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Influence of seed treatment and priming on growth performance of *Eryngium foetidum*

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Keywords

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seed treatment.

Abstract

Growth performance of *Eryngium foetidum* L. with different seed treatment and priming duration was studied at the field laboratory of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during November 2011 to June 2013. Treatment of seeds with growth regulator and priming of seeds enhanced seed germination in the field. Consecutive 96 hours soaking and drying (8 hours soaking and 4 hours drying - 8 times) of Bilatidhonia seeds treated with GA_3 500 ppm and Kinetin 50 ppm gave the maximum germination (57.61%) and enhanced germination (13.0 days). Chemicals (Tetracycline plus copper oxi-chloride had no significant effect on germination. Consecutive 72 to 96 hours soaking with growth regulator treatment showed better performance in the field and gave maximum biomass (39.4 t/ha). The untreated or pesticide treated seeds showed poor germination and growth performance.

Introduction

Eryngium foetidum L. is a high valued promising Horticultural crops belongs to the family Apiaceae which includes other culinary herb viz. parsley (*Petroselinum crispum*), celery (*Apium graveolens*) and parsnip (*Pastinaca sativa*). It is originated from tropical America, West Indies, Vietnam, Asam and Bangladesh (Nienga, 1995, Rashid, 1999, Rubatzky *et al*., 1999). It is known as many as 73 names in different countries such as *Eryngium*, Eringo, Bangladhonia, Bilatidhonia, Bandhonia, Long coriander, Spiny coriander, Mexican coriander, False coriander, Culantro, Cilantro, Shadobeni, Feetweed etc. (Sankat and Maharaj, 1996). Worldwide cultivation and consumption of this crop is rapidly increasing due to its higher aromatic, nutritive and medicinal value. In Bangladesh, it is a major cash crop in the eastern hilly areas and cultivation expanding other parts of the country. Farmers are very much interested to cultivate this crop as it gives a very high return ignoring the germination problem of *Eryngium* seeds. Low germination rate (6-10%) and un-uniform seed germinations as well as unavailability of adequate amounts of seeds also limit the cultivation of *Eryngium* (Moniruzzaman *et al.*, 2000). Higher seed rate (40 kg/ha) of Eryngium (*E. foetidum*) negatively affects the cost of cultivation (Moniruzzaman *et al*., 2002). To increase the germination, combined application of GA_3 (1000 ppm) and Kinetin (50 ppm) proved effective for enhancing seed germination up to 28.54% (Mozumder, 2009).

Increased seed germination may be increased farmers profitability reducing cost of production with lower seed rate. Moreover, more area can be cultivated with a limited amount of seed. Previously developed technology is not sufficient to increased seed germination near 100% inhibiting the negative effect of the germination by a chemical ‘Coumarin’ presents in *Eryngium* seeds (Ekpong, *et al.*, 2008). Researches are required for complete removal of ‘Coumarin’ and increased germination percentage as well as identifying proper priming duration. On the other hand, some seeds fails germinate due to pre germination fungus infestation. Seed treatment with appropriate fungicide might be helpful in preventing the germination failure. The present experiment was designed with an emphasis to increase germination with application of growth regulators (GA_3 and Kinetin) and pesticide with seed priming for lowering the coumarin level to decrease seed rate which will be cost effective in *Erygium* cultivation. Therefore, the experiment was conducted to increase the germination rate for better germination, growth and biomass production to increase farmer’s profitability decreasing the production (seed) cost in *Eryngium foetidum* cultivation.

Methodology

The experiment was conducted at Horticulture Field Laboratory of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during November 2011 to June 2013. The experiments comprised with two different factors such as growth regulator treatment and soaking duration. Eighteen treatment combinations of two factors viz. three seed treatment comprising growth regulator (GA_3 500ppm + Kinetin 50 ppm), pesticide (copper oxi-chloride 0.2% + tetracycline 1000 ppm) and control (distilled water) with six soaking levels viz. 0, 12, 24, 48, 72 and 96 hours soaking with 8 hours consecutive soaking and 4 hours drying was used in the experiments.

The 18 treatment combinations consisting of Factor A (Seed treatment) and B (Soaking duration) are :

Treatment combinations	Factor A: Seed treatment (C)	Factor B: Priming duration (D)
C_1D_1	: Distilled water	Control (No soaking)
C_1D_2	: Distilled water	12 hours
C_1D_3	: Distilled water	24 hours
C_1D_4	: Distilled water	48 hours
C_1D_5	: Distilled water	72 hours
C_1D_6	: Distilled water	96 hours
C_2D_1	: Growth regulator	Control
C_2D_2	: Growth regulator	12 hours
C_2D_3	: Growth regulator	24 hours
C_2D_4	: Growth regulator	48 hours
C_2D_5	: Growth regulator	72 hours
C_2D_6	: Growth regulator	96 hours
C_3D_1	: Pesticide	Control
C_3D_2	: Pesticide	12 hours
C_3D_3	: Pesticide	24 hours
C_3D_4	: Pesticide	48 hours
C_3D_5	: Pesticide	72 hours
C_3D_6	: Pesticide	96 hours

The experiment was laid out in a split plot design assigning seed treatment in the main plot and soaking duration in the sub plot with three replications. The unit plot size was 3×1m and total sub-plots were 54. The adjacent plots and neighboring blocks were separated by 0.5 m and 1.0 m wide drain, respectively. The experimental land was fertilized with decomposed cowdung @ 15 t/ha, 200 kg-N, 120 kg-P and 150 kg K (Islam *et al*., 2003). Seeds were finally soaked with different growth regulator solutions for one hour before sowing then dried in shade on newsprint paper for one hour to remove extra solution before sowing. Seeds of *Eryngium* was sown in December 27, 2011 by broadcasting and mixed with soil at 0.1-1.0cm depth. Bamboo with black mosquito net (2mm loop) covered light shade was be made to discard about 40-50% sunlight to ensure lengthy and succulent leaves (Moniruzzaman, 2002).

Weeding (5 times), irrigation and other cultural practices were done timely. Harvesting was done from the first week of May to third week of June with an interval of 20 days when the leaves became most succulent. Data on days to germination, number of seedlings, plant height, leaves per plant, leaf size, plant weight, harvested plants/m^2 total biomass were properly counted recorded. Plant dry weight were taken by drying 10 plants in oven at 72^0C for 72 hours and the average dry matter % was calculated. All the data were compiled properly and analyzed statistically by MS Excel, MSTAT-C Program and mean separation was done following the Duncan's Multiple Range Test (Zaman, *et al.* 1987).

Results and Discussion

Effect of chemical treatments

All the characters studied for the effect of chemical treatments on seed germination and performance of *Eryngium* were significant except root length, number of leaves/plant and leaf size. Plant growth regulator showed better performance in respect to seed germination (Table 1.a). Early germination (16.1 DAS = days after sowing) was found with growth regulator (GR = GA_3 500ppm + Kinetin 50ppm) treatment while control and pesticide treated plots took longer time (19.4 and 19.1 days, respectively). The application of growth regulator enhances the germination of Eryngium seeds is supported by the reports of Dutt *et al.* (2001) that increased seed germination in GA_3 treatment.

Table 1.a Effect of chemicals on germination of *Eryngium* seeds

Chemical treatment (C)	Days to first germination	Seedlings/m^2		Germination (%)		% GP increase	Harvested plants/m^2	Harvested plants (%)
		30 DAS	60 DAS	30 DAS	60 DAS			
Control	19.4a	408.2b	639.9b	16.46b	25.80b	0.00c	550.4c	88.74a
PGR	16.1b	681.6a	1057.0a	27.46a	42.62a	16.42a	813.8a	79.50b
Pesticide	19.1a	454.1b	746.4b	18.31b	30.10b	4.30b	638.9b	87.09a
Significance	**	**	**	**	**	*	**	**
CV%	5.15	7.75	7.88	7.75	7.88	10.52	8.12	3.23

Chemicals: PGR = Plant growth regulator (GA_3 500 ppm +Kinetin 50 ppm); Pesticide (Copper oxy-chloride +Tetracycline)

Means followed by same or without letter in a column are not differed significantly at 5% level. * and ** indicated the level of significance at 5% and 1% level, respectively.

Significantly higher number of seedlings was obtained at 30 and 60 days after sowing in the growth regulator treated plots. The maximum number of seedlings at 30 days 682/m^2 and 60 days 1057/m^2 were counted with growth regulators treated plots. Lower number of seedlings was obtained from the control (408 and 640 seedlings/m^2 at 30 and 60 days) in control which was statistically similar with pesticide treated plots (454 and 746 seedlings/m^2 at 30 and 60 days, respectively). The germination percentage was higher in growth regulator treated plots. The maximum germination percentage was 27.46 and 42.62 at 30 and 60 days after sowing, respectively, were obtained from the seeds treated with mixed solution of GA_3 500 ppm + Kinetin 50 ppm. Both control and pesticides treated plots gave significantly lower germination rate. The increase of germination percentage at 60 days after sowing was maximum (16.82%) where GA_3 and Kinetin was applied together. Nadafi *et al.* (2005) found the highest germination rate and percentage of *Teucrium polium* seeds at concentrations of 500–2500 ppm GA_3.

The cause of enhanced germination with GA_3 and Kinetin is enhanced amylase activity induced by applied GA_3 and Kinetin. Moraes *et al*. (1998) reported that coriander seeds germination increased when seeds were treated with gibberellic acid (GA_3 200 ppm). Samaan *et al.* (2000) reported that kinetin could increase seed germination replacing the effect of moist chilling. This result ensured the report of Khider (1999) that GA_3 promoted alpha-amylase activity which was further enhanced if GA_3 was applied together with Kinetin. Reducing sugars content increased as α-amylase activity increased. These reducing sugars are used for the development of new cell organelles during cell division for the growth of hypocotyl and epicotyl of embryo thus enhanced germination after imbibitions. Bewly and Black (1986) reported that kinetin promotes seed germination of dormant lettuce seeds in combination with low light and ethylene but most effectively in the presence of light and gibberellins. Application of gibberellins to hazel seeds causes an increase in total RNA synthesis, as detected by the incorporation radioactive precursors, apparently is promoted and on this basis it has been suggested that the growth regulator increases DNA template availability and RNA activity; i.e., gibberellins depresses certain genes. However, evidence that RNA synthesis is enhanced and no evidence that there is synthesis of RNA(s) essential for germination. Some stimulation of gibberellins of polyribosome formation and protein synthesis occurs in lettuce and charlock. Similarly, cytokinins increase RNA and protein synthesis especially when they overcome the inhibitory effects of ABA (Bewley and Black, 1986).

Harvestable plants/m^2 was significantly increased by the application of growth regulators (Table 1). The higher number of plant (813.8/m^2) was obtained from the application of GA_3 500 ppm plus kinetin 50 ppm while it was significantly lower in control treatment (550.4/m^2) and pesticide treatment (638.9/m^2). Higher harvestable plants from hormone treated plots might be the cause of increased seed germination. The percentage of harvested plants over germination gave the opposite to the germination percentage. The higher percentage of harvested plants were obtained from the control plot (88.74) closely followed by pesticide treated plots (87.09) and it was significantly lower in hormone treated plots (79.09) over number of seedling per unit area. This might be due to the cause of higher competition among the plants in densely populated plots that some plants were not attained at the harvestable size. Root length of *Eryngium* was not differed significantly due to growth regulator or pesticide application (Table 1.b). Roots are not the edible part of this crop but it is the important part that relates the growth of aerial parts of the plant that uptake nutrients and water from the soil and also regulated for water stress tolerance of the plant. Growth regulator or pesticides were not showed any significance on root growth rather than germination percentage.

Table 1.b Effect of chemicals on quantitative performances of *Eryngium*

Chemical treatment (C)	Root length (cm)	Number of leaves/plan t	Length of leaf (cm)	Width of leaf (cm)	Single plant wt. (g)	Dry matter (%)	Biomass (t/ha)
Control	15.5	6.9	17.4	2.05	4.28a	14.40a	3.33c
PGR	15.4	7.0	17.6	2.11	4.15ab	14.13b	4.73a
Pesticide	15.1	6.8	17.7	2.05	4.21b	14.23b	3.79b
Significance	NS	NS	NS	NS	*	*	**
CV%	3.63	1.39	1.74	2.76	1.65	1.02	8.32

PGR = Plant growth regulator (GA_3+Kinetin); Pesticide (Copper oxy-chloride +Tetracycline)
Means followed by same letter or without letter in a column are not differed significantly at 5% level. * and ** indicated the level of significance at 5% and 1% level, respectively.

Leaves per plant and size of leaf did not differed significantly with the application of growth regulators or pesticide (Table 1.b). Comparatively higher number of leaves (7.0) per plant and leaf width (2.11 cm) was found in growth regulator treated plot. The length of leaf was slight higher in pesticide treated plots (17.7 cm) compared to control (1.7.4 cm) and growth regulator treated plots (17.6 cm). Single plant weight was varied due to the application of growth regulator and pesticide. Control plot showed comparatively higher single plant weight (4.28 g) followed by chemical treatment 94.21 g) and it was lower in growth regulator treated plots (4.15 g). The mean of single plant weight was almost similar to the report of Mozumder *et al.*, (2007) who obtained 4.66 g per plant. Lower single plant weight was obtained when germination rates as well as number of plants were higher. The result seems that the single plant weight was varied due to the population density rather than the application of chemicals. Higher plant density lowered the single plant weight and dry matter (Table 2.1c). The maximum dry matter percentage (14.40) was obtained from the control plots while it was lower (14.13) in hormone treated plots which was statistically similar with fungicide treatment (14.23). The lower dry matter percentage in the hormone treated plots might be due to the rapid growth of densely populated plants that helps the plant remain more succulent at the time of harvest. Both plant growth regulator and fungicide treatment showed significant effect on total biomass production of Eryngium. Plant growth regulator treated plots gave the maximum (4.73 t/ha) biomass than control (3.33 t/ha) and fungicide treated plot (3.79 t/ha). Total biomass was higher where higher number of plants harvested from plant growth regulator treated plots than control.

Effect of Priming Duration

Most of the parameters except root length, leaf size and single plant weight were significantly varied due to the soaking duration in *Eryngium*. Gradual increase of soaking duration declined the germination period (Table 2.a). Control treatment took significantly longer period (22.1 DAS) for first germination while it required minimum time (14.6 DAS) when seeds were soaked for 96 hours. The cause of rapid germination in lengthy soaking might be the cause that longer time of soaking helps to imbibe sufficient water that helps in early germination.

Table 2.a Effect of seed soaking on germination of *Eryngium* seeds

Soaking duration (D)	Days to first germination	Seedlings/m^2		Germination (%)		% GP increased	Harvested plants/m^2	Harvested plants (%)
		30 DAS	60 DAS	30 DAS	60 DAS			
Control	22.1a	161.9f	308.4e	6.53f	12.44e	0.00e	285.0e	93.09a
12 hours (D_2)	20.1b	263.6e	543.4d	10.63e	21.91d	9.49d	484.0d	89.98b
24 hours (D_3)	18.9c	429.7d	721.8c	17.33d	29.10c	16.67c	616.8c	87.05c
48 hours (D_4)	17.8d	579.1c	978.9b	24.08c	39.48b	27.04b	809.8b	83.71d
72 hours (D_5)	15.7e	748.2b	1139.0a	30.18b	45.93a	33.50a	894.4a	79.31e
96 hours (D_6)	14.6f	887.0a	1195.0a	35.79a	48.19a	35.76a	916.4a	77.54e
Significance	**	**	**	**	**	**	**	*
CV%	8.12	3.63	1.39	1.74	1.76	10.25	8.12	3.23

Means followed by same letter or without letter in a column are not differed significantly at 5% level. * and ** indicated the level of significance at 5% and 1% level, respectively.

The number of seedlings/m^2 rapidly increased with the increase of soaking duration (Table 2.2a). Number of seedlings/m^2 was the higher at 30 (887) and 60 (1195) DAS in 96 hours soaking followed by 72 hours soaking (748 and 1139, respectively). Lower number of seedlings/m^2 at 30 (162) and 60 (308) DAS were obtained when seeds are not soaked. Longer time of soaking and changing water increase germination removing the germination inhibitor “coumarin” and increasing α-amylase activities that required for seed germination while higher coumarin levels present in un-soaked seeds inhibits germination. Higher seed germination percentage at 30 DAS (35.79) and 60 DAS (48.19) was observed when seeds were soaked for 96 hours closely followed by 72 hours soaking (30.18 and 45.93) and it was lower (6.53 and 12.44, respectively) in control. Long time soaking caused 35.76% more germination over un-soaked control. Number harvestable plant also higher in the plots where larger number of seedlings was germinated (Table 2.a). Higher number of harvested plants (916.4/m^2) was counted from 96 hours soaked plots closely followed by 72 hours soaking (894.4/m^2). The un-soaked control plot gave lower number of harvested plants (285/m^2). The percentage of harvested plants were declined with increasing seedling number. Higher harvest percent over seedlings in the respective plots (93.09) were count in control plots while it was lower (77.54) when the seeds soaked for longer period. Lower number of harvestable plant in higher seedling population might be the cause over crowding hampered proper development of plant to attain harvestable size of all plants. Because tiny plants were not harvested that were ultimately uncounted. Root length was not varied significantly due to different soaking duration. Root length ranged from 15.1 cm (control) to 15.5 cm (48 and 96 hours soaking).

Number of leaves per plant showed significant variation due to different time of soaking. Increased soaking time with higher number of seedling per unit area decreased number of leaves per plant. Control lot gave higher number of leaves per plant (7.13) while it was lower (6.74 and 6.79) in 72 and 96 hours soaking, respectively. Length of leaves did not show any variation due to soaking duration. Leaf length ranged 17.18 to 17.9 cm. Width of leaf showed significant variation among the treatments. Wider leaves (2.22 cm) produced from the un-soaked control while narrower leaves (1.96 cm) found in 96 hours soaking.

Table 2.b Effect of seed soaking on quantitative performance of Eryngium

Soaking duration (D)	Root length (cm)	Number of leaves /plant	Length of leaf (cm)	Width of leaf (cm)	Single plant wt. (g)	Dry matter (%)	Biomass (t/ha)
Control (D_1)	15.1	7.13a	17.18	2.22a	4.45	14.42a	1.81e
12 hours (D_2)	15.2	6.97b	17.39	2.23b	4.31	14.36a	2.98d
24 hours (D_3)	15.3	6.90bc	17.39	2.09c	4.28	14.32ab	3.71c
48 hours (D_4)	15.5	6.83cd	17.51	2.05d	4.17	14.21b	4.79b
72 hours (D_5)	15.4	6.74d	17.90	2.99e	4.10	14.18b	5.19a
96 hours (D_6)	15.5	6.79d	17.90	1.96f	4.05	14.03c	5.21a
Significance	NS	*	**	*	NS	*	**
CV%	3.63	1.39	1.74	2.76	1.65	1.02	8.32

Means followed by same letter or without letter in a column are not differed significantly at 5% level. * and ** indicated the level of significance at 5% and 1% level, respectively.

Single plant weight did not show any significance due to soaking duration (Table 2.b). Single plant weight ranged from 4.05 g (96 hours soaking) to 4.45g (control). A slight decreased was observed from control to higher soaking duration. The lower single plant weight in higher seed rates might be due the higher number of plants in higher seed rates resulted severe competition for space and nutrient. Dry matter percentages in harvested plants showed little but significant variation due to different soaking duration (Table 2.b). Higher dry matter percentage in harvested plant (14.42%) obtained from control closely followed by 12 hours soaking (14.36%) and it was lower (14.02%0 in 96 hours soaking. Soaking duration had a significant effect on biomass production of *Eryngium*. Increasing soaking duration increased the total biomass. Higher biomass production observed in 96 hours soaking (5.21 t/ha) closely followed by 72 hours soaking (5.19 t/ha) while it was much lower in un-soaked plots (that gave only 1.81 t/ha of biomass.

Combined effect of growth regulator and seed rate

The combined effect of seed treatment and soaking duration was significant in case of most of the characters except individual plant performances and dry matter percentage. Almost all the variations were depended on the number of harvestable plants that varied due to germination rates influenced by different treatment combinations.

Gradual increase of soaking duration with different seed treatment declined the germination period (Table 3.a). Control treatment took the longest period (23.7 DAS) for first germination while it required minimum time (13.0 DAS) when seeds were soaked for 96 hours woth grtowth regulator treatment. The cause of rapid germination in lengthy soaking might be the cause that longer time of soaking helps to imbibe sufficient water and growth regulator (GA & Kinetin) enhanced seed germination activating α- amylase in seeds during germination that helps in early germination.

The number of seedlings/m^2 increased with the application of growth regulator and increase of soaking duration and (Table 3.a). The maximum number of seedlings/m^2 was counted at 30 (1110) and 60 (1429) DAS in 96 hours soaking with GR treatment followed by 72 hours soaking (925 and 1374, respectively). The lowest number of seedlings/m^2 at 30 (107.7) and 60 (204) DAS were obtained when untreated seeds were not soaked.

Higher seed germination percentage at 30 DAS (35.79) and 60 DAS (48.19) was observed when seeds were soaked for 96 hours closely followed by 72 hours soaking (30.18 and 45.93) and it was lower (6.53 and 12.44, respectively) in control. Long time (96 hrs) soaking with growth regulator treatment caused 49.38% more germination over un-soaked control. Longer time of soaking and changing water increase germination removing the germination inhibitor "coumarin" and growth regulator increased α-amylase activities that increased seed germination. In this experiment the control plot also gave good seed germination (8.39%) which was higher than Moniruzzaman *et al.,* (2000) who obtained only 6-10% germination.

Number harvestable plant also higher in the plots where larger number of seedlings was germinated (Table 3.a). The maximum number of harvested plants (996.0/m^2) was counted from 96 hours soaked seeds treated with growth regulator closely followed by 72 hours soaking (989.8/m^2) with GR treatment. The un-soaked control plot gave the lowest number of harvested plants (192.8/m^2). The percentage of harvested plants showed the opposite trends with the number of harvested plants per unit area. Higher harvest percent over seedlings in the respective plots (95.12) were count in 12 hours soaked control treatment which was much closed to un-soaked control (94.57) while it was lower (69.09) when the seeds soaked for longer period with GR treatment. Lower number of harvestable plant in higher seedling population might be the cause of their severe competition for nutrient and spacing in very dense population that hinders some plants to attain harvestable size. As a result the percentage of un-harvested as well as uncounted plants was higher that lowered the harvest percentage over seedlings in well soaked and GR treated plots.

Table 3.a Combined effect of chemicals and seed priming on germination of Eryngium seeds

Treat-ments	Days to first germination	Seedlings/m^2		Germination (%)		% GP increase	Harvested plants/m^2	Harvested plants (%)
		30 DAS	60 DAS	30 DAS	60 DAS			
C_1D_1	23.7a	107.7j	204.0i	4.34j	8.23i	00.00i	192.8h	94.57a
C_1D_2	20.7cd	177.0ij	291.7i	7.14ij	11.77i	3.53i	277.7h	95.12a
C_1D_3	20.0cde	272.3h	515.0gh	10.99h	20.78gh	12.54gh	471.0fg	91.52ab
C_1D_4	19.7def	498.3f	807.7f	20.09f	32.58f	24.34f	702.0e	86.97b-f
C_1D_5	17.3gh	658.7e	963.3de	26.56e	38.84de	30.61de	802.8cd	83.22efg
C_1D_6	15.3ij	735.3d	1058.0cd	29.66d	42.67cd	34.43cd	856.7bc	81.07h
C_2D_1	20.0cde	258.0h	449.3h	10.40h	18.12h	9.89h	403.3g	89.69bc
C_2D_2	18.0fg	400.7g	880.7f	16.16g	32.29f	24.05f	715.0de	89.29bc
C_2D_3	16.0hi	625.7e	1075.0cd	25.23e	43.37cd	35.13cd	872.3bc	81.21gh
C_2D_4	15.3ij	770.0cd	1214.0b	31.05cd	48.96b	40.72b	926.8ab	76.40h
C_2D_5	14.0jk	925.3b	1374.0a	37.31b	55.39a	47.16a	989.8a	71.37i
C_2D_6	13.0k	1110.0a	1429.0a	44.76a	57.61a	49.38a	986.0a	69.09i
C_3D_1	22.7ab	120.0j	272.0i	4.84j	10.98i	2.74i	259.0h	95.02a
C_3D_2	21.7bc	213.0hi	538.0gh	8.59hi	21.70gh	13.46gh	459.3fg	85.52c-g
C_3D_3	20.7cd	391.0g	575.0g	15.78g	23.20g	14.96g	507.0f	88.41bcd
C_3D_4	18.3efg	523.0f	915.0ef	21.09f	36.90ef	28.67e	808.0cd	87.79b-e
C_3D_5	15.7hij	660.7e	1080.0cd	26.64e	43.56cd	35.32c	901.0ab	83.34d-g
C_1D_6	15.3ij	817.0c	1098.0bc	32.94c	44.29bc	36.06c	906.8ab	82.47fg
Signi,	**	**	**	**	**	**	**	**
CV%	5.15	7.75	7.88	7.75	7.88	10.52	8.12	3.23

Means followed by same letter or without letter in a column are not differed significantly at 5% level. * and ** indicated the level of significance at 5% and 1% level, respectively.

Root length was not varied significantly due to the combined effect of soaking duration and seed treatment. Root length ranged from 15.0 cm to 15.7 cm. Number of leaves per plant as well as leaf size showed insignificant variation due to combined effect of time of soaking and seed treatment. Number of leaves per plant ranged from 6.7 to 7.2 per plant. Leaf length and width ranged from 17.1 to 18.1cm and 1.92 to 2.24cm, respectively. Single plant weight did not showed any significance due to combined effect of seed treatment and soaking duration. Single plant weight ranged from 3.98 g to 4.54g (control). A slight decreased was observed from control to higher soaking duration. The lower single plant weight in GR treated and full soaked treatment might be due the higher number of plants per unit area resulted thinner pants. Dry matter percentages in harvested plants showed little but insignificant variation due to combined effect of seed treatment and different soaking duration (Table 3.b).

Table 3.b Combined effect of chemicals and seed priming on quantitative performance of Eryngium

Treatments	Root length (cm)	Number of leaves /plant	Length of leaf (cm)	Width of leaf (cm)	Single plant wt. (g)	Dry matter (%)	Biomass (t/ha)
C_1D_1	15.4	7.2	17.2	2.21	4.54	14.65	1.28e
C_1D_2	15.3	6.9	17.3	2.11	4.36	14.49	1.75e
C_1D_3	15.5	6.9	17.4	2.05	4.26	14.47	2.90d
C_1D_4	15.3	6.8	17.3	2.01	4.26	14.27	4.27c
C_1D_5	15.7	6.7	17.7	1.96	4.16	14.40	4.82bc
C_1D_6	15.7	6.8	17.6	1.95	4.10	14.11	4.96ab
C_2D_1	15.2	7.2	17.2	2.24	4.43	14.25	2.52d
C_2D_2	15.4	7.1	17.4	2.16	4.27	14.26	4.35c
C_2D_3	15.3	7.0	17.6	2.12	4.16	14.27	5.17ab
C_2D_4	15.4	6.9	17.4	2.08	4.09	14.07	5.32ab
C_2D_5	15.4	6.8	17.9	2.03	4.02	13.99	5.51a
C_2D_6	15.7	6.8	18.0	2.02	3.98	13.92	5.46a
C_3D_1	15.7	7.0	17.1	2.20	4.37	14.35	1.63e
C_3D_2	15.0	6.9	17.4	2.14	4.31	14.33	2.84d
C_3D_3	15.1	6.8	17.4	2.08	4.24	14.22	3.06b
C_3D_4	15.7	6.8	17.9	2.05	4.16	14.29	4.76bc
C_3D_5	15.2	6.7	18.1	2.01	4.10	14.14	5.23ab
C_3D_6	15.0	6.8	18.1	1.92	4.08	14.04	5.20ab
Signi.	NS	NS	NS	NS	NS	NS	**
CV%	3.63	1.39	1.74	2.76	1.65	1.02	8.32

PGR = Plant growth regulator (GA_3+Kinetin); Pesticide (Copper oxy-chloride +Tetracycline)
Means followed by same letter or without letter in a column are not differed significantly at 5% level. * and ** indicated the level of significance at 5% and 1% level, respectively.

The dry matter percentage in harvested plant ranged from 13.98 to 14.65. Seed treatment and Soaking duration had a significant combined effect on biomass production of *Eryngium*. Increasing soaking duration increased the total biomass in all seed treatment combinations. The maximum biomass production observed in GR treated 72 hours (C_2D_5) priming (5.51 t/ha) closely followed by 96 hours priming (5.46 t/ha) while it was much lower in un-soaked plots that gave only 1.28 t/ha of biomass.

Conclusion

Growth regulator treatment (GA_3 500 ppm and kinetin 50 ppm) with 72 hours priming gave the highest seed germination and biomass yield of *Eryngium* that reduced about 75% seed cost thus increase profit.

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