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ORIGINAL ARTICLE

Pinus eldarica Cone Cellulosic Peat: A New Healthy, Organic, and Eco-friendly Substrate for Seed Germination of some Ornamental Plants (Report for the First Time)

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KEYWORDS

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ABSTRACT: The production of high-quality plants is influenced by several factors, among which the choice of appropriate substrate is crucial. Seeds play a vital role in perpetuating plant life by initiating the cycle of new plant creation, with germination being the first step towards fulfilling this role. Organic substrates like cocopeat and peat moss, commonly used for ornamental plant seedlings, are expensive and imported into Iran. Therefore, it is essential to find and utilize a substrate that is of good quality, more affordable, and readily available compared to cocopeat and peat moss. The objective of this study was to evaluate the effects of *Pinus eldarica* cone cellulosic peat on the seed germination of *Zinnia elegans*, *Gaillardia aristata*, *Helianthus annuus*, *Osteospermum ecklonis*, *Petunia* × *atkinsiana*, and *Adenium arbicum* in an experiment based on a completely randomized design with a factorial arrangement and three replications. The analysis of variance indicated that both the simple and interactive effects of the substrate and plant species were significant ($P < 0.01$ and $P < 0.05$) on the mean germination time, coefficient of velocity of germination, mean daily germination percentage, and final germination percentage. The highest and lowest final germination percentages were observed in *A. arbicum* and *G. aristata* in pine cone peat, respectively. Furthermore, the highest and lowest coefficients of velocity of germination were obtained from *O. ecklonis* in cocopeat and *H. annuus* in pine cone peat, respectively. Since *P. eldarica* cone peat is an economical substrate that is cheaper than cocopeat—costing about half as much—and is commercially produced by the Diana Bastar Kasht company in Iran and it is eco-friendly and natural was observed to be free of pathogens and weed seeds in this study, and contains macro and micronutrients with appropriate pH and electrical conductivity (EC) levels, it is recommended to further investigate its effects on other ornamental plants for the production of plug seedlings.

INTRODUCTION

Quality crop production hinges on several factors, including the use of appropriate substrates [1]. Seeds play a fundamental role in all plants, ensuring the continuation of life and survival by initiating the growth of new plants, with seed germination being the initial step in this process. The attributes of seed germination, such as germination rate, speed, and uniformity, influence plant production efficiency by affecting the seedling establishment rate and vigor, as well as plant density [2].

Selecting and preparing an appropriate substrate significantly enhances the success of ornamental plant

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production. Nowadays, a substantial number of producers adopt the plug production method for plant production, making it a vital aspect of the ornamental plant industry [3]. A suitable substrate should not only possess favorable physical and chemical properties to facilitate better nutrient uptake and optimal seed germination but also be cost-effective and lightweight, both organic and inorganic materials can serve as substrate components [4].

Typical substrates for plug production include cocopeat, perlite, palm peat, and peat moss, either used alone or in various combinations. Perlite is a popular mineral culture medium known for its neutral pH and excellent drainage capabilities, often mixed with other organic substrates [5]. Since organic substrates like cocopeat and peat moss are extensively used for ornamental seedling production, whereas they are extensive and imported from other countries to Iran, it is essential to find and utilize a cultivation substrate that is more affordable and accessible, yet of comparable quality. Renewable resources like tree bark are also viable options for substrate production [6]. One of the cultivation media that can have such characteristics is pine cone cellulosic peat.

The flowers' quality and growth are influenced by a lot of factors, one of the most important ones being the substrate. It is always tried to use substrates that are, in addition to ensuring the flower quality and growth, economic and harmless to water and soil [7]. When healthy growing media is used, contaminants are not transferred to plants, and in addition to the environment, the use of harmful and dangerous chemicals is minimized, and human health is much less at risk from this perspective.

Tree bark is a rich source of organic compounds, including lignins, fats, resins, and glycosides, which can influence plant and seedling germination [8]. Pine cones represent an underutilized renewable resource. While they have found such applications as mulch production or crafts, their demand remains limited. Analysis of pine cone compounds has revealed the presence of substances like lignin and glucose [9]. According to Stocker et al. (2024), the application of lignin nanofibers boosted the germination rates of radish and cress seeds by 95% [10].

Various cultivation substrates have been examined to determine the optimal germination percentage and seedling quality for ornamental plants. Research indicated that the best germination substrate for cyclamen plants was a blend of sand, peat, and perlite [11]. Dhawani and Kumari (2023) suggested that cocopeat as a culture substrate significantly enhances the germination of Adenium compared to sand and vermicompost [12]. Another study discovered that pine wood and bark fibers were beneficial for the germination of Blueberry Saplings [8]. For the cultivation of flowering ornamental plants in green spaces across various climates, including tropical and semi-tropical regions, it is necessary to produce plug seedlings using suitable cultivation substrates. This study aimed to evaluate and compare the effects of pine cone peat + cocopeat substrate on the germination of *Zinnia elegans*, *Gaillardia aristata*, *Helianthus annuus*, *Osteospermum ecklonis*, *Petunia* × *atkinsiana*, and *Adenium arbicum*.

MATERIALS AND METHODS

The study was carried out at the Faculty of Agriculture, Hormozgan University, in 2024, utilizing a completely randomized design with a factorial layout and three replications. The substrates consisted of cocopeat and cellulose peat derived from *Pinus eldarica* cones. The properties of the substrates, which were purchased from Diana Bestar Company, are detailed in Table 1. Since cocopeat, perlite, and pine cone cellulose peat are processed at high temperatures, they do not require disinfection when used for the first time.

The seeds of the studied plants, including *Z. elegans*, *G. aristata*, *H. annuus*, *O. ecklonis*, *Petunia* × *atkinsiana*, and *A. arbicum*, were procured from Pakan Bazr Company in Isfahan, Iran. Table 2 presents the characteristics of the species and cultivars. The seeds were sown in 140-cell culture trays, with each tray corresponding to one replication of each plant's seeds. In the place used for seed germination, the temperature was 28±2° Celsius, the humidity was 70±5% and the light was 1500 lux cd·sr·m^{-2}. The parameters measured included the final germination percentage, the mean germination time, the coefficient of velocity of germination, the germination index, and the average daily germination percentage. These metrics were recorded from the first day of sowing until the conclusion of the experiment, which took 14 days.

Table 1. The specifications of the substrates used in the experiment (Tehran Khakazma Negin Company, 2023).

Substrate	pH	EC	CEC	N	P	K	Ca	Mn	Mg	Fe	Cu
Cocopeat	6.57	0.53	207	3.14	382	396	1380	10.	597	362	16
Pine cone peat	6.43	0.61	241	2.85	413	419	1438	58	1770	800	309

Table 2. The seeds of the plants used in the experiment.

Scientific name	Cultivar
Zinnia elegans	Will Rogers
Gaillardia aristata	Gallo yellow
helianthus annuus	Giraffe
Osteospermum ecklonis	Compactum
Petunia* × *atkinsiana	Super cascade
Adenium arbicum	Paper bite

The final germination percentage (GP) was calculated by Eq. (1) [13], in which *N* represents the number of seeds germinated until the conclusion day of the experiment and N_1 represents the total number of the seeds.

$$GP=N/N1 \qquad (1)$$

The mean germination time (MGT) was determined by Eq. (2) [14], in which *n* represents the number of seeds germinated per day, *d* represents the number of days from the experiment initiation, and *N* represents the total number of seeds germinated until the conclusion day of the experiment.

$$MGT= (n\times d)/N \qquad (2)$$

Eq. (3) was used to determine the coefficient of the velocity of germination (CVG) [15], in which *Ni* represents the number of seeds germinated per day and *Ti* represents the number of days from sowing related to N.

$$CVG= (N1+N2+\cdots Ni*100)/(N1*T1+N2*T2+\cdots Ni*Ti) \qquad (3)$$

The germination index (Gi) was estimated by Eq. (4) [16], in which *Ni* is the number of seeds germinated per day and *Di* is the day of counting the germinated seeds.

$$Gi=Ni/Di \qquad (4)$$

The mean day germination percentage (MGD) was determined by Eq. (5) [17], in which *GP* is the final germination percentage, and *ND* is the number of experiment days.

$$MGD=GP/ND \qquad (5)$$

Data analysis was conducted using SPSS software, and the data means were compared using Duncan's multiple range test.

RESULTS

The analysis of variance revealed that both the simple and interactive effects of the substrate and plant species significantly influenced the average germination time, the coefficient of velocity of germination, and average daily germination percentage at the $P < 0.01$ level. Additionally, the influence of plant species and its interaction with the substrate was significant ($P < 0.01$) on the final germination percentage and germination index, whereas the impact of the substrate was significant on these traits at the $P < 0.05$ level (Table 3).

Table 3. Analysis of variance for the effect of substrate and cultivar on the measured traits of the studied plants

Sources of variations	df	GP	MGT	CVG	Gi	MGD
Substrate	1	18.734*	6.610**	14.215**	0.602*	9.392**
Cultivar	5	2135.476**	17.330**	108.990**	42.263**	70.125**
Substrate × cultivar	11	1010.657**	110.598**	54.373**	20.786**	38.452**
Error	29	15.302	0.619	1.444	0.600	2.176
Coefficient of variations		1.041	4.428	9.316	3.897	15.342

GP = Final germination percentage; MGT = Mean germination time; CVG = Coefficient of velocity of germination; Gi = Germination index; MGD = Mean daily germination percentage

Final germination percentage

The comparison of data means indicated that the highest and lowest final seed germination percentage was obtained from *Petunia × atkinsiana* and *G. aristata* in the pine cone peat substrate, respectively (Table 4).

Table 4. The comparison of means for the effect of substrate and cultivar on the measured traits of the studied plant species

Substrate	Species	GP	MGT	CVG	Gi	MGD
Pine cone peat	*Zinnia elegans*	55^{gh}	6.743^{g}	15.280^{d}	5.927^{f}	3.928^{gh}
	Gaillardia aristata	43.486^{j}	7.820^{ef}	13.303^{gh}	5.408^{g}	3.623^{i}
	helianthus annuus	53.556^{h}	10.326^{a}	9.545^{j}	5.228^{g}	3.825^{h}
	Osteospermum ecklonis	68.380^{e}	5.679^{h}	20.533^{b}	10.400^{b}	7.597^{d}
	Petunia × atkinsiana	83.840^{d}	7.900^{ef}	13.668^{fg}	6.649^{e}	8.384^{c}
	Adenium arbicum	95.173^{a}	8.453^{bc}	14.352^{e}	7.181^{cd}	15.862^{a}
Cocopeat	*Zinnia elegans*	54.690^{gh}	3.145^{i}	17.511^{c}	5.529^{g}	4.971^{f}
	Gaillardia aristata	55.763^{g}	8.214^{d}	12.258^{i}	4.711^{h}	3.983^{g}
	helianthus annuus	51.703^{i}	8.690^{b}	12^{i}	4.304^{i}	3.693^{i}
	Osteospermum ecklonis	62.626^{f}	5.870^{h}	25.317^{a}	13.555^{a}	6.958^{e}
	Petunia × atkinsiana	92.940^{b}	7.774^{f}	13.046^{h}	6.949^{d}	8.449^{c}
	Adenium arbicum	90.370^{c}	8.085^{de}	14.900^{ef}	7.297^{c}	9.037^{b}

GP = Final germination percentage; MGT = Mean germination time; CVG = Coefficient of velocity of germination; Gi = Germination index; MGD = Mean daily germination percentage

Mean germination time

The data demonstrated that the longest mean germination time occurred in *H. annuus* planted in pine cone peat, whereas the shortest was for *Z. elegans* in cocopeat (Table 4).

Coefficient of velocity of germination

As per Table 4, the highest coefficient of velocity of germination was related to *O. ecklonis* in cocopeat, and the lowest to *H. annuus* in pine cone peat.

Germination index

The comparison of data means revealed that *O. ecklonis* achieved both the highest and lowest germination index – the highest in cocopeat but the lowest in pine cone peat (Table 4).

Mean daily germination percentage

According to Table 4, *A. arbicum* exhibited the highest germination index in pine cone peat and the lowest in cocopeat.

DISCUSSION

The findings indicated that cocopeat and pine cone peat as growth substrates had distinct effects on the germination of the ornamental seeds cultivated in this research, although all the seeds were from tropical and semi-tropical ornamental plants. Nutrient-rich substrates with high water retention and adequate porosity play a crucial role not only in seed germination but also in producing high-yielding potent plants [18, 19]. A study investigated the germination rates of four Goniolimon species, a genus of wild ornamental plants, using various substrates. The results demonstrated that perlite and peat doubled the germination rates of the plants [20].

In the current research, the majority of seeds exhibited satisfactory germination velocities in the cocopeat substrate. Sharma et al. (2021) found that a mix of cocopeat and perlite maximized the germination percentage and minimized the germination period for papaya seeds in culture trays [21], agreeing with our results. Additionally, another study highlighted that the seed germination index and velocity of *Semecarpus anacardium* were enhanced in cocopeat compared to other substrates.

In our research, *H. annuus*, *O. ecklonis*, and *A. arbicum* showed higher germination percentages in pine cone peat than in cocopeat. Moazen et al. (2020) observed that seeds in culture trays containing moss peat exhibited higher germination percentages than those in cocopeat, corroborating our findings [22]. In a study, palm peat was compared with peat moss as an alternative substrate for *Dahlia variabilis*, *Tagetes erecta*, *Z. elegans*, and *Cosmos bipinnatus*, revealing higher seed germination rates in palm peat [23].

In our study, the germination index for *Z. elegans*, *G. aristata*, and *H. annuus* was significantly higher in pine cone peat than in cocopeat. Consistent with our findings, Zeilabpour et al. (2019) reported increased tomato plant productivity in the compost of pine residues (leaves and cones) [24]. Macroelements and microelements are among the items that significantly influence seed germination. The growth of seedlings derived from seeds is bolstered by increasing the concentration of micronutrients [25, 26]. In the present study, the seeds of some plants (e.g., *A. arbicum* and *H. annuus*) showed relative or absolute superiority in the measured traits (final germination percentage, mean germination time, and mean daily germination percentage) in the pine cone peat. Conversely, some seeds exhibited results akin to those in cocopeat (coefficient of velocity of germination and germination index of *O. ecklonis*), partially due to higher micro and macronutrient content (except for nitrogen) in the pine cone peat (see Table 1).

Based on the standard germination test, the germination velocity is calculated in order to assess seed quality. Germination velocity serves as a measure of seed vigor, used to indicate the germination velocity of a seed lot rather than individual seeds [27]. Researchers have emphasized the significant role of nutrients in enhancing both the percentage and velocity of seed germination [28 - 30]. It was reported that vermicompost boosted the germination percentage and velocity of cumin seeds due to its nutrient content [31].

CONCLUSIONS

Pinus eldarica cone peat is an economical substrate that is cheaper than cocopeat—costing about half as much—and is commercially produced by the Diana Bastar Kasht company in Iran. This substrate is eco-friendly and natural, is devoid of pathogens and weeds, and contains macro and micronutrients with appropriate pH and electrical conductivity (EC) levels. The present study revealed that it enhanced the germination rates of *A. arbicum*, *H. annuus*, and *O. ecklonis* seeds compared to cocopeat. For *Z. elegans*, there was no significant difference in germination percentage between the pine cone peat and cocopeat. It is recommended to further investigate its effects on other ornamental plants for the production of plug seedlings.

Conflict of interests

Informed consent was obtained from all individual participants included in the study.

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