Influence of Colchicine Concentrations on Wheat Seeds Germination and Seedling Quality

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Abstract

The study investigated the effect of colchicine (C) on seeds germination, as well as morph physiological traits of wheat, where dry wheat seeds were treated with colchicine at concentrations of (C) were (0.02, 0.04, 0.06, and 0.08 %) compared to soaking in distilled water (control). The variance analysis results of laboratory germination experiments as well as in field experiments under rain-fed conditions showed that there were significant differences ($P < 0.05$) in the mean of most of the studied quantitative traits: germination quality such as germination force (%), germination energy (%), and laboratory germination (%). Leaf area (cm^2), root spread, stem diameter (cm), as well as wet and dry weight under the influence of the different concentrations of colchicine. Where the results showed that when used wheat seeds which pre-soaked with colchicine solution at a concentration of (0.06) % for 56 hours pre-sowing, led to an obvious significant increase in all studied traits morph physiological properties and seedling vigor when compared to the control (untreated seeds - treated with distilled water only) as well as when compared with other concentrations of colchicine.

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Introduction

Arid and semi-arid regions represent about 40% of the Earth's surface area, on which a large number of people live, and who work in various agricultural activities to meet their basic needs. However, agricultural activities in these regions face diverse constraints including low and erratic rainfall, extreme heat and frequent drought, and salinity in some low land regions. Which limited soil productivity in these regions, which also negatively affected the productivity of crop plants. Therefore, this was an impetus to come up with some different agricultural practices to cope with these challenges, modify and recommend them to maintain agricultural production, and improve the productivity of crops grown in these regions, which most of them are suffering from food insecure (Qader *et al.*, 2018; Golla, 2021).

Libya is one of the countries located within the arid and semi-arid lands, where located in the northern part of the continent of Africa and is the fourth largest African country. Agricultural activities represent an important part of the Libyan economy, as this sector comprises approximately 5% of the labor force and participates in 9 % of the gross domestic product. (The regions northeastern and western regions are the most arable areas in Libya (Al-Jabal al Akhdar and Al Jifarah Plain), amounting to 2.2 million hectares (FAO, 2009).

Changes in climatic factors and restrictions on agricultural lands led to restricting cereals production to only wheat and barley in Libya, just like all countries in

the arid and semi-arid regions. The agriculture of these cereals crops extends along the coastal strip depending on rainfall during the winter growing season (from November to April). Wheat is the most important cereal crop in the world, as well as arid and semi-arid areas in terms of cultivated area and production, but it comes in second place after barley under Libyan conditions where the cultivated area in 2020 amounted to 160 thousand hectares, and the total production amounted to 200 thousand hectares tons. Despite this, the value of wheat imports in the same year amounted to 1.5 million tons, as reported by the FAO.

It was found that one of the current trends to improve the productivity of crops in general and rainfed crops is to obtain good characteristics of crop seedlings in terms of vigorous growth, strong and rapid root spread to overcome these climatic conditions. Where it was found that the use of colchicine has an important role in improving the productivity of plants by improving the qualities and quality of seedlings and accelerating the germination and growth of many crops. In 2015 Eunice Essel and others found that the use of colchicine led to a significant improvement in all vegetative growth characteristics, as well as an increase in the number of leaves and tillers per plant. Which ultimately positively affects productivity.

Materials and Methods

Experiments were conducted in the department of environmental sciences, Faculty of natural resources and environmental sciences, University of Tobruk, Libya.

In a laboratory experiment the effect of soaking wheat seeds (Mexican variety) in a solution of colchicine at different concentrations (0.02, 0.04 0.06, and 0.08) % compared to soaking in distilled water (control), was studied to determine the efficiency of colchicine in improving germination properties. The percentage of energy germination was estimated after 4 days of planting and laboratory germination after a week according to what was mentioned by (Abdel Hamid S.E.A, Bugaev P.D, 2018), as well as the germination force that was estimated during 14 days of cultivation. The seeds were soaked for 56 hours before sowing using a completely random design in 3 replicates during the 2020 season.

Another experiment was conducted in boxes in the open field under rainfed conditions, where Mexican wheat was planted (using a completely random design in 3 replicates) each replicate with 100 seeds and the effect of colchicine on the morpho-physiological characteristics of wheat seedlings was studied, (where the wheat seeds were soaked 56 hours pre-sowing). Where the data was recorded during two stages (the stage of seedling growth 14 days after planting), and the second after two weeks from the first stage (for each replicate). Root and feather length (cm), wet and dry weight (g), leaf area (cm^2), and stem diameter (cm) were calculated during the two study stages.

Statistical analysis

Data were analyzed by using software IBM SPSS Statistics 20, and analysis of variance (ANOVA) significant treatment means were compared using the least significance difference (L.S.D) test at 0.05 according to (Gomez and Gomez, 1980)

Results and Discussion

The results in figure 1 showed the effect of the pre-soaked wheat seeds in colchicine, and pre-sowing on the quality of wheat seedling. The Laboratory germination, force, and energy of germination. Laboratory results showed that morpho-physiological evaluation of seedlings and the effect of the seed treatments pre-sowing (soaking), where obtained data showed that the response of wheat seeds to the different concentrations of colchicine. The use of

colchicine led to an improvement and increase in germination characteristics, the differences were significant when comparing the different concentrations of colchicine when compared to the control (untreated seeds). The percentage of germination energy, laboratory germination, and germination force increased when soaking in (0.06) % concentration by (5.6, 4.5 and 8) % respectively, compared to the control, which reached (89, 92 and 88) %, respectively.

On the other hand, the performance of seedlings did not differ, and the differences were not significant at (0.08) % concentration with the control, while the results were somewhat similar at (0.02 and 0.06) % concentrations. These results are consistent with what was reached and mentioned by (Mensah *et al.*, 2007) on the sesame. The results are also in agreement with what was done by Kolhe and others in 2020 when they used colchicine on coriander, where explained that the use of colchicine led to a remarkable improvement in the vegetative growth, which led to an increase in productivity,

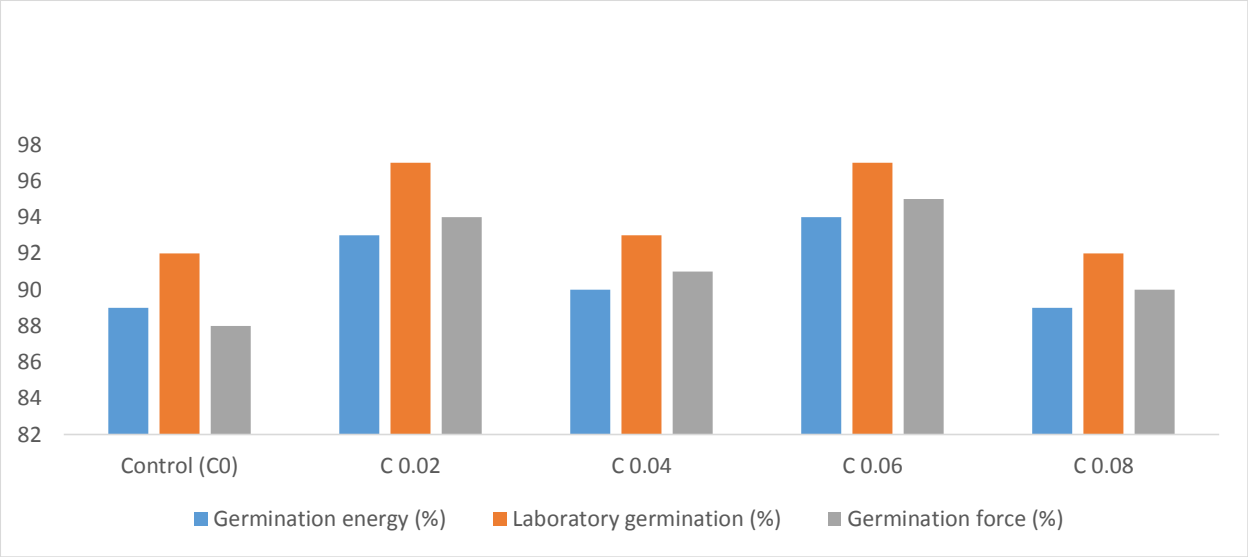

Figure 1. Effect of different concentrations of colchicine on germination traits (%)

The data presented in Table 1 shows the effect of colchicine on the vigor of germination and the emergence of seedlings by calculating the number of days from planting until the appearance of the first seedling. Where we find that the use of colchicine led to an increase in the speed of germination compared to the control, knowing that this differed with the different concentrations of colchicine and the results were significant differences. The results recorded an increase in the speed of seed germination and force of seedlings by (38.5 and 34.6) % when pre-soaking wheat seeds in colchicine pre-sowing at a concentration of (0.06 and 0.020) % compared to the control, respectively.We note, according to the data in the table, that the emergence of the first germination of wheat seeds was after 26 days of planting in untreated seeds (soaking in distilled water (control), while germination was after (16, 17, 21, and 23) days when used pre-soaked wheat seeds in colchicine, at these four different concentrations of colchicine, respectively.

Table 1. Impact of colchicine on wheat seeds germination (day)

Colchicine concentration (%)	Number of days after planting							
	7	10	13	16	17	21	23	26
Control)	-	-	-	-	-	-	-	✓
0.2	-	-	-	-	✓	-	-	-
0.4	-	-	-	-	-	-	✓	-
0.6	-	-	-	✓	-	-	-	-
0.8	-	-	-	-	-	✓	-	-

The effect of different colchicine concentrations on root and feather length in the field is shown in Fig(2) at colchicine concentration (0.02 to 0.08)% in the first phase in the 14 th day after planting, the root length ranges from(8.8 to 5.3) cm respectively, While the root length was 3.8 cm by control. Root length also increased during the second stage, in the 28 th day after planting by (36, 34, 35 and 49) %, respectively, while the root length increased in untreated seeds by (28) %.

As for the feather length, the wheat seeds pre-soaked with a colchicine concentration of (0.6) % recorded the best results, as the feather length increased by (92.5) % in the first stage, and (149.2) % in the second stage compared to the control (untreated seeds).

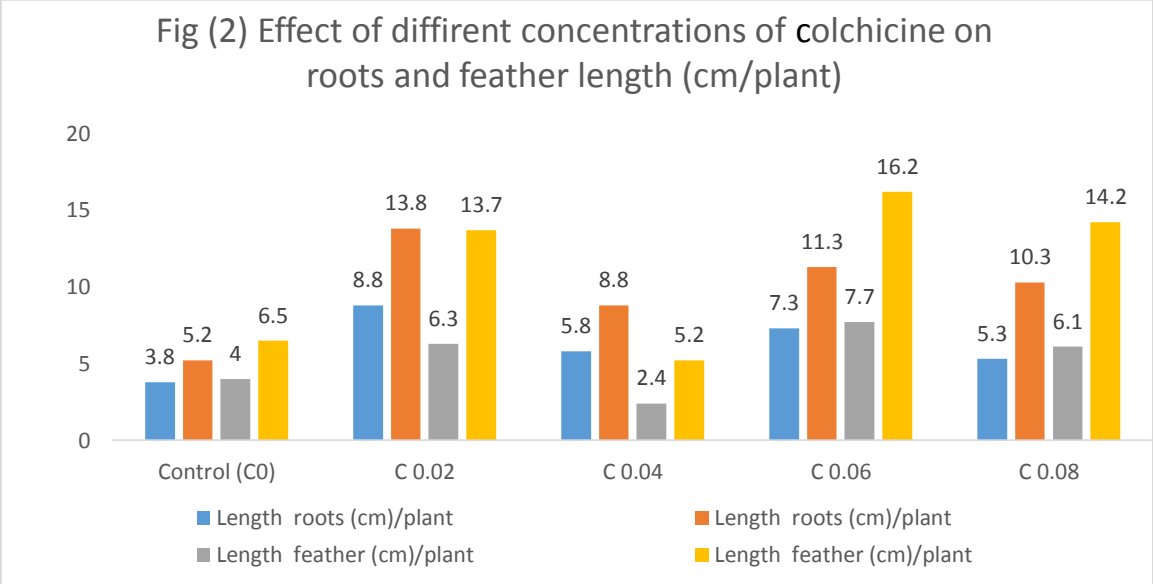

Figure 2. Effect of different concentrations of colchicine on root and feather length (cm/plant)

The following figure 3 shows the fresh and dry weight of plants during the two study phases (14 and 28) days after planting This indicates the discrepancy in the performance of wheat with the different concentrations of colchicine and we found a clear superiority in the performance of seedlings when using the 0.6 concentration, which increased the wet weight by (167 and 139) % compared to the control respectively. Also the accumulation of dry matter increased by (85 and 90) % compared to the control during the two growth phases under study, respectively.

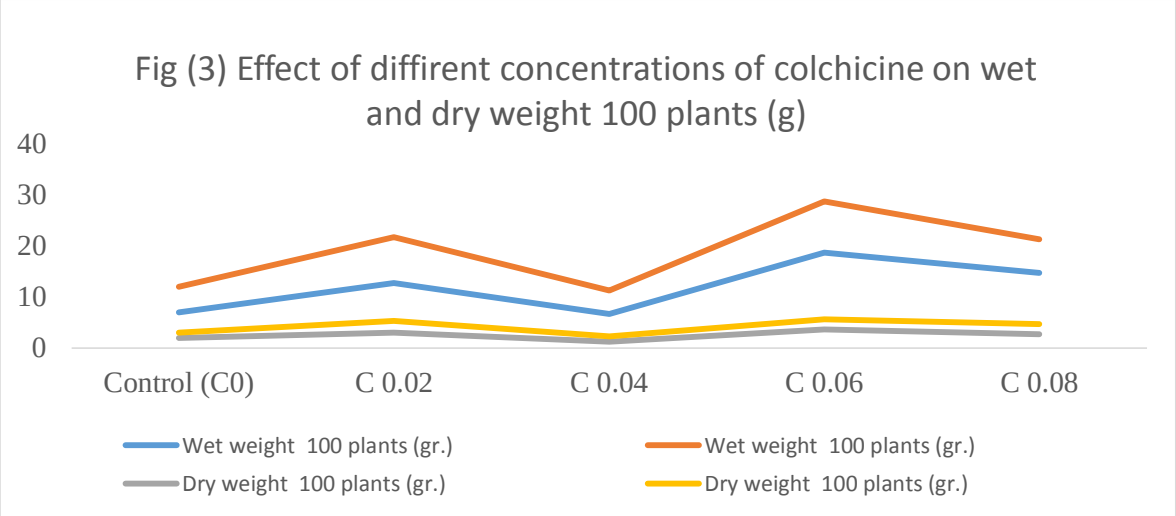

Figure 3. Effect of different concentrations of Colchicine on wet and dry weight (100 plants (g)

Colchicine had a positive effect on both the leaf area as well as the stem diameter. We note a significant and clear increase in the leaf area of wheat seedlings in Table 2 which increased during the first stage of recording and enumerating the data from (60) cm^2 for untreated wheat seeds to (203.7) cm^2 when the wheat seeds were soaked in colchicine solution at a concentration of (0.06) % and thus the increase was (240) %.

During the second stage (28) days after sowing, leaf area increased by (336) % as well when soaking in colchicine solution at a concentration of (0.06) % compared to control.

The improvement and increase in these traits when presoaking wheat seeds may be due to chromosomal doubling, which led to an increase in vegetative growth indicators, tissue thickness development and an increase in cell size (Dehghan *et al.*, 2010; Hiaba and Mohamed, 2009).

Table 2. Impact of different concentrations of colchicine on leaf area (cm^2) and stem diameter (cm)

Colchicine concentration (%)	leaf area (cm^2)		stem diameter (cm)	
	after 14 days	after 28 days	after 14 days	after 28 days
Control	60.00	75.00	0.50	0.50
0.2	116.3	261.3	0.60	0.74
0.4	59.00	75.50	0.60	0.70
0.6	203.7	327.0	0.82	0.94
0.8	120.7	300.0	0.60	0.80

Table 3 deals with the effect of colchicine on both the number of lateral roots as well as the number of leaves of each plant during the two study phases (14 and 28) days after planting. The results of colchicine treatments didn't achieve significant differences on the number of roots, which was clearly reflected evident on the number of leaves per plant, which was represented by three leaves for all treatments during the first stage. Despite the slight increase in the number of roots during the second stage (14) days after planting, It didn't affect the number of leaves of the plant when the seeds were treated with a concentration of (0.02 and 0.04) % of colchicine, as well as the untreated seeds. On the other hand, the number of leaves increased with an increase the concentration of colchicine to (0.06 and 0.08) % by (67 and 33) % respectively compared to the control.

Table 3. Effect of different concentrations of colchicine on number of roots and leaves per plant

Colchicine concentration (%)	Number of roots per plant		Number of leaves per plant	
	after 14 days	after 28 days	after 14 days	after 28 days
Control	4	5	3	3
0.2	6	7	3	3
0.4	5	5	3	3
0.6	6	8	3	5
0.8	4	5	3	4

Conclusion

According to the results obtained by using colchicine solution to soak wheat seeds (Mexican variety) pre-sowing it was found that colchicine had a positive effect on the germination traits and quality of wheat seeds as well as the force and speed of seedling growth during laboratory germination experiments as well as in field experiments under rain-fed conditions. Through the use of wheat seeds pre-soaked with colchicine solution at a concentration of (0.06) % for 56 hours pre-sowing, there were significant differences in most of the studied traits, such as germination energy, laboratory germination, seedling vigor, growth force, spread roots and leaf area.

Conflict of Interest

The authors declare that they have no conflict of interest.

Acknowledgments

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References

Abd Elkader, A. E. S. E., & Bugaev, P. D. (2018). Effect of seed treatments on barley germination quality. *Bioscience Research*, *15*(4), 4243-4247.

Association of Official Seed Analysts [AOSA]. (1983). Seed Vigor Testing Handbook. AOSA, Ithaca, NY, USA. (Contribution to the Handbook on Seed Testing, 32).

Atlas of natural resources for agricultural use in Libya. (2009). Available online: http://www.fao.org/geospatial/resources/detail/en/c/1024739/

Dehghan, E., Häkkinen, S. T., Oksman-Caldentey, K. M., & Shahriari Ahmadi, F. (2012). Production of tropane alkaloids in diploid and tetraploid plants and in vitro hairy root cultures of Egyptian henbane (Hyoscyamus muticus L.). *Plant Cell, Tissue and Organ Culture (PCTOC)*, *110*(1), 35-44.

Hiaba, A. A., & Mohamed, A. Y. (2009). Comparative studies on diploid and tetraploid levels of Nicotiana alata. *Academic Journal of Plant Sciences*, *2*(3), 182-188.

Essel, E., Asante, I. K., & Laing, E. (2015). Effect of colchicine treatment on seed germination, plant growth and yield traits of cowpea (Vigna unguiculata (L.) Walp). *Canadian Journal of Pure and Applied Sciences*, *9*(3), 3573-3576.

FAO, Status of the World's Soil Resources. (2015). In Food and agriculture organization of the United Nations and intergovernmental technical panel on soils; Rome, Italy, P: 650.

Golla, B. (2021). Agricultural production system in arid and semi-arid regions. *J Agric Sc Food Technol*, *7*(2), 234-244.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research*. John wiley & sons.

Kolhe, P. N., Varne, M. D., Deshmukh, S. N., Harke, S. N., & Wagh, S. G. (2020). Assessment of mutagenicity induced by different mutagens in coriander (Coriandrum sativum L.). *Biotechnology Journal International*, *24*(5), 12-21.

Mensah, J. K., Obadoni, B. O., Akomeah, P. A., Ikhajiagbe, B., & Ajibolu, J. (2007). The effects of sodium azide and colchicine treatments on morphological and yield traits of sesame seed (Sesame indicum L.). *African Journal of Biotechnology*, *6*(5):534-538.

Prashant N. Kolhe, Mrunalini D. Varne, Sumit N. Deshmukh, Sanjay N. Harke and Sopan G. Wagh .(2020). Assessment of mutagenicity induced by different mutagens in coriander (*Coriandrum sativum* L.). *BioTechn. J. Int.l 24* (5): 12-21.

Qader, S. H., Dash, J., & Atkinson, P. M. (2018). Forecasting wheat and barley crop production in arid and semi-arid regions using remotely sensed primary productivity and crop phenology: A case study in Iraq. *Science of the total Environment*, *613*, 250-262.

Thomas, H. (1975). The growth responses to weather of simulated vegetative swards of a single genotype of Lolium perenne. *The Journal of Agricultural Science*, *84*(2), 333-343.