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Effect of using seed coating on germination and seedling growth characteristics of various crops under different environmental storage conditions

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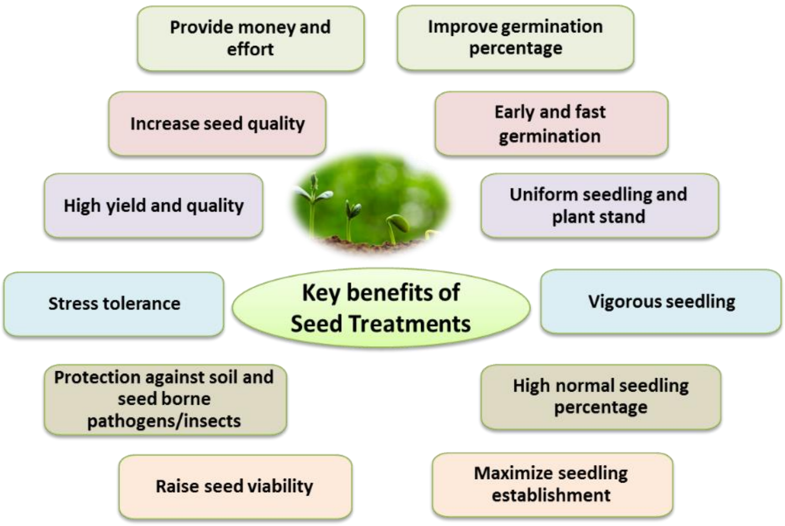
ONE of the best technologies to enhance seed germination is treating seed before growing. Effect of Extra Seed Power as a seed coating on germination and seedling growth of Corn, Sorghum, Millet, Faba bean, Mung bean, Lupine, Lentil, Egyptian clover, Cowpea, Cyamposis, Flax, Sugar beet, Zucchini and Rocket seeds were studied. Vigor of treated seedlings were studied in four replications in both laboratory and greenhouse experiments in two seasons (2021-2022 and 2022-2023). These experiments evaluated effect of ESP-treated seeds for enhancement of the germination, seedling growth and vigor after long and/or poor storage. Data showed that germination characteristics improved with ESP treatment compared with un-treated seeds (control) for all crops under investigation. ESP treatment gave higher values for germination percentage, germination rate and germination speed index traits (SGI), and gave positive effect with mean germination time (day) trait, which has highly significant values by ESP treatment. Seedling shoot length (cm), seedling shoot length (cm) and seedling length (cm) increase significant in all crops by using ESP treatment. There was high variation between control and ESP treatment for seedling fresh weight (g) and seedling dry weight (g). The same trend with seedling vigor I (SVI) and seedling vigor II (SVII) to all crops under study by ESP. This suggests that using Extra seed power as new treatment for seed, it was a suitable treatment for different seeds species and the best; and can improve germination percentage and seedling growth through increasing seed viability and seedling vigor under stress conditions as poor and long storage.

Keywords: Field crops, Seed treatment, Extra Seed Power, Germination, Seedling establishment.



Graphical Abstract

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Introduction

Cereals and vegetables growth the main sources all of the time. However, climate change and increasing demand for food are affecting production systems in various ways. For instance, some areas that were previously not used for agriculture may be brought into crop production due to more favorable environmental conditions or increased pressure on land resources. These changes have significant implications for food security and sustainability. (Tilman et al 2001, Fischer et al 2002 and FAO 2003).

When it comes to crop production, the quality of the seeds is crucial for achieving optimal crop stand and high production quality and quantity. As the demand for high-quality seeds increases, there is a growing need for new methods to improve seed quality. It is important to note that not only high-quality seeds are needed but also seeds with uniform physical characteristics, such as shape, size, and weight, as well as high seed value in terms of purity and germination capacity (Procházka et al 2019 and Ahmed et al 2022). Seed germination is a crucial step in the plant life cycle. The ability of seed imbibition to start germination is considered a vital regulatory step in plant development. That's why seed treatments are used to protect seeds and improve the establishment of healthy crops. To ensure a successful crop, it's important to not only focus on after-harvest treatments like purification and calibration, but also on pre-sowing treatments that enhance seed uniformity and germination. This will make it easier to handle and distribute the seeds evenly during sowing, resulting in a more uniform and precisely established crop (Shah et al 2017). Seed treatments can include biological, physical, and chemical agents and techniques to help increase germination, promote uniform seedling emergence, and protect seeds or seedlings from early season diseases and insects (Johnson 2000).

The technology for treating cereal seed was developed in the 1930s by Germains (a British seed company). This process is used to improve germination and homogenize stand establishment. While coating can sometimes result in lower germination rates, the seeds that do germinate grow more vigorously and clear strongly reduced respiratory losses during reserve mobilization (Asch, 2014). Coating seeds can improve conservation during storage and protect young seedlings from low temperatures, diseases, and pests (Sharratt and Gesch 2008). Seed coats can contain specific substances like nutrients, peroxides that provide oxygen, and hormones (Silcock and Smith 1982, Scott 1989 and Hassan et al 1990). The effects of a seed treatment on germination rate, seedling growth, and mobilization efficiency in three different cereals. It was found that a seed treatment could benefit seedlings beyond just increasing water availability. It can promote fast absorption of water into the seed, resulting in increased germination speed and early root growth. This, in turn, improves the seedling's access to water and nutrients. Interestingly, seeds within coatings absorbed significantly more moisture than uncoated seeds (Asch, 2014). To establish a successful mixed culture system, it's important to use seed treatments that lead to a precisely established stand. Kintl et al 2018 and 2020 showed that, there are three main groups of pre-sowing treatments that can be used: moistening treatments for pre-germination, biological treatments using fungi and bacteria to control soil pathogens and seed-borne pathogens, and coating of seeds, also known as pelletization. Using these treatments can support the use of legumes within the system. The coating of seed makes it also possible to eliminate the influence of drought or salinization by enhancing the availability of water for sown seeds during the period of germination and emergence (Bicakci et al 2018). Water deficit is one of the important factors that prevent germination of seed in field conditions (Misra et al., 2002). Stresses in the period of germination can significantly affect the quality of emerging vegetation and, subsequently, the planned yield. In gardening and farming, the coating of seeds is commonly used in flowers, vegetables and sugar beet (Ehsanfar and Modarres-Sanavy 2005 and Al-Naggar et al 2023). One of the possibilities for adaptation to the effect of drought and weather extremes, aiming to maintain quantity and quality of agricultural production, is the selection of species and varieties naturally capable of tolerance to these stressors.

Storing seeds is important to consider the conditions and practices that will ensure their quality and promote healthy seedling growth. The way in which seeds are stored can impact their establishment and the success of their integration into forest ecosystems. By understanding the effects of storage practices on seed quality and seedling establishment, we can cultivate high-quality seeds that have the best chance for successful reproduction (Grossnickle 2005 and Ahmed et al 2022). Storing seeds is a crucial step in preserving seed plants for the long term. It's important to maintain seed viability for a longer period to ensure genetic integrity in stored samples. There are several factors that affect seed longevity during storage, such as temperature, seed moisture content, relative humidity, and the nature of the seeds themselves. It's essential to take all of these factors into account when it comes to seed storage to ensure their continued viability (Onyekwelua and Fayose 2007 and Pradhan and Badola 2008). It is important to consider the relationship between seed viability and genetic damage during storage. Research shows that there is a correlation between the two, with the accumulation of genetic damage being a contributing factor to loss of viability (Rao et al 1987). It's important to consider the duration and method of drying and storing seeds, as this can greatly impact their viability. If not properly stored, seeds may experience a significant reduction in germination or even die off completely. However, with the right storage conditions, it is possible to retain a high level of viability in seeds over a long period of time. to ensure that seeds remain viable and ready for planting when the time comes, should give them the right care and attention they need during storage (Chen et al., 2007 and Wawrzyniak et al., 2020). This work confirms the high importance of agricultural and applied sciences in different fields as shown in a lot of papers published before (Abdel-Raheem et al (2022), Drar et al (2023), Abdel-Raheem et al (2023), El Bakri et al (2023) and Ibrahim et al (2024)).

The research focused on the impact of seed treatment using the Extra Seed Power (ESP) compound on the germination and growth characteristics of various plant species like Corn, Sorghum, Millet, Faba bean, Mung bean, Lupine, Lentil, Egyptian clover, Cowpea, Cyamposis, Flax, Sugar beet, Zucchini, and Rocket, compared with non- treatment.

The objectives of the research were to determine, how to ESP treatment can improve the germination traits, seedling establishment and growth of different plant species under different stress conditions, beside to farmers can easily use this method before planting to ensure the success of their crops.

Materials and Methods

The study aims to evaluate the effect of seed coating by Extra Seed Power (ESP) compared with control (un-treatment) on germination traits, seedling development for seed poor storage and long storage of Corn, Sorghum, Millet, Faba bean, Mung bean, Lupine, Lentil, Egyptian clover, Cowpea, Cyamposis, Flax, Sugar beet, Zucchini and Rocket during two seasons (2021-2022 and 2022-2023).

1. Laboratory Experiment

According to previous studies about seed treatment, this is a new compound as a seed treatment; it named an Extra Seed Power compound. It consists of antioxidants, polyphenols compounds, macro and micro elements, which are important to raise the plant's ability to tolerance of stress in the emergency stage, as it helps in producing the necessary proteins inside cells to increase the plant tolerance, beside to promotion enzymes activities and hormones to help embryo to make it more viable during germination. Therefore, ESP is considered as fertilizer nutritious and enhancer for seed vitality.

Evaluation of the germination test was performed according to ISTA (1999), whereas 50 seeds for each crop (200 seeds/ 4 replicate) were separately germinated in each replication in sandy soil at seedling trays and sterilized Petri dishes covered at the bottom with two sheets of Whitman filter paper with distilled water. Germination conditions and growth of stage in the incubator at 25 ± 2°C for summer crops and 20± 2°C for winter crops. The counting of germinated seeds was done every day. A seed was considered germinated when a radicle length of 2 mm was obtained. The seed treatment by ESP performance was assessed based on seed germination traits and seedling growth potential under control conditions. The laboratory experiments laid out in Completely Randomized Design (CRD) with four replications.

1.1 Germination characteristics

According to ISTA (1999), Germination test was performed at certain temperature and number of days for each crop. Total numbers of seeds germinated were counted daily and percentage.

Germination percentage (GP): (Number of germinated seeds/Total number of seeds) x 100.

Germination rate (GR): it was calculated as following formula:

GR= a + (a +b) + (a + b + c) …… (a + b + c + m)/ n (a + b + c + m).

Where a, b, c is No. of seedlings in the first, second and third count, m is No. of seedlings in final count, n is the number of counts.

Speed germination index (SGI): It was calculated as described by the Association of Official Seed Analysis (A.O.S.A., 2005) using the following equation:

SGI= (No. of germinated seed/day of first count) + (……. /…….) + (No. of germinated seed/day of final count).

Mean Germination Time (MGT): It was calculated based on the following formula of ISTA (1999).

MGT= Σ Dn/ Σn, where (n) is the number of seeds, which were germinated for the day, (D) is number of days counted from the beginning of germination.

1.2. Seedling Characteristics

Ten seedlings from each replicate were used for data collection on seedling traits. Collected data was done number of days for each crop after seed sowing date. Data were recorded on the following traits.

Seedling length, shoot and root: lengths were measured with the help of scale and average of ten seedlings for each replicates was used for statistical analysis.

Seedling fresh and dry weight: Ten normal seedlings after planting were measured by electric balance to determine their fresh weight then dried in a hot-air oven at 85 ^oC for 12 hours to obtain their dry weight (g).

Seedling vigor (SV): Seedling vigor was determined as the product of the germination percentage and that of seedling length and seedling dry weight. It was calculated as follow:

Seedling Vigor Index I (SVI) = Germination (%) x Total seedling dry weight (g).

Seedling Vigor Index II (SVII) = Germination (%) x Total seedling length (cm).

TABLE 1. Seed classification, sources and storage conditions.

No.	Crop	Family	Source	Storage Conditions
1	Corn (*Zea mays*, L.)	Poaceae	Maize Research Dept., FCRI., ARC	Stored for 3 years in room temperature
2	Sorghum (*Sorghum bicolor*, L.)	Poaceae	Sorghum Research Dept., FCRI., ARC.	Stored for 13 years in refrigerator (+5^{0}C)
3	Millet (*Panicum miliaceum*, L.)	Poaceae	Fodder crops Research Dept., FCRI., ARC	Stored for 9 years in refrigerator (+5^{0}C)
4	Faba bean (*Vicia faba*, L.)	Fabaceae	Legumes crops Research Dept., ARC	Stored for 6 years in refrigerator (+5^{0}C)
5	Mung bean (*Vigna radiate*, L.)	Fabaceae	India	Imparted variety and stored for 7 years in refrigerator (+5^{0}C)
6	Lupine (*Lupines albus*,.L)	Fabaceae	Legumes crops Research Dept., ARC	Stored for 5 years in refrigerator (+5^{0}C)
7	Lentil (*Lens culinaris*,.L)	Fabaceae	Legumes crops Research Dept., ARC	Stored for 5 years in refrigerator (+5^{0}C)
8	Egyptian clover (*Trifolium alexandrinum*, L.)	Fabaceae	Fodder crops Research Dept., FCRI., ARC	Stored for 11 years in refrigerator (+5^{0}C)
9	Cowpea (*Vigna anguiculata*, L.)	Fabaceae	Fodder crops Research Dept., FCRI., ARC	Stored for 10 years in refrigerator (+5^{0}C)
10	Guar (*Cyamposis tetragonoloba*, L.)	Fabaceae	Fodder crops Research Dept., FCRI., ARC	Stored for 10 years in refrigerator (+5^{0}C)
11	Flax (*Linum usitatissimum*, L.)	Linaceae	Genetic Resources Dept., FCRI., ARC	Stored for 9 years in refrigerator (+5^{0}C)
12	Sugar beet (*Beta vulgaris*, L.)	Amaranthaceae	Suger Crops Research Institute, ARC.	Stored for 4 years in room temperature
13	Zucchini (*Cucurbita pepo*, L.)	Cucurbitaceae	USA	Imported variety, expire date from 2019 and stored in room temperature for 3 years.
14	Rocket (*Eruca vesicaria*, L.)	Brassicaceae	China	Imported variety and stored in room temperature for 3 years.

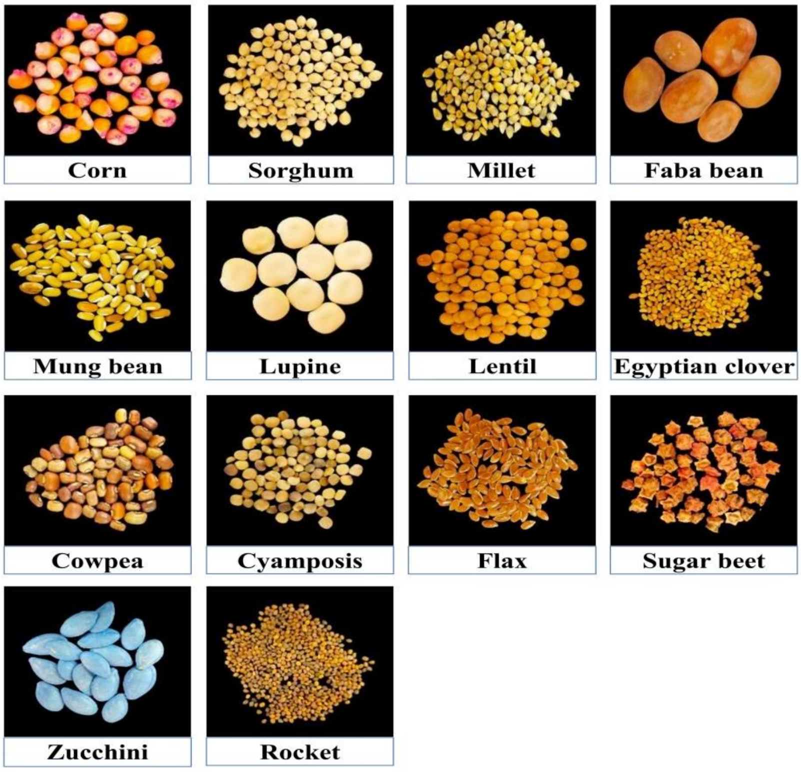

Fig. 1. General view of the different crops seed under investigation.

2. Pots emergence experiment.

Control and treated seeds were sown in 10 kg plastic pots (25cm of diameter and 30 of depth) containing moist clay and sand (2/1, respectively), replicated four times and were placed in greenhouse during summer and winter seasons according to growth season of crop and laid in a Randomized Complete Blocks Design (RCBD). Tested characters were field emergence (%), seedling dry weight (mg) and seedling vigor after 20 to 25 days from sowing according to type of crop under investigation.

Statistical analysis:

Analysis of variance of studied traits of each season was performed. The least significant differences (L.S.D) test with a significance level of 5% (Gomez and Gomez, 1984). The measured variables were analyzed by ANOVA using the CoStat system for Windows, Version 6.311 (CoHort software, Berkeley, CA 94701).

Results

1. Laboratory experiment

Using ESP seed coating adversely affected germination and seedling establishment traits of the crops (Corn, Sorghum, Millet, Faba bean, Mung bean, Lupine, Lentil, Egyptian clover, Cowpea, Cyamposis, Flax, Sugar beet, Zucchini and Rocket) under investigation. Significance ($P \leq 0.05$) was observed due to increasing efficiency of ESP treatment, for all studied traits

1.1. Germination Characteristics

Figure (2) illustrates the frequency distribution bars of germination characters of the different crops under ESP treatment and control (untreated seed).

Data demonstrated in Figure 2 of germination percentage (G%), germination rate (GR), mean germination time (MGT) and speed germination index (SGI) clearly indicated significant differences at ($P < 0.05$) between ESP treatment and control (un-treatment seed) for all crops.

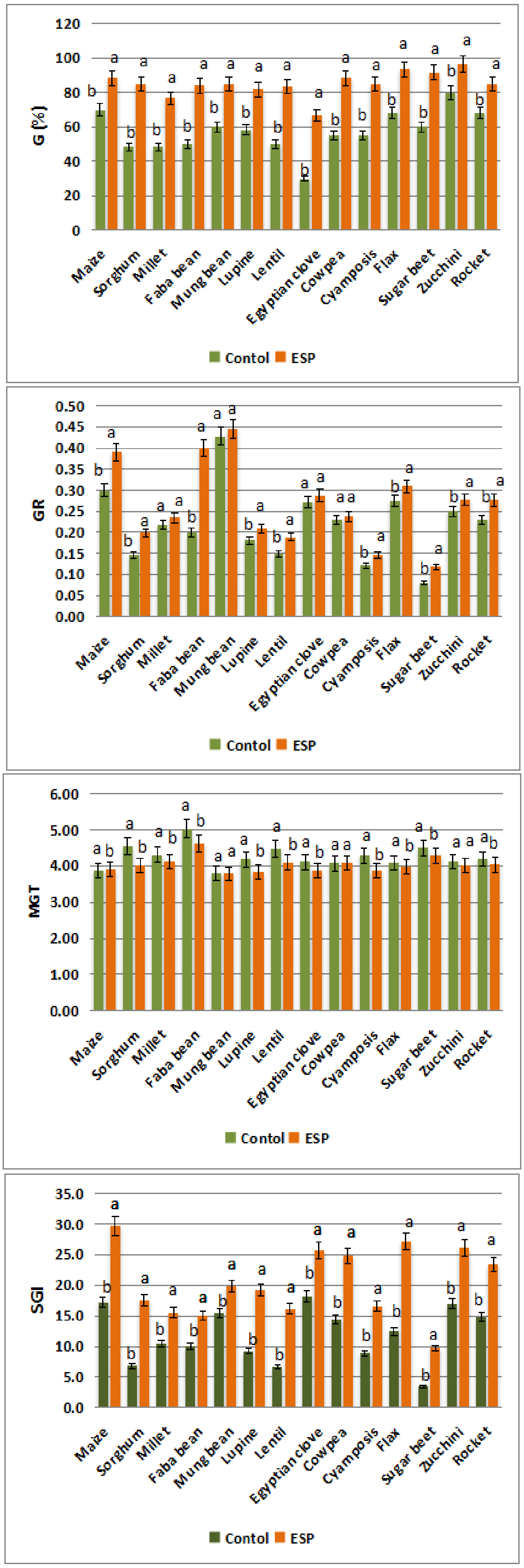

Fig. 2. Seed Germination Percentage (G%), Germination Rate (GR), Mean Germination Time (MGT) and Speed Germination Index (SGI) of seed crops treated with ESP treatment and Control (un-treated seed). Different letters above bars indicate significantly different means according to Duncan test (α = 5%).

A reduction in all germination characters with control was observed. Data showed that the highest values of germination % were observed by ESP treatment, while the un-treated seed recorded the lowest percentage. Increasing reach to 26.14, 75.78, 58.70, 68, 41.67, 40.14, 66.66, 70, 60.55, 54.55, 36.60, 52.53, 20.88 and 24.45% for Corn, Sorghum, Millet, Faba bean, Mung bean, Lupine, Lentil, Egyptian clover, Cowpea, Cyamopsis, Flax, Sugar beet, Zucchini and Rocket, respectively, compared to control. Significant increases in germination rate were found with ESP treatment for all crops except, Millet, Mung bean, Egyptian clover and Cowpea which cleared non-significant response compared to control. On the other hand, a significant increase in mean germination time was found with control for all crops compared to ESP treatment except Mung bean, Cowpea and Zucchini, which showed non-significant differences between treatment and un-treatment seed. ESP had the superior values of speed germination index for Corn, Sorghum, Lupine, Lentil, Egyptian clover, Cowpea, Cyamposis, Flax, Sugar beet, Zucchini and Rocket, followed by Millet, Faba bean, Mung bean, whereas control gave the minimum values of SGI.

1.2. Seedling Characteristics

The addition of ESP to seeds affected the growth of seedlings of all the studied crops. Seedling traits (i.e., seedling length, shoot length and root length, seedling fresh and its dry weight and vigor), they were positively and significantly affected by seed treatment (ESP) compared with un-treated seeds under laboratory conditions (Tables 2, 3and 4).

ESP treatment increased the length, total biomass produced and vigor in all crops compared to that of the un-treated seeds. Seed treatment slightly enhanced length of seedling, shoot and root in cereals crops (37.11, 27.38 and 55.68% for Corn, 68.83, 86.95 and 71.95% for Sorghum and 49.37, 47.91 and 51.90% for Millet); legumes crops (33.59, 23.39 and 52.32 % for faba bean, 10.21, 9.25 and 23.08 % for mung bean, 35.90, 34.45 and 37.46% for lupine, 44.61, 56.07 and 18.77% for lentil, 23.23, 35.01 and 4.52% for Egyptian clover, 106.5, 125.0 and 87.04% for Cowpea and 16.90, 5.62 and 36.67% for Cyamposis, respectively); whereas there was increase for Linaceae family reach to 47.69, 53.72 and 38.29 for Flax; the same trend with Amaranthaceae, Cucurbitaceae and Brassicaceae families which had increase significant by 73.94, 111.62 and 60.88% for suger beat, 52.41, 34.55 and 77.3% for zucchini and 12.58, 32.14 and 20.0% for Rocket to length of seedling, shoot and root, respectively.

On the other hand, Data recorded the highest values with seedling fresh weight and dry when using the enhancer germination and growth ESP seed treatment comparing with control to Corn, Sorghum, Millet, Faba bean, Mung bean, Lupine, Lentil, Egyptian clover, Cowpea, Cyamposis, Flax, Sugar beet, Zucchini and Rocket which increased by 15.48, 70.15, 38.93, 19.09, 36.05, 16.26, 22.92, 110.56, 39.89, 7.33, 46.39, 105.63, 30.40, 10.66%, for seedling fresh weight (g) and 3.54, 58.33, 27.96, 62.94, 35.29, 70.11, 15.53, 132.47, 42.30, 33.49, 70.59, 105.26, 27.89, 60.0% for seedling dry weight (g), respectively.

Data in Tables (2, 3 and 4) showed that significant difference was observed in seedling vigor 1 (SV1) and seedling vigor 2 (SV2) regarding ESP treatment with untreated different crops seeds.

Treated seed by ESP gave the highest percentage compared with control, which was 30.97 and 73.93% (Corn), 103.91 and 196.06% (Sorghum), 100.93 and 139.17 % (Millet),173.75 and 135.45% (Faba bean), 92.22 and 61.43% (Mung bean), 137.02 and 91.74% (Lupine), 91.48 and 138.06% (Lentil), 264.4 and 188.14% (Egyptian clover), 128.01 and 234.45% (Cowpea), 83.00 and 61.1% (Cyamposis), 129.39 and 102.36% (Flax), 219.26 and 171.97% (Sugar beet), 52.57 and 84.48 % (Zucchini), 110.57 and 56.37% (Rocket) for SVI and SVII, respectively.

TABLE 2. Effect of seed treatment by ESP on seedling growth parameters of Corn, Sorghum, Millet, Faba bean, Mung bean and Lupine.

Traits	Corn			Sorghum		
	Control	**ESP**	**Increases %**	**Control**	**ESP**	**Increases %**
Seedling length (cm)	25.6b	35.1a	37.11	16.17b	27.3a	68.83
Shoot length (cm)	16.8b	21.4a	27.38	7.97b	14.9a	86.95
Root length (cm)	8.8b	13.7a	55.68	8.20b	14.1a	71.95
Seedling fresh wt. (mg)	149.9a	173.1a	15.48	20.1b	34.2a	70.15
Seedling dry wt.(mg)	25.4a	26.3a	3.54	2.4b	3.8a	58.33
Seedling vigor index I (SVI)	1750.9a	2293.1a	30.97	115.1b	234.7a	103.91
Seedling vigor index II (SVII)	1785.7b	3105.9b	73.93	782.6b	2317.0a	196.06
Traits	**Millet**			**Faba bean**		
	Control	**ESP**	**Increases %**	**Control**	**ESP**	**Increases %**
Seedling length (cm)	16.67b	24.9a	49.37	31.59b	42.2a	33.59
Shoot length (cm)	9.56b	14.14a	47.91	20.39b	25.16a	23.39
Root length (cm)	7.11a	10.8a	51.90	11.20b	17.06a	52.32
Seedling fresh wt. (mg)	84.5b	117.4a	38.93	1084.0b	1290.9a	19.09
Seedling dry wt.(mg)	9.3a	11.9a	27.96	258.5b	421.2a	62.94
Seedling vigor index I (SVI)	441.3b	886.7a	100.93	12924.3b	35379.8a	173.75
Seedling vigor index II (SVII)	795.8b	1903.3a	139.17	1584.1b	3729.8a	135.45
Traits	**Mung bean**			**Lupine**		
	Control	**ESP**	**Increases%**	**ESP**	**Control**	**Increases%**
Seedling length (cm)	25.08b	27.64a	10.21	10.67b	14.50a	35.90
Shoot length (cm)	17.3a	18.9a	9.25	5.08a	6.83a	34.45
Root length (cm)	7.8b	9.6a	23.08	5.58b	7.67a	37.46
Seedling fresh wt. (mg)	402.8a	548.0a	36.05	1884.3a	2190.7a	16.26
Seedling dry wt.(mg)	35.7b	48.3a	35.29	131.5b	223.7a	70.11
Seedling vigor index I (SVI)	2141.7b	4116.7a	92.22	7706.7b	18266.7a	137.02
Seedling vigor index II (SVII)	1505.0b	2429.5a	61.43	620.0b	1188.8a	91.74

TABLE 3. Effect of seed treatment by ESP on seedling growth parameters of Lentil, Egyptian clover, Cowpea, Cyamposis, Flax and Sugar beet.

Traits	Lentil			Egyptian clover		
	Control	ESP	Increases %	Control	ESP	Increases %
Seedling length (cm)	10.58b	15.30a	44.61	8.48b	10.45a	23.23
Shoot length (cm)	7.33b	11.44a	56.07	5.17b	6.98a	35.01
Root length (cm)	3.25a	3.86a	18.77	3.32a	3.47a	4.52
Seedling fresh wt. (mg)	311.1a	382.4a	22.92	46.4b	97.7a	110.56
Seedling dry wt.(mg)	47.0b	54.3a	15.53	7.7b	17.9a	132.47
Seedling vigor index I (SVI)	2371.3b	4540.0a	91.48	213.7b	778.7a	264.4
Seedling vigor index II (SVII)	531.3b	1264.8a	138.06	247.8b	714.0a	188.14
Traits	Cowpea			Cyamposis		
	Control	ESP	Increases %	Control	ESP	Increases %
Seedling length (cm)	12.3b	25.4a	106.50	15.50b	18.12a	16.90
Shoot length (cm)	6.8b	15.3a	125.00	9.40b	9.9a	5.32
Root length (cm)	5.4b	10.1a	87.04	6.00b	8.2a	36.67
Seedling fresh wt. (mg)	730.3b	1021.6a	39.89	349.1a	374.7a	7.33
Seedling dry wt.(mg)	71.4a	101.6a	42.30	20.9b	27.9a	33.49
Seedling vigor index I (SVI)	3933.3b	8968.3a	128.01	1283.9b	2349.6a	83.00
Seedling vigor index II (SVII)	670.0b	2240.8a	234.45	955.8b	1539.8a	61.10
Traits	Flax			Sugar beet		
	Control	ESP	Increases %	Control	ESP	Increases %
Seedling length (cm)	13.44b	19.85a	47.69	6.87b	11.95a	73.94
Shoot length (cm)	8.19b	12.59a	53.72	3.70b	7.83a	111.62
Root length (cm)	5.25b	7.26a	38.29	3.17a	5.10a	60.88
Seedling fresh wt. (mg)	16.60b	24.30a	46.39	23.1b	47.50a	105.63
Seedling dry wt.(mg)	1.70b	2.90a	70.59	1.9b	3.90a	105.26
Seedling vigor index I (SVI)	116.7b	267.7a	129.39	113.7b	363.0a	219.26
Seedling vigor index II (SVII)	915.0b	1851.6a	102.36	414.5b	1127.3a	171.97

TABLE 4. Effect of seed treatment by ESP on seedling growth parameters of Zucchini and Rocket.

Traits	Zucchini			Rocket		
	Control	ESP	Increases %	Control	ESP	Increases %
Seedling length (cm)	19.29b	29.40a	52.41	5.833a	6.567a	12.58
Shoot length (cm)	11.23b	15.11a	34.55	2.8b	3.7a	32.14
Root length (cm)	8.06b	14.29a	77.30	2.5b	3.0a	20.00
Seedling fresh wt. (mg)	138.5b	180.6a	30.40	24.4b	27.0a	10.66
Seedling dry wt.(mg)	14.7b	18.8a	27.89	0.5b	0.8a	60.00
Seedling vigor index I (SVI)	1185.0b	1808.0a	52.57	33.1b	69.7a	110.57
Seedling vigor index II (SVII)	1539.6b	2840.3a	84.48	365.8b	572.0a	56.37

2. Pots emergence experiment.

Emergence percentage, dry/ seedling (g) and seedling vigor (SVII) in Table (5 and 6) showed significant differences among ESP treatment and control (un- treatment) on the different crops.
Data cleared significant differences, among emergence traits by using ESP.

Results showed that the ESP treatment produced the best values for pots emergence% compared to the control which it had the lowest values. Emergences % by ESP treatment were 89.0, 68.3, 82.3, 83.9, 82.7, 89.3, 75.0, 77.4, 82.2, 82.0, 65.0,87.7, 90.0 and 88.0% for Corn, Sorghum, Millet, Faba bean, Mung bean, Lupine, Lentil, Egyptian clover, Cowpea, Cyamposis, Flax, Sugar beet, Zucchini and Rocket, respectively. Dry wt. was also significantly increased by ESP with compared to control in all crops under experiment. However, it was highly significant for Corn, Sorghum, Faba bean, Lupine, Lentil, Egyptian clover, Cowpea, Flax, Sugar beet and Zucchini. While it was medium significant for Millet, Mung bean, Cyamposis and Rocket. Moreover, the best SVII gave superior values with ESP reached to (36.0, 336.3 and 173.8% for Corn, Sorghum, Millet, 191.16, 70.0, 76.27, 121.4, 119.3, 71.0 and ١٢٤,٧% for Faba bean, Mung bean, Lupine, Lentil, Egyptian clover, Cowpea, Cyamposis, 90.7% for Flax, 87.2% for Sugar beet, 156.1% for Zucchini and 116.0 % Rocket) compared to the control.

TABLE 5. Effect of seed treatment by Extra Seed Power (ESP) on field emergence and its parameters of different plant species.

Crops	Treatment	Field emergence %	Dry/ seedling	Seedling Vigor (SVII)
Corn	Control	65.0b	0.23b	15.59b
	ESP	89.0a	0.27a	24.36a
F test		**	***	***
CV%		4.85	2.01	5.14
Sorghum	Control	20.0b	0.17b	0.77b
	ESP	68.3a	0.22a	3.36a
F test		***	**	***
CV%		6.66	20.44	12.43
Millet	Control	47.3b	0.01b	0.42b
	ESP	82.3a	0.02a	1.15a
F test		**	*	***
CV%		16.01	17.75	24.45
Faba bean	Control	37.8b	0.52b	19.01b
	ESP	83.9a	0.68a	55.35a
F test		***	***	***
CV%		6.02	7.02	6.34
Mung bean	Control	58.3b	0.03b	1.80b
	ESP	82.7a	0.03a	3.06a
F test		**	*	**
CV%		11.17	22.2	19.77
Lupine	Control	65.0b	0.25b	15.51b
	ESP	89.3a	0.31a	27.34a
F test		**	**	***
CV%		4.07	3.81	4.19
Lentil	Control	43.3b	0.014b	0.56b
	ESP	75.0a	0.019a	1.24a
F test		***	**	***
CV%		7.18	3.84	2.74
Egyptian clover	Control	48.1b	0.012b	0.31b
	ESP	77.4a	0.018a	0.68a
F test		***	**	***
CV%		5.42	7.69	9.09
Cowpea	Control	57.8b	0.14b	1.86b
	ESP	82.2a	0.16a	3.18a
F test		**	**	***
CV%		5.49	7.35	5.37

TABLE 6. Effect of Extra Seed Power (ESP) on field emergence and its parameters of different plant species.

Crop	Treatment	Field emergence %	Dry/ seedling	Seedling vigor (SVII)
Cyamposis	Control	58.0b	0.03b	1.54b
	ESP	82.0a	0.17a	3.46a
F test		**	*	***
CV%		4.94	21.19	2.07
Flax	Control	25.0b	0.02b	0.54b
	ESP	65.0a	0.03a	1.03a
F test		***	**	**
CV%		11.11	13.27	17.09
Sugar beet	Control	57.3b	0.01b	0.78b
	ESP	87.7a	0.02a	1.46a
F test		**	**	***
CV%		8.86	10.63	5.58
Zucchini	Control	66.4b	0.10b	6.42b
	ESP	90.0a	0.17a	16.44a
F test		***	**	***
CV%		3.03	13.2	13.26
Rocket	Control	61.0b	0.02b	0.25b
	ESP	88.0a	0.03a	0.54a
F test		***	*	***
CV%		5.11	15.22	5.61

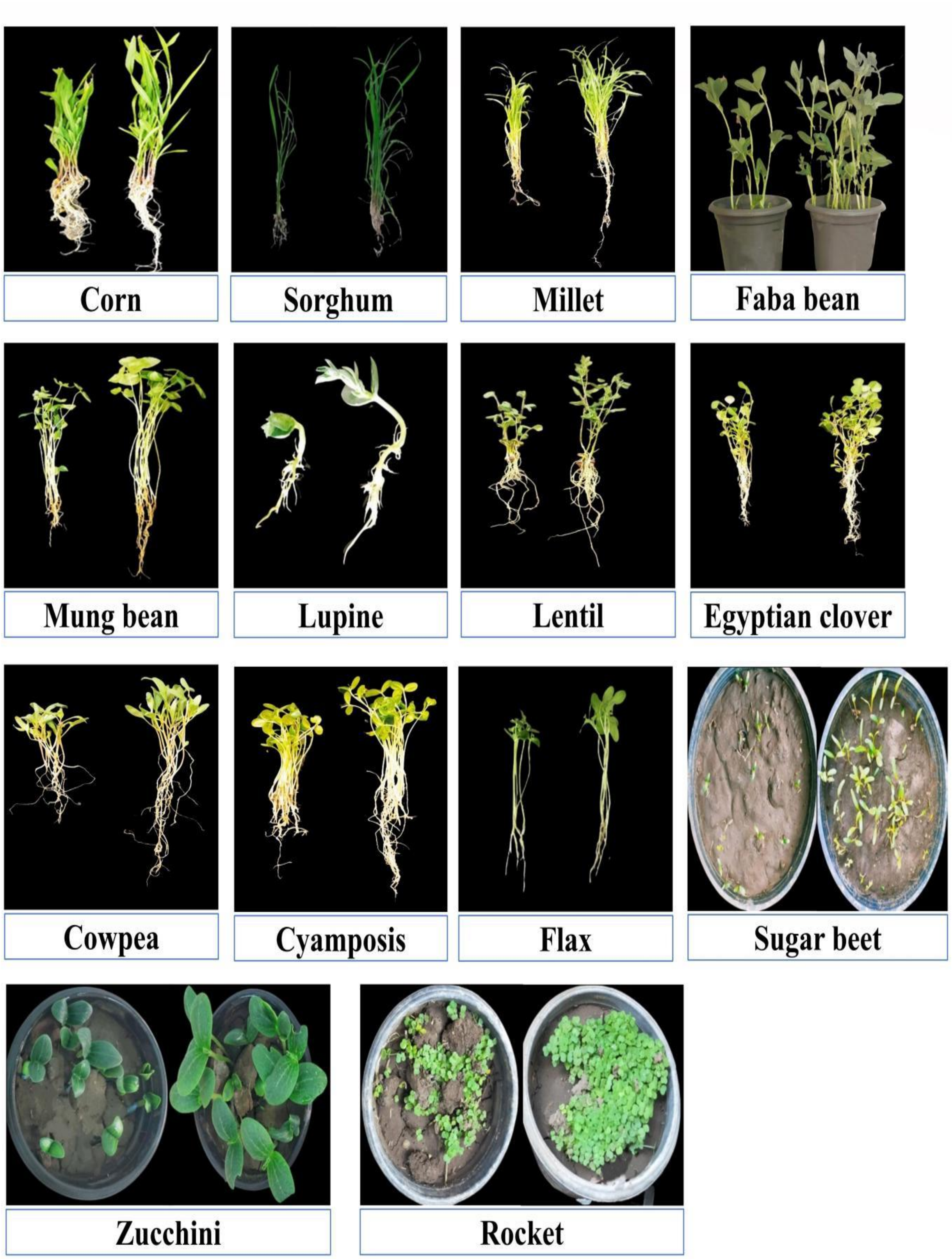

Fig. 3. Comparison between ESP treatment and Control (un-treatment) for different crops during germination and seedling growth.

Discussion

It is crucial to ensure the successful germination and establishment of better seedlings for healthy plant growth. Unfortunately, various factors can hinder this process, such as low seed vigor, inadequate seedbed preparation, improper storage, unfavorable climate conditions, and pests and diseases. To combat these issues, it's recommended to treat the seeds before planting, as this can significantly improve germination rates and plant establishment. By taking this proactive approach, it can increase crop populations and promote desirable plant growth. In this study, seed was treated with Extra seed power (ESP) for investigation as a new seed treatment.

The seed coating method is a highly effective way to promote better seedling development. This technique can boost the germination rate and overall plant performance by regulating pre-germination metabolic activity. By using this pre-sowing approach, growers can improve the growth and germination of their seeds even in challenging the divers' environmental conditions.

This research has found that the use of Extra Seed Power (ESP) as a seed coating treatment is the optimal choice for improving seed quality and viability. Seed coating by ESP increased the root and shoot establishment and dry weights in laboratory and greenhouse conditions. Interestingly, this finding is consistent with some research about seed treatment, it found that Seed germination is controlled by many of physiological mechanisms (Zhang et al., 2022). These mechanisms are essential and benefit for the growth of embryo and embryo development. Hussain et al., 2016; Hozayn and Ahmed, 2019; Hozayn et al., 2019; Ahmed and El-Mahdy, 2022; Ahmed, 2023 reported that the seed treatment significantly increased germination and seedling growth traits beside some activities of enzymes such as polyphenoloxidase, peroxidase and chitinase increased with treated seed comparing with untreated seeds. Seed treatment promotes germination percentage and subsequent growth under optimum conditions and also it can helps in broadening the range of temperature during germination stage, which finally enhances yield of crop (Murray, 1990; Zheng et al., 1994; and Farooq et al., 2008; Esmaeilpour and Van Damme, 2016). Seed coating is an effective method that is being applied and developed in modern agriculture. It has many functions, such as improving seedling vigor, enhancing seedling growth, and reducing the occurrence of diseases and pests. Ensuring the proper emergence and growth of seeds is essential for maximizing a plant's genetic and physiological capabilities (Junges et al., 2013). Coating was effective at near limiting moisture tensions and when seed was exposed to light, however, these effects did not seem related to soil texture or low to moderate moisture tensions, these findings were based on research conducted by (Scott, 1975). It has been discovered that seedlings growing from hydro-absorber coated barley, rye, and wheat that have coat shares greater than 75% of the average seed tend to promote better seedling growth than those growing from uncoated seeds (Asch , 2014). In fact, coated seeds showed an earlier compensation for the initial dry weight (DW) loss due to respiration compared to their uncoated counterparts, as demonstrated. Seed treatment methods have been used to increase germination characteristics under stress conditions. The beneficial impacts of seed treatment are related with different biochemical and physiological changes, such as using Antioxidant which protects and prevents oxidative deterioration of lipids and maintains structural and functional integrity of cells (Govindaraj et al., 2017).

Coating seeds with different substances is a good practice, aims to enhance seed performance under various conditions such as limited water and nutrients, seed dormancy, or unfavorable temperatures (Karanam and Vadez 2010; Masuaskas et al., 2008). Researchers have found that coating seeds with specific materials can improve water availability to seedlings and promote nutrient absorption, leading to better germination rates and early seedling growth (Sedghi et al., 2010; Leinauer et al., 2010; Serena et al., 2012; Govindaraj et al., 2017). Gorim and Asch (2017) they found that seeds within coatings absorbed significantly more moisture than uncoated seeds. The seeds from within the coating showed a much steeper initial uptake (Asch, 2014). In other studies conducted, it was discovered that coated seeds showed higher mobilization efficiencies than their uncoated counterparts (Asch, 2014). Furthermore, the onset of photo autotrophy was found to be earlier in coated grains for all species when compared to the uncoated seed. The higher mobilization efficiencies in coated seeds suggest that a larger proportion of endosperm reserves were directly converted into growth, leading to lower respiration rates. This was evident in the seedling dry weight (DW), which was consistently higher for coated seeds of all species throughout the entire growth period compared to the uncoated seeds. The contribution of seedling photosynthesis to growth was higher in uncoated seeds than in coated seeds, as a means of compensating losses to respiration (Asch, 2014). However, the mobilization efficiency observed in coated seeds was higher, resulting in faster growth rates, smaller respiration losses, and earlier compensation of respiration losses during germination. This suggests a difference in the sugar metabolic pathway during seedling growth between coated and uncoated seeds. The study also found that glucose levels in growing seedlings were higher in coated seeds, indicating more efficient metabolism of glucose into tissue structures in young seedlings from coated seeds. Seed priming can be a defense line for facing stresses as biotic and abiotic stresses. Treating wheat seeds resulted in significant increases in root length, shoot length, fresh weight, dry weight, and seed vigor under both normal and stressful conditions (Afzal et al., 2005). Priming treatments, including hydro-priming, led to increased activity of α-amylase, which helped mobilize stored carbohydrate reserves and improved germination and traits of rice under stressful conditions (Finch-Savage et al., 2004, Kata et al., 2014 and Drar et al., 2023). These findings highlight the potential benefits of seed treatments in improving crop growth and quality, particularly in challenging environments.

Thus, the ESP could help in increasing the activity of energy and other plant components that lead to fast and better germination of various crops seeds.

Conclusion and Recommendations

Based on the apply study, it can say that, seed coating by Extra Seed Power ESP (Commercial name) as a new seed treatment and under registration as an invention in Academy of Scientific Research and Technology, Egypt, can be a great option for improving the germination rate in various crops. It has been found to be a superior treatment compared to leaving the seeds untreated. ESP seed treatment has been shown to promote the growth of seedlings, stimulate rapid germination, and improve the seedling stage for different crops. These results in strong and healthy seedlings even under stress conditions. As a result, farmers and gardeners can rest assured that they give their crops the best chance for success from starting seed germination to seed yield through treating their seeds by ESP coat before planting.

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