Original Article:

Response of *Imperata cylindrica* (L.) weed Seeds germination to some environmental factors

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ABSTRACT

Halfa or cogongrass (*Imperata cylindrica* L.) is one of the noxious/problematic species which not only threatens agriculture productivity, but also causes environmental damage to the ecosystem, whereas the invasive alien weeds are affected greatly by seed germination that depends on the temperature and light as well as other environmental factors. Therefore, the germination behavior of *I. cylindrica* at the optimum temperature regimes (25/35 °C) was chosen to test the effect of different light regimes, some growth regulators i.e. indole butyric acid (IBA), gibberellic acid (GA3), and naphthalene acetic acid + naphthalene acetamide (NAA + NAD), and chemical substances i.e. Potassium nitrate (KNO_3) and Si-Si-6, acetic acid on seed germination of cogon grass (*I. cylindrica*). The higher germination percent of *I. cylindrica* seeds was observed after soaking for 12 hours in the growth regulators at 200, 800, 400, and 1000 ppm which exhibited germination of 56.67, 71.11, 73.33, and 56. 67% after soaking in gibberellic acid and 65.56, 71.11, 73.33, and 56.67% after soaking in indole butyric acid, respectively under 16/8 hours of light/darkness. The maximum germination of *I. cylindrica* seeds (22.44%) was also achieved after exposure to 1% acetic acid for 1min. under 16/8 h light/ dark and the same temperature, while the greater level of germination (55.56% and 35.56%) was attained after 12 h. soaking in 10% from Si-Si-6 (Potassium sulphonate 10% SL) and KNO_3, respectively. It can be concluded that *I. cylindrica* germination rate depends on the environmental factors and its time of exposure which are the driving force for changes in *I. cylindrica* seed dormancy. This information could help in preventing and predicting their invasion as well as may lead to improving its management strategies.

Introduction

Imperata cylindrica (L.) is a serious perennial weed belonging to the family Poaceae (Chikoye *et al.*, 2006), designated as the tenth worst weed in the world (Rusdy, 2020). It is one of the world's 36 worst Invasive plant species (IPS) and has a high potential for expanding within biodiversity hotspots and threatening global plant diversity. *Imperata cylindrica* is one of the ten worst global invasive plants and is reportedly established on more than 500 million hectares in tropical and subtropical climates. Infestations reduce landscape biodiversity prevent, forest recreation and hunting, hinder forest regeneration, and present an extreme fire hazard (Bryson and Carter, 1993; Dozier *et al.*, 1998). It is resulting in significant losses impoverishes the soil decreases productivity and severely retards growth crops (oil palm, rubber, and cocoa), a warmer region is one of the most noxious widely considered (Mangoensoekarjo and Kadnan, 1976). It is invading the forest lands of the USA threatening their ecological and economic integrity (Ramsey *et al*., 2003). *I. cylindrica* is given of 41 insect species (belonging to families and orders) (Tawfik *et al*., 1974). It causes demonstrates the existence of allergic contact dermatitis from grass (Koh *et al.*, 1997). This can directly reduce crop yield accounting for between 62 and 90% yield reduction in Maize, and 28.5 to 52.6% yield reduction in soybean (Avav, 2000; Chikoye *et al*., 2001). *I. cylindrica* was the host, which harbored all insect stages in Upper Egypt governorates (Abdel-Moniem, 2003). Cogongrass extracts may contain allelochemicals that may contribute to its invasiveness and extreme competitiveness (Koger and Bryson, 2004). Three new Aceria species of eriophyoid mites were collected from *I. cylindrica* (L.) in Egypt (Ashraf *et al*., 2018). Cogongrass is a problematic weed which causes significant losses in cultivated and non-cultivated areas and is difficult to control (Mohamad *et al.,* 2011).

Cogongrass is readily adaptable to a wide range of environmental conditions (Holzmueller and Jose, 2010), though it is mostly favoring acidic soils (Collins *et al*., 2007). It adapts to a wide variety of soil types and can form stout, extensively creeping, it has the leaves originate directly from the ground level and linear to lanceolate leaves as well as the length range from one to four feet (Bhaskar Datta and Dey, 2010). Cogongrass has a light compensation point of 32 to 35 mol.m^{-2} s^{-1}(approximately 2% full sunlight) indicating the ability to survive as an understory species. This would explain its ability to both rapidly invade deforested areas and persist in plantation crops (Ramsey *et al*., 2003). Although it is a sun-loving species, it can be found in areas with low levels of sunlight, such as dense forests, and it can survive temperatures as low as −14°C (6.8°F) (Wilcut *et al*., 1988). Temperature markedly affects shoot and rhizome growth, with increased growth occurring at 29º/23ºC (day/night), compared to lower temperatures (Patterson *et al*., 1980). Cogongrass seedlings tend to emerge in groups and seeds require light for germination (Burnell *et al.,* 2003). The root morphology characteristics allowed it to be a great competitor species identity could be more important than species or functional richness in determining community resistance to invasion and is the root and rhizome system often composes 60% or more of the total plant biomass and is found in the upper 15–40 cm of soil (Daneshgar and Jose, 2009). Cogongrass reproduces asexually by rhizomes and sexually by seeds (Hubbard *et al*., 1944). It is propagated by rhizomatous (stem parts underground) (Perera and Nilanthi, 2015). The fragmentation of rhizomes increased the regenerative potential of *I. cylindrica* and the age and the length of the rhizome affected the regenerative capacity (Omezine and Skiri-Harzalla, 2009). *Imperata cylindrica* rhizomes revealed greater sprouting (82.5%) under a light/dark regime compared with only 10% sprouting in continuous darkness (Hamidavi *et al*., 2021). Cogongrass produces as many as 3,000 seeds per plant sexually produced seeds are capable of long-distance dispersal, ranging from an average of 15 m to 100 m (Holm *et al.*, 1977). Having no dormancy, seeds are highly germinable within three months after maturity (Shilling *et al.*, 1997). *I. cylindrica* seeds had germination of 84.5% after 3 weeks under alternating temperatures of 15/35ºC (Lee, 1978). While, the optimum temperature for germination was found to be 30ºC. (Dickens and Moore, 1974).

This study hypothesized that growth regulators and environmental factors-mediated seed germination of *I. cylindrica* germination. Consequently, the invasion prediction should need to accurately calculate their seed germination and rates under different environmental conditions. Therefore, understanding their ecological requirement is needed to reduce their germination and prevent their invasion. Therefore, the study was designed to determine the requirement for *I. cylindrica* germination under the optimum temperature from light regimes and supportive growth regulators and chemical substances.

Materials and Methods

1- Plant materials and seed preparations

Seed of *Imperata cylindrica* populations was collected from various locations in the Toshka region, South of Egypt and preserved at Desert Research Center, Egypt. The seeds were subject to sterilizing before use with bleach (0.5% sodium hypochlorite) for 2 minutes, then it was washed multiple times with distilled water followed by sterile water to get rid of the bleach residues. The viability of *I. cylindrica* seeds was tested with Triphenyl Tetrazolium Chloride according to the International Seed Testing Association (1999). Caryopses were allowed to imbibe water for 16 hours at 25°C, then after punctured and soaked in 0.5% TZ solution for 3 hours at 40°C in the dark. Caryopses were dissected longitudinally, and then they were inspected under a dissecting microscope to determine tissue viability (Grabe, 1970).

2. Seed germination of I. cylindrica responses to plant growth regulators

The study assesses the influence of light on the germination of *Imperata cylindrica* seeds and some growth regulators. The germination experiments are taken by setting the incubators at alternative temperatures of 25/35°C + 2°C and one from the three light /dark regimes. The seed sets were soaked in some chemical for 12, 24, and 48 hours of indole butyric acid (IBA), gibberellic acid (GA_3), and naphthalene acetic acid + naphthalene acetamide (NAA + NAD) at 200, 400, 800, and 1000 ppm. Then, all treatments were kept at temperatures of 25/35°C, 16/8 h light/dark, 12/12 h light/dark, and 8/16 h light/dark, 70-80% humidity in a growth chamber. The number of germinated seeds was counted every day for 3 weeks at the same time. Final seed germination was reported and the control which seeds soaked in distilled water was incubated at the same condition after 3 weeks.

3. Seed germination of I. cylindrica requirements and responses

Thirty sterilized seeds of *I. cylindrica* with 0.5% sodium hypochlorite were placed in each glass Petri dish 11 cm with two layers of filter paper at the dish bottom as the culture bed and incubated at the germinator in three repetitions. The seed sets were soaked in some chemicals for 12, 24, and 48 hours. These chemicals are Potassium nitrate (KNO_3) and Si-Si-6 (Potassium sulphonate 10%SL), it is an anionic surfactant prepared by Dr. A.a. El-Sisi (Agriculture Research Center) by neutralization of sulphonic acid with potassium alkaline) at 5, 10, 15, and 20%, while acetic acid (CH_3COOH) at 1, 5, 10, and 20% was soaked for 1, 5, 10 minute, respectively. Then, all treatments were kept at temperatures of 25/35°C, 16/8 h light/dark, 12/12 h light/dark, and 8/16 h light/dark, 70-80% humidity in a growth chamber. The number of germinated seeds was counted every day for 3 weeks at the same time. The control which seeds soaked in distilled water incubated at the same condition after 3 weeks.

4. Statistical analysis

To calculate the parameters of light exposure under one alternative temperature regime, each treatment was repeated at least once in five replications. The data were taken for analysis via a three-way ANOVA of temperature, light, and other treatments in SPSS IPM19. While Tukey tests were chosen for multiple comparisons when the results of variance homogeneity were ≤ 0.05 for light and chemical promoters to compare the treatments.

Results and Discussion

1. Viability of Imperata cylindrica seeds

Seeds of this species were subjected to stain and germination to investigate their viability, and thus the results revealed that seeds viability ranged from 22.23 to 42.96%. However**,** the non-viable seeds ranged from 57.04 to 77.78% which didn't stain with any color (Table 1 and Figure 1).

Table 1. Viability of *I. cylindrica* under different light regimes

Light regimes	Viable seeds	Non-viable seeds
16/8h light/ dark	42.96±2	57.04±1.5
12/12h light/ dark	28.52±4	71.48±3
8/16h light/ dark	22.23±3	77.78±2

16/8 h light/ dark

Figure 1. Viability of *I. cylindrica* seeds collected from the Toshka region

2. Effect of some plant growth regulators on seed germination of I. cylindrica under different light/ dark regimes

2.1 Effect of some plant growth regulators on seed germination of I. cylindrica an under light under 16/8 h light/ dark conditions

After 12 hours of exposure to plant growth regulators of indole butyric acid (IBA), gibberellic acid (GA3), and naphthalene acetic acid + naphthalene acetamide (NAA + NAD), *I. cylindrica* seeds germinated at 25/35 °C+2 °C temperature and 16/8 h light/dark. The highest degree of germination achieved by GA3 at 800 ppm considerably enhanced seed germination by 73.33%. The minimal seed germination was produced at 1000 ppm by 56.67%, as compared to the control. When compared with the control, the maximum germination of GA3 at 800ppm was 72.22% after 24 hours. The lower induced by 1000 ppm had seed germination by 55.56%. After 48 hours, the greater germination was attained from GA3 at 400 ppm by 68.81%. In contrast, the lower germination showed at 1000 ppm by 52.22% higher than the control (Table 2).

Seeds of this species were exposed to IBA for 12 hours, and the maximum germination of *I. cylindrica* was obtained from IBA at 200 ppm, which increased germination by 65.56%, nevertheless IBA at 1000 ppm established the lower germination by 46.67%, as compared with the control. The high level of germination achieved from IBA at 200 ppm was 61.11% after 24 hours, whereas the lower level of germination achieved from IBA at 1000 ppm by 45.56%, as compared to the control. The maximum germination achieved with IBA at 200 ppm reached 57.77% after 48 hours. However, the lower seed germination was found at 1000 ppm by 42.22% as compared with the control.

When seeds were exposed to NAA+NAD for 12 hours, a higher level of germination of *I. cylindrica* was achieved from NAA+NAD at 400 ppm, which holds seed germination by 58.89%, but the minimum seed germination at 1000 ppm significantly increased seed germination by 45.44% when compared with the control. After 24 hours, NAA+NAD at 400 ppm produced the higher seed germination reaching 57.78%, but NAA+NAD at 1000 ppm produced the lower seed germination by 44.44% rather than the control. When compared with the control, the maximum germination attained from NAA+NAD at 400 ppm was 54.44%, while the lower seed germination at 1000 ppm was 36.66%. Within the treatment and concentration groups, the interaction effect was significant ($F = 3.21$, P 0.04).

Table 2. Effectiveness of some plant growth regulators on seed germination of *I. cylindrica* under 16/8 h light/ dark conditions after 3 weeks

Temp	Light	Soaking Time h.	Conc. ppm	GA3		IBA		NAA+NAD		Control	
				mean	G%	mean	G%	Mean	G%	mean	G%
25/35° C±2°C.	16/8h light/ dark	12h.	200	17.00[a]	56.67	19.67[a]	65.56	14.00[b]	46.67	13.33[b]	44.44
			400	21.33[a]	71.11	18.00[a]	60.00	17.67[a]	58.89		
			800	22.00[a]	73.33	15.33[b]	51.11	17.00[ab]	56.67		
			1000	17.00[a]	56.67	14.00[b]	46.67	13.33[b]	45.44		
		24h.	200	16.67[a]	55.56	18.33	61.11	13.67[b]	45.56	13.00[b]	43.33
			400	20.33[a]	67.78	17.67[a]	58.89	17.33[ab]	57.78		
			800	21.67[a]	72.22	15.00[b]	50.00	16.67[a]	55.56		
			1000	16.67[a]	55.56	13.67[b]	45.56	13.33[b]	44.44		
		48h.	200	16.00[b]	53.33	17.33[a]	57.77	13.00[b]	43.33	12.33[b]	41.11
			400	21.33[a]	68.81	16.33[ab]	54.44	16.33[ab]	54.44		
			800	20.33[a]	67.77	14.00[b]	46.66	15.67[ab]	52.22		
			1000	15.67[b]	52.22	12.67[b]	42.22	11.00[b]	36.66		
F(p value)						2260.422(0.00)					
Treat.						0.758(0.47)					
Conc.						3.42(0.02)					
Time						3.21(0.04)					
Treat * Conc.						0.14(0.99)					
Treat * time						0.25(0.90)					
Conc. * Time						0.000					
Treat * Conc. * Time						0.000					

2.2 Effect of some growth regulators on seed germination of I. cylindrica under 12/12h light/ dark condition

Table (3) illustrates the germination of *I. cylindrica* at temperatures of 25 /35°C + 2°C and 12/12 h light/dark. After 12 hours, soak in indole butyric acid (IBA), gibberellic acid (GA3), and naphthalene acetic acid + naphthalene acetamide (NAA + NAD) plant growth regulators. The high level of germination obtained from GA3 at 800 ppm presented considerably increased seed germination by 61.11%, whereas the lower level of germination obtained from GA3 at 200 and 1000 ppm dramatically produced seed germination by 48.89%, when compared with the control. The major germination from GA3 at 800 ppm was 58.89% after 24 hours, while the lower was 200 ppm by 46.67%. The maximum germination of *I. cylindrica* obtained from GA3 at 400 ppm was 54.44% after 48 hours, whereas the lower was 1000 ppm by 40.0% as compared with the control.

The greater level of *I. cylindrica* germination achieved from IBA at 200 ppm had seed germination by 56.67%, whereas the minimum seed germination at 1000 ppm accomplished germination significantly by 36.67%. After 24 hours, IBA at 200 ppm resulted in the higher germination reaching 54.44 %, whereas IBA at 1000 ppm resulted in the lower seed germination reaching 34.44%. In comparison with the control, the greater germination of *I. cylindrica* achieved from IBA at 200 ppm was 51.11% after 48 hours, while the lower germination hold at 1000 ppm was 26.67% as compared with the control.

The findings after soaking for 12 hours with NAA+NAD revealed that NAA+NAD at 400 and 800 ppm presented seed germination by 50.0 and

50.0%, while the minimum seed germination at 1000 ppm by 37.78% was much lower than the control. After 24 hours, the maximum germination from NAA+NAD at 400 and 800 ppm was 47.78% and 47.78%, while the lower germination was at 1000 ppm reaching 35.56%, when compared with the control. The greater germination attained from NAA+NAD at 400 & 800 ppm was 44.44 & 44.44%, while the lower seed germination at 1000 ppm was 33.33%, as compared with the control.

Table 3. Effectiveness of some growth regulators on seed germination of *I. cylindrica* under 12/12 h light/ dark condition

Temp	Light	Soaking Time h.	Conc. ppm	GA3 Mean	GA3 G%	IBA Mean	IBA G%	NAA+NAD Mean	NAA+NAD G%	Control Mean	Control G%
25/35° C±2°C .	12/12 h light/ dark	12h.	200	14.67[a]	48.89	17.00[a]	56.67	11.67[b]	38.89	9.33[b]	31.11
			400	18.00[a]	60.00	16.00[a]	53.33	15.00[a]	50.00		
			800	18.33[a]	61.11	13.00[b]	43.33	15.00[a]	50.00		
			1000	14.67[a]	48.89	11.00[b]	36.67	11.33[b]	37.78		
		24h.	200	14.00[ab]	46.67	16.33[a]	54.44	11.00[b]	36.67	8.67[b]	28.89
			400	17.33[a]	57.78	15.33[a]	51.11	14.33[ab]	47.78		
			800	17.67[a]	58.89	12.33[b]	41.11	14.33[ab]	47.78		
			1000	14.33[ab]	47.78	10.33[b]	34.44	10.67[b]	35.56		
		48h.	200	13.00[ab]	43.33	15.33[a]	51.11	10.00[b]	33.33	7.67[b]	25.56
			400	16.33[a]	54.44	14.00[ab]	46.67	13.33[ab]	44.44		
			800	15.33[a]	51.11	11.33[b]	37.78	13.33[ab]	44.44		
			1000	12.00[b]	40.00	8.00[b]	26.67	10.00[b]	33.33		
F(p value)						1634.533(0.00)					
Treat.						3.22(0.04)					
Conc.						3.01(0.03)					
Time						1.35(0.26)					
Treat * Conc.						0.04(1.00)					
Treat * time						0.05(0.99)					
Conc. * Time						-					
Treat * Conc. * Time						-					

2.3 Effect of some plant growth regulators on seed germination of I. cylindrica under light under 8/16 h light/ dark condition

Table (4) indicates how *I. cylindrica* germinated at 25 /35 °C +2 °C temperature and under 8/16 h light/dark conditions in the presence of growth regulators. After 12 hours of soaking in plant growth regulators such as indole butyric acid (IBA), gibberellic acid (GA3), and naphthalene acetic acid + naphthalene acetamide (NAA + NAD), when compared with the control, the higher degree achieved by GA3 at 400 ppm resulted in 43.33% of seed germination, while the lower achieved by GA3 at 200 and 1000 ppm resulted in 30.00% of seed germination. After soaking for 24 h, the maximum germination achieved from GA_3 at 400 ppm increased significantly by 38.89%, while the lower seed germination at 200 and 1000 ppm by 25.56 and 25.56 %, respectively. After 48 hours, the maximum germination achieved from GA_3 at 400 ppm by 36.67%, while the lower seed germination at 1000 ppm reached 17.78% as compared with the control.

After soaking the seed for 12 hours in IBA, the higher degree of *I. cylindrica* germination was attained at 200 ppm, which had seed germination by 37.78%, while the minimum seed germination at 1000 ppm reached 24.44%, as compared with the control.

The maximum attained from IBA at 200 ppm by 33.33% of seed germination after 24 hours of soaking, whereas the lower germination at 1000 ppm increased by 20.00 %. After 48 hours, the maximum germination attained from IBA at 200 ppm resulted in a 31.11% in seed germination, while the lower level exhibited at 1000 ppm resulted in a 15.56% of seed germination.

Table 4. Effectiveness of some plant growth regulators on seed germination of I. cylindrica under 8/16 h light/ dark condition

Temp.	Light	Time h.	Conc. ppm	GA_3		IBA		NAA+NAD		Control	
				mean	G%	mean	G%	mean	G%	mean	G%
25/35 °C ±2 °C	8/16 h light/ dark	12h.	200	9.00^{a}	30.00	11.33^{a}	37.78	6.67^{bc}	22.22		
		12h.	400	13.00^{a}	43.33	10.33^{a}	34.44	11.33^{a}	37.78		
		12h.	800	12.67^{a}	42.22	8.67^{ab}	28.89	11.00^{a}	36.67		
		12h.	1000	9.00^{ab}	30.00	7.33^{b}	24.44	6.67^{bc}	22.22	7.67^{ab}	25.56
		24 h.	200	7.67^{b}	25.56	10.00^{a}	33.33	5.33^{c}	17.78		
		24 h.	400	11.67^{a}	38.89	9.00^{ab}	30.00	9.67^{a}	32.22		
		24 h.	800	11.33^{a}	37.78	7.33^{bc}	24.44	9.67^{a}	32.22	6.33^{c}	21.11
		24 h.	1000	7.67^{b}	25.56	6.00^{c}	20.00	5.33^{c}	17.78		
		48 h.	200	7.00^{bc}	23.33	9.33^{ab}	31.11	4.67^{c}	15.56		
		48 h.	400	11.00^{a}	36.67	8.33^{ab}	27.78	9.00^{ab}	30.00		
		48 h.	800	10.67^{a}	35.56	7.00^{bc}	23.33	5.67^{c}	18.89	6.00^{c}	20.00
		48 h.	1000	5.33^{c}	17.78	4.67^{c}	15.56	6.00^{c}	20.00		
F(p value)							1307.282(0.00)				
Treat.							7.45(0.00)				
Conc.							7.15(0.00)				
Time mash							0.62(0.54)				
Treat * Conc.							0.25(0.95)				
Treat * time							0.33(0.85)				
Conc. * Time							-				
Treat * Conc. * Time							-				

When comparing the results of germination after soaking the seed for 12 hours in NAA+NAD, the greater degree of *I. cylindrica* germination was attained at 400 ppm reaching 37.78%, while the minimum level of germination was observed at 200 and 1000 ppm by 22.22%. After 24 hours, the maximum germination attained from NAA+NAD at 400 and 800 ppm was 32.22%, whereas the lower germination was 17.78 and 17.78% at 200 and 1000 ppm, respectively. After soaking for 48 hours, the maximum germination from NAA+NAD at 400 ppm was 30.00p%, while the lower germination was 15.56% at 200 ppm as compared with the control.

3. Effect of some chemical substances on seed germination of I. cylindrica of under different light/ dark regimes

3.1 Effect of some chemical substances on seed germination of I. cylindrica under 16/8 h light/ dark condition

Table (5) represents that after 1 minute of exposure to acetic acid, the higher level at 1% Conc. reached 24.44% of germination, while the lower level achieved from acetic acid at 20% Conc. was 16.67%, as compared to the control. The higher germination achieved at 1% Conc. was 20.0% when compared with the control after 5 minutes of exposure. In comparison with the control, the lower level of acetic acid at 20% resulted in a 12.22% of germination. After 10 minutes of exposure, the maximum germination was attained at 1% Conc. by 11.11 %, while the lower level was achieved at 20% acetic acid in germination by 2.22% when compared with the control.

After soaking the seed in Si-Si-6 for 12 hours, the higher degree of germination was achieved at 10% Conc. by 55.56%, while the lower germination was achieved from Si-Si-6 at 20% of *I. cylindrica* seeds by 50.00% as compared with the control. When compared with the control, the higher germination was achieved at 10% Conc. by 46.67 percent, while the lower level of germination was achieved from Si-Si-6 at 15 & 20% in germination by 38.89 & 38.89 %, respectively, when compared with the control. The higher germination was achieved at 10% Conc. by 32.22%, while the lower level of germination was achieved from Si-Si-6 at 20% in germination by 23.33% when compared with the control.

Table 5. Effect of some chemical substances on seed germination of *I. cylindrica* under 16/8 h light/dark condition

Tem.	Light	Time Min.	Conc. %	$CH_3CO\ OH$		Cont.		Time (h.)	Conc. %	Si-Si-6		KNO_3		Cont.	
				G%	Mean	G%	Mean			G%	Mean	G%	Mean	G%	Mean
25/35°C±2°C	16/8h light dark	1min	1%	24.44	7.33[a]	40.00	12.00[a]	12h.	5%	51.11	15.33[a]	35.56	10.67[a]	44.44	13.33[a]
			5%	21.11	6.33[a]				10%	55.56	16.67[a]	30.00	9.00[a]		
			10%	18.89	5.67[a]				15%	51.11	15.33[a]	25.56	7.67[a]		
			20%	16.67	5.00[ab]				20%	50.00	15.00[a]	24.44	7.33[a]		
		5min	1%	20.00	6.00[a]	41.11	12.33[a]	24h.	5%	38.89	11.67[a]	26.67	8.00[a]	43.33	13.00[a]
			5%	17.78	5.33[ab]				10%	46.67	14.00[a]	24.44	7.33[a]		
			10%	15.56	4.67[ab]				15%	38.89	11.67[a]	21.11	6.33[a]		
			20%	12.22	3.67[ab]				20%	38.89	11.67[a]	18.89	5.67[a]		
		10min	1%	11.11	3.33[ab]	27.78	8.33[a]	48h.	5%	24.44	7.33[a]	18.89	5.67[a]	41.11	12.33[a]
			5%	7.78	2.33[b]				10%	32.22	9.67[a]	16.67	5.00[ab]		
			10%	4.44	1.33[c]				15%	24.44	7.33[a]	14.44	4.33[ab]		
			20%	2.22	0.67[c]				20%	23.33	7.00[a]	13.33	4.00[ab]		
F(p value)										1071.01(0.00)					
Treat.										57.98(0.00)					
Conc.										130.09(0.00)					
Time										135.53(0.00)					
Treat * Conc.										0.65(0.68)					
Treat * time										3.49(0.01)					
Conc. * Time										303.12(0.00)					
Treat * Conc. * Time										14.32(0.00)					

In terms of the effect of potassium nitrate (KNO_3) on *I. cylindrica* germination, after soaking for 12 hours, the higher level of germination was achieved at 5% Conc. by 35.56 %, while the lower activation was achieved from Potassium nitrate at 20% Conc. by 24.44% in germination as compared with the control. In comparison with the control, after 24 hours, the higher germination was attained at 5% Conc. by 26.67% of soaking. Potassium nitrate at 20% Conc. had a lower level of seed germination by 18.89% when compared with the control. After 48 hours of soaking, the higher germination was achieved at 5% Conc. by 18.89%, while the lower level was achieved at

20% KNO_3 in germination by 13.33%, as compared with the control.

3.2 Effect of some chemical substances under 12/12h light/ dark on seed germination of I. cylindrica after 3 weeks.

Table (6) shows that after 1 minute of exposure to acetic acid, the greater degree of germination was achieved at 1% Conc. by 18.89%, while the lower level was achieved from acetic acid at 20 % in germination by 13.33% when compared with the control. After 5 minutes of exposure, the high level in germination was achieved at 1% Conc. by 16.67%, whereas the lower level was achieved from acetic acid at 10% and 20% in germination was 13.33 & 11.11%. After 10 minutes of exposure, the maximum level achieved at 1% Conc. was 7.78%, while the lower level achieved by acetic acid at 20% Conc. was 3.33% of germination.

Table 6. The effect of some chemical substances on germination of *I. cylindrica* under 12/12 h light/dark

Tem.	Light h.	Time Min.	Conc. %	CH_3CO OH		Cont.		Time (h.)	Conc. %	Si-Si-6		KNO_3		Cont.	
				G%	Mean	G%	Mean			G%	Mean	G%	Mean	G%	Mean
25/35° C±2°C	12/12h light dark	1min	1%	18.89	5.67^{a}	32.22	9.67	12h.	5%	36.67	11.00^{a}	27.78	8.33^{a}	31.11	9.33^{a}
			5%	16.67	5.00^{a}				10%	42.22	12.67^{a}	25.56	7.67^{a}		
			10%	13.33	4.00^{ab}				15%	37.78	11.33^{a}	20.00	6.00^{a}		
			20%	13.33	4.00^{ab}				20%	37.78	11.33^{a}	20.00	6.00^{a}		
		5min	1%	16.67	5.00^{a}	30.00	9.00	24h.	5%	28.89	8.67^{a}	20.00	6.00^{a}	26.67	8.00^{a}
			5%	13.33	4.00^{ab}				10%	34.44	10.33^{a}	21.11	6.33^{a}		
			10%	13.33	4.00^{ab}				15%	30.00	9.00^{a}	16.67	5.00^{a}		
			20%	11.11	3.33^{ab}				20%	32.22	9.67^{a}	15.56	4.67^{a}		
		10min	1%	7.78	2.33^{b}	26.67	8.00	48h.	5%	17.78	5.33^{a}	14.44	4.33^{a}	25.56	7.67^{a}
			5%	6.67	2.00^{b}				10%	26.67	8.00^{a}	12.22	3.67^{ab}		
			10%	5.56	1.67^{b}				15%	18.89	5.67^{a}	12.22	3.67^{ab}		
			20%	3.33	1.00^{bc}				20%	14.44	4.33^{a}	10.00	3.00^{ab}		
F(p value)										887.01(0.00)					
Treat.										31.06(0.00)					
Conc.										103.07(0.00)					
Time										120.67(0.00)					
Treat * Conc.										0.55(0.76)					
Treat * time										2.24(0.07)					
Conc. * Time										247.22(0.00)					
Treat * Conc. * Time										8.17(0.00)					

The findings of germination after soaking the seed for 12 hours in Si-Si-6 revealed that the higher level of germination achieved at 10% Conc. reached 42.22%, while the lower level achieved from Si-Si-6 at 20% in germination by 37.78% as compared with the control. After soaking for 24 hours, the higher level was at 10% Conc. by 34.44%, while the lower stimulation was from Si-Si-6 at 15% in germination by 28.89%. After soaking for 48 hours, the high level of germination was achieved at 10% Conc. by 26.67%, while the lower level was achieved at 20% Conc. by 14.44 % in germination.

Regarding the effect of soaking the seeds in potassium nitrate for 12 hours, the germination of *I. cylindrica* was more remarkable at 5% Conc. by 27.78% of germination. Potassium nitrate at 20% Conc. was achieved germination reached 20.00% compared to the control. After 24 hours of soaking, the maximum level at 5% Conc. reached 21.11% of germination. The lower level achieved of potassium nitrate at 20% Conc. was 15.56% of germination, after 48 hours of immersion, and the maximum level at 5% Conc. was 14.44%. The lower level of germination achieved at 20% Conc. of potassium nitrate reached 10.00%, compared with control.

3.3 Effect of some chemical substances under 8/16 h light/ dark on seed germination of I. cylindrica after 3 weeks

Data in Table (7) for treating seeds of *I. cylindrica* by acetic acid, after 1 min. exposure revealed that higher germination was attained from 1% Conc. of acetic acid by 14.44%, while the lower germination was obtained from acetic acid at 20% reached 11.11% compared to the control. After 5 minutes exposure, the maximum germination was achieved at 1% Conc. by 13.33%, while the smallest germination obtained from acetic acid at 10% and 20% during germination was 8.89%. After 10 minutes exposure, the maximum germination was achieved at 1% conc. by 6.67%, while a lower level was obtained from 20% acetic acid by 2.22% of germination.

Table 7. Effect of some chemical substances on germination of I. cylindrica under 8/16 h light/dark

Tem.	Light h.	Time Min.	Conc. %	$CH_3CO\ OH$ G%	$CH_3CO\ OH$ Mean	Cont. G%	Cont. Mean	Time (h.)	Conc. %	Si-Si-6 G%	Si-Si-6 Mean	KNO_3 G%	KNO_3 Mean	Cont. G%	Cont. Mean
25/35° C±2°C	8/16h light dark	1 min.	1%	14.44	4.33^{a}	25.56	7.67^{a}	12h.	5%	22.22	6.67^{a}	16.67	5.00^{a}	25.56	7.67^{a}
			5%	12.22	3.67^{a}				10%	30.00	9.00^{a}	16.67	5.00^{a}		
			10%	11.11	3.33^{a}				15%	24.44	7.33^{a}	15.56	4.67^{a}		
			20%	11.11	3.33^{a}				20%	24.44	7.33^{a}	11.11	3.33^{a}		
		5 min.	1%	13.33	4.00^{a}	22.22	6.67^{a}	24h.	5%	20.00	6.00^{a}	14.44	4.33^{a}	21.11	6.33^{b}
			5%	10.00	3.00^{ab}				10%	22.22	6.67^{a}	13.33	4.00^{a}		
			10%	11.11	3.33^{a}				15%	18.89	5.67^{a}	11.11	3.33^{a}		
			20%	8.89	2.67^{ab}				20%	18.89	5.67^{a}	10.00	3.00^{ab}		
		10 min.	1%	6.67	2.00^{ab}	17.78	5.33^{a}	48h.	5%	13.33	4.00^{a}	10.00	3.00^{ab}	20.00	6.00^{ab}
			5%	4.44	1.33^{b}				10%	14.44	4.33^{a}	7.78	2.33^{ab}		
			10%	2.22	0.67^{b}				15%	12.22	3.67^{a}	6.67	2.00^{ab}		
			20%	2.22	0.67^{b}				20%	8.89	2.67^{ab}	5.56	1.67^{b}		
F(p value)									695.50(0.00)						
Treat.									36.55(0.00)						
Conc.									81.12(0.00)						
Time									94.08(0.00)						
Treat * Conc.									0.35(0.90)						
Treat * time									1.95(0.11)						
Conc. * Time									184.48(0.00)						
Treat * Conc. * Time									9.25(0.00)						

The consequences of germination after soaking the seed 12 h in Si-Si-6 indicated that the higher degree of germination was accomplished at 10% Conc. through 30.00%, while the decreased degree accomplished from Si-Si-6 at 5% Conc. had germination by 22.22% compared with the control. After soaking 24 h., the most germination was accomplished at 10 %, Conc. reached 22.22%, while the minimum germination accomplished from Si-Si-6 at 15 and 20% in germination through 18.89 and 18.89%. After soaking 48 h., the most germination accomplished at 10% Conc. germination through 14.44%, while the lower germination accomplished from Si-Si-6 at 20% reached 8.89% of germination.

Results after 12 hours of soaking in potassium nitrate and germination of *I. cylindrica*, showed the higher germination at 5% Conc. reached 16.67%, while the level of germination accomplished at 20% Conc. reached 11.11% compared with the control. After 24 hours of soaking, the maximum level at 10% Conc. reached 14.44%, while lower germination after 48 hours of soaking, at 5% Conc. the high level of germination reached 10.00%, but the lower was obtained from potassium nitrate at 20% Conc. germination rate 5.56% compared with the control (Table 7).*Imperata cylindrica* (L.) is an invasive weed species which threatens the ecosystem in Egypt, therefore, information about their requirement for germination and establishment is useful to prevent their invasion and improve their integrated management program. Therefore, experiments dealt with the role of various environmental factors on *I. cylindrica* seed germination. The viability assessment of *I. cylindrica* seed indicated that more than 50% of *I. cylindrica* seeds have dormancy. The experiments took the optimum germinating regime (25/35°C ± 2°C) to test the different effects of light/dark regimes (16/8 h, 12/12 h and 8/16 h light/dark) and some chemical substances including growth regulators. Burnell *et al.*, (2004) showed that germination in *I. cylindrica* seed occurred from 11 to 43 ºC with an optimum temperature of 30ºC, seedlings tend to emerge in groups and seeds require light for germination. An optimum temperature for germination is near 86°F (Dickens and Moore, 1974). The results found that *I. cylindrica* seemed to have a similar germination rate in 24 and 48 hours of soaking time when kept in the 16/8 h light/ dark as compared with 12/12 h light/dark and 8/16 h light/dark, respectively. While it failed to germinate at constant dark. Cogon grass is a C_4 grass species and it is best adapted to full sun (Paul and Elmore, 1984). Our experiments provide evidence that growth regulators and some chemicals in different degrees produced a high percentage of germination. While the best combination of alternating applied temperatures of 25/35 ºC was 12h/12 h cycles in the presence of GA_3, IBA followed by Si-Si-6, and finally KNO_3 chemical substances. The germination response varied according to the concentrations and types of some plant growth regulators substances to different degrees. These results were in agreement with (Lee, 1978). While, germination is under strict regulation of plant hormones (Han and Yang, 2015). Breaking of *I. cylindrica* seed dormancy by Gibberellic acid speed up their germination (Gupta & Chakrabarty, 2013). Gibberellins (GAs) are further important plant hormones for numerous physiological plant processes, including seed germination (Ogawa & Iwabuchi, 2001). GAs stimulate the production of hydrolytic enzyme i.e., ά-amylase, in the aleuron layer of germinating cereal grains. (Yamauchi *et al*., 2004, Seo *et al.*, 2009). Seed treatment with potassium nitrate (KNO_3) has been associated with dormancy breaking, improved germination, and enhanced seedling growth and uniformity in a variety of plant species (Hernández *et al*., 2022). The positive role of potassium nitrate (KNO_3) as a seed priming agent on seedling establishment and vigor (Mohammadi *et al*., 2009). Seed priming is a process of regulating inhibition and active metabolism phases of germination before radical emergence followed by drying and maintenance of near to the original moisture content (Farooq *et al*., 2005). Seed priming improved germination and seedling vigor in tomatoes by activation of antioxidants (Farooq *et al*., 2009). While using Potassium sulphonate may increase the K movement to seeds to stimulate and germinate, especially if it is formulated in a nonionic surfactant formulation. Potassium is required for various biochemical and physiological processes such as enzyme activation (Wang *et al*., 2013). The effects of some environmental factors on the germination of *I. cylindrica* after 3 weeks under alternating temperatures of 25/35 ºC were demonstrated in this study. The wide spectrum of germination under different conditions is likely to make *I. cylindrica* difficult to control which able to germinate under various environmental factors. Time exposure and concentration of various chemical and physical promotors have significant effects on germination and breaking seed dormancy (Balah *et al*., 2021), whereas germination is a facilitative element in the invasions of plants (Gioria *et al.*, 2016, Balah *et al*., 2021). Finally, this study proved that growth regulators of GA_3, IBA, and environmental factors of temperature and light-mediated seed germination of *I. cylindrica*. While Si-Si-6 (Potassium sulphonate 10%SL) and acetic acid with only a small amount attained remarkable stimulation to *I. cylindrica* germination under different light and optimum temperature regimes. This makes them as the available and cheap materials as well as the good candidates for inclusion to get rid of this weed seedbed. Therefore, the integrated consideration includes agriculture practices and some nominated materials are potential and alternative options to *I. cylindrica* weeds management.

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