	1840.16	2778.18	1500.01	597.54	724.38	1250.56	1968.89	2666.62	1441.60
C4 (KNO3 2%)	921.44	903.59	1587.37	2263.46	2681.43	1671.46	854.90	1037.24	1727.92	2226.35	2272.41	1623.76
C5 (Thiourea 1%)	776.64	928.40	1552.65	2147.87	2453.64	1571.84	671.26	764.60	1303.18	2010.82	2299.44	1409.86
C6 (Thiourea 2%)	1037.13	1013.19	1756.36	2578.12	2758.28	1828.62	939.59	1165.90	1822.48	2602.58	3185.03	1943.12
C7 (Control)	460.66	507.72	872.57	1192.06	1482.02	903.01	439.36	559.25	967.92	1240.84	1676.31	976.74
Mean	845.45	923.97	1540.19	2153.97	2610.38	1614.79	780.28	934.56	1521.04	2151.99	2609.95	1599.56
	T		**C**		**T × C**		**T**		**C**		**T × C**	
SEm (±)	22.935		27.138		60.682		26.386		31.220		69.811	
CD @ 5%	65.83		77.90		174.19		75.74		89.62		200.39	

(T_1 – control, T_2 – 48 hours soaking in water, T_3 –hot water treatment for 20 minutes + 48 hours soaking in water, T_4 – scarification + 48 hours soaking in water, T_5 - removal of seed coat + 48 hours soaking in water)

Table 8. Effect of different physical and chemical treatments on seedling Vigour index-I (Pooled)

	Pooled					
	T1	**T2**	**T3**	**T4**	**T5**	**Mean**
C1 (GA3 100 ppm)	1117.76	1331.38	2028.03	2868.10	3410.17	2151.09
C2 (GA3 200 ppm)	863.76	969.14	1586.39	2167.18	2734.29	1664.15
C3 (KNO3 1%)	658.02	764.40	1304.68	1904.53	2722.40	1470.80
C4 (KNO3 2%)	888.17	970.42	1657.65	2244.91	2476.92	1647.61
C5 (Thiourea 1%)	723.95	846.50	1427.92	2079.35	2376.54	1490.85
C6 (Thiourea 2%)	988.36	1089.55	1789.42	2590.35	2971.66	1885.87
C7 (Control)	450.01	533.49	920.25	1216.45	1579.17	939.87
Mean	812.86	929.27	1530.62	2152.98	2610.16	1607.18
	T	**C**	**T x C**	**Y X T**	**Y X C**	**Y X T X C**
SEm (±)	17.480	20.683	46.249	24.721	29.250	65.406
CD @ 5%	49.29	58.32	130.42	NS	82.49	184.45

(T_1 – control, T_2 – 48 hours soaking in water, T_3 –hot water treatment for 20 minutes + 48 hours soaking in water, T_4 – scarification + 48 hours soaking in water, T_5 - removal of seed coat + 48 hours soaking in water)

Table 9. Effect of different physical and chemical treatments on seedling Vigour index-II during 2019-20 & 2020-21

	2019-20						2020-21					
	T1	**T2**	**T3**	**T4**	**T5**	**Mean**	**T1**	**T2**	**T3**	**T4**	**T5**	**Mean**
C1 (GA3 100 ppm)	19280.30	23852.90	32982.00	44987.90	55966.60	35413.94	17956.20	20706.20	33408.80	47921.00	51632.10	34324.86
C2 (GA3 200 ppm)	13563.00	14847.60	27901.10	39057.40	41636.00	27401.02	14898.10	18229.70	26211.10	34915.40	46066.20	28064.10
C3 (KNO3 1%)	12183.00	13128.90	23792.90	32248.70	46171.80	25505.06	10490.40	12631.10	21610.00	35364.00	42168.30	24452.76
C4 (KNO3 2%)	15634.40	15421.70	25389.10	39438.40	44025.60	27981.84	13893.50	16624.50	30635.20	38056.30	38415.30	27524.96
C5 (Thiourea 1%)	13148.80	15611.80	27332.80	38322.00	37155.30	26314.14	11632.40	13030.50	22077.20	34433.00	39013.60	24037.34
C6 (Thiourea 2%)	16456.20	16446.70	29212.50	42579.70	50351.10	31009.24	16165.90	20081.50	30433.00	45394.80	49616.80	32338.40
C7 (Control)	9102.80	9564.70	16722.60	22607.00	25677.80	16734.98	8252.40	10515.20	19374.00	23126.00	30423.80	18338.28
Mean	14195.50	15553.47	26190.43	37034.44	42997.74	27194.32	13326.99	15974.10	26249.90	37030.07	42476.59	27011.53
	T		**C**		**T × C**		**T**		**C**		**T × C**	
SEm (±)	519.085		614.190		1373.371		612.704		724.961		1621.062	
CD @ 5%	1490.07		1763.07		3942.36		1758.81		2081.05		4653.37	

(T_1 – control, T_2 – 48 hours soaking in water, T_3 –hot water treatment for 20 minutes + 48 hours soaking in water, T_4 – scarification + 48 hours soaking in water, T_5 - removal of seed coat + 48 hours soaking in water)

Table 10. Effect of different physical and chemical treatments on seedling Vigour index-II (Pooled)

	Pooled					
	T1	**T2**	**T3**	**T4**	**T5**	**Mean**
C1 (GA3 100 ppm)	18618.25	22279.55	33195.40	46454.45	53799.35	34869.40
C2 (GA3 200 ppm)	14230.55	16538.65	27056.10	36986.40	43851.10	27732.56
C3 (KNO3 1%)	11336.70	12880.00	22701.45	33806.35	44170.05	24978.91
C4 (KNO3 2%)	14763.95	16023.10	28012.15	38747.35	41220.45	27753.40
C5 (Thiourea 1%)	12390.60	14321.15	24705.00	36377.50	38084.45	25175.74
C6 (Thiourea 2%)	16311.05	18264.10	29822.75	43987.25	49983.95	31673.82
C7 (Control)	8677.60	10039.95	18048.30	22866.50	28050.80	17536.63
Mean	13761.24	15763.79	26220.16	37032.26	42737.16	27102.92
	T	**C**	**T x C**	**Y X T**	**Y X C**	**Y X T X C**
SEm (±)	401.515	475.078	1062.308	567.827	671.862	1502.330
CD @ 5%	1132.32	1339.78	2995.85	NS	1894.74	4236.77

(T_1 – control, T_2 – 48 hours soaking in water, T_3 –hot water treatment for 20 minutes + 48 hours soaking in water, T_4 – scarification + 48 hours soaking in water, T_5 - removal of seed coat + 48 hours soaking in water)

In the present investigation different chemicals such as GA_3, KNO_3 and thiourea were tested in combination with different physical treatments to know its effect on seed germination and seedling vigour. It was observed that GA_3 100 ppm recorded highest germination and produced vigourous seedlings. The lowest values were recorded in case of control. All the chemicals were found superior to control. This is due to the beneficial effect of these chemicals in breaking seed dormancy. Similar results were also reported by Devi and Selvaraj [11] in bitter gourd, Vijayaraghavan [12] in Bhendi and Panchbhai et al., [13] in spine gourd. The antagonism between growth promoters and naturally occurring germination inhibitors plays an important role in seed dormancy and the external application of gibberellin interacts with growth inhibitors in dormant seeds lowering the inhibitors concentration and facilitating germination by breaking seed dormancy at an early date [14] and increasing germination. Therefore dormancy in kakrol seeds seems to be controlled by the balance between inhibitors and promoters. The exogenous application of gibberellic acid might have shifted the balance towards promoter side there by breaking the seed dormancy. Further GA_3 at higher concentration (200 ppm) might have triggered alternative respiration which may be detrimental for seed germination resulting in lower percentage of germination. Similar results were also reported by Caisini and Salvadori [15] in jujuba, Vijayaraghavan [12] in Bhendi and Ram Asrey et al., [16] in muskmelon. Compared to control, the seeds treated with thiourea and KNO_3 showed higher germination, seedling length, dry weight and vigour. The stimulative effect of thiourea on seed germination can be attributed to a reduction of the preventive effect of seed coat and its cytokinin activity in overcoming inhibition. Similar results regarding the effects of thiourea on germination were recorded in some other species by Stidham et al., [17] & Agrawal and Dadlani [18]. Use of KNO_3 has been an important seed treatment in seed testing laboratories for many years without a good explanation for its action [19]. KNO_3 was found to be effective in breaking dormancy of many species [18].

Among the interaction effect, seed coat removed seeds soaked in water for 48 hours followed by GA_3 100 ppm treatment found superior than rest of the treatment combinations. Removing the seed coat with application of GA_3 100 ppm may have allowed the seeds to soak in a solution of gibberellic acid which promotes production of α-amylase enzyme which transmutes starch into its simple sugar units which transfer to the embryo to be used as food. This treatment combination favoured the seedling growth and the increase in seedling vigour index – I & II may be due to increased germination, seedling length and dry weight.

5. CONCLUSION

From the present investigation, it is concluded that, among different physical treatments, removal of seed coat followed by 48 hours soaking in water and in case of chemicals, GA_3 100 ppm treatment were found most effective in enhancing germination, seedling length, dry weight and seedling vigour. Among the interaction between physical and chemical treatments, seed coat removed seeds soaked for 48 hours followed by treatment with GA_3 100 ppm was found superior to others. Thus, thes treatments can be recommended for breaking seed dormancy and enhancing germination and seedling vigour in spine gourd.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Raj NM, Prasanna KP, Peter KV. *Momordica spp*. In kallo G. Berge Bo (Eds).Genetic improvement of vegetables crops. Pergamon Press; Oxford. 1993;239-243.
2. Rashid MM. Vegetables in Bangladesh (in Bengali). 1st Edn, Bangla Academy, Dhaka, Bangladesh.1976;494.
3. Rakh MS, Chaudhari SR.Literature survey of plant Momordica dioica Roxb. Wild. An update. Int. J Pharmacol Res Develop. 2010;1-8.
4. Basumatara P, Bora GC, Kalita UC, Saikia L and Deka NC. Variability and correlation studies in spine gourd (*Momordica dioica* Roxb.). Journal of Agriculture and Food Science. 2014 :77-81.
5. Rasul MG. Study on parthenocarpy and genetic divergence in kakrol (*Momordica dioica* Roxb.).Ph. D. Thesis. Kyushu University, Fukuoka, Japan; 2003.
6. Bewley JD and Black M. Seeds, Physiology of Development and Germination. Second Edition. New York, Plenum Press.1994.

7. Heidari M, Rahemi M and Daneshvar M. Effect of Mechanical, Chemical Scarification and Stratification on seed Germination of *Prunus scoparia* (Spach) and Prunus webbii (Spach) Vierh. American –Eurasian J. Agric. and Environ. Sci. 2008;3(1):114-117.
8. Pandey S, Devi C, Kak A, Khan YJ and Gupta V. Breaking seed dormancy in sweet gourd (*Momordica cochinchinensis*). Seed Sci. & Technol. 2013;41:133-136.
9. Chaodumrikul S, Kaewsorn P, Chulaka P and Chanprasert W. Breaking seed dormancy in smooth loofah (*Luffa cylindrica* (L.) M. Roem.) using scarification and dry heat treatment. Agriculture and Natural Resources. 2016;50:85-88.
10. Rincon R, Culebro N, Gutierrez FA and Dendooven L. Scarification of seeds of Acacia angustissima Mill Kuntze and its effect on germination. Seed Science and Technology.2003; 31:301-307.
11. Devi JR and Selvaraj JA. Effect of pre sowing treatment on germination and vigour in bittergourd (*Momordica charantia* L) cv. Co. 1. Seed Research. 1994;22(1):64-65.
12. Vijayaraghavan H. Effect of Seed treatment with plant growth regulators on bhendi (*Abelmoschus esculentus* L.) grown under sodic soil conditions. Madras Agricultural Journal.1999;86(4-6):247-249.
13. Panchbhai DM, Shirsat L and Jogdane NK. Effect of GA_3 and chemicals on germination, growth and yield of Spine gourd (*Momordica dioica* Roxb.). The Orissa Journal of Horticulture. 2005; 33(1):61-64.
14. Wareing PFJ, Staden V and Webb DP. Endogenous hormones in the control of seed dormancy. In Seed Ecology ed. Wheydecker, Butterworths, London. 1973; 145-155.
15. Casini E and Salvadori S .The germination of seeds of jujuba (*Zizyphus sativa*) and effect of gibberellic acid on seeds with and without endocarp. Review of Agricultural Subtropicals.1980;74:39-47.
16. Ram Asrey, Singh GN and' Shukla HS. Effect of seed soaking with gibberellic acid on growth and fruiting of muskmelon (*Cucumis melo* L.) .Haryana Journal of Horticultural Sciences. 2003;32(3-4):297-298.
17. Stidham ND, Ahoursing RM, Powell J and Claypool PL. Chemical scarification moist pre-chilling and thiourea effects on germination at 18 shoursub species. Journal of Range Management. 1980; 33:115-118.
18. Agrawal PK and Dadlani M. Techniques in Seed Science and Technology. South Asian Publishers New Delhi International Book Company Absecon Highlands. 1994;109-113.
19. Hartmann HT, Kester DE, Davies F Jr. and Geneve RL. Plant Propagation Principles and Practices. Sixth Edition. New Jersy, Prentice Hall; 1997.

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