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Influence of Soil Conditioner Rate on Seed Germination and Growth of Cucumber Plants (*Cucumis sativus* L.)

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ABSTRACT. The effect of five levels (0, 0.2, 0.4, 0.6 and 0.8% on dry matter basis) of gel-forming conditioner (Broad leaf P4) on seed germination and growth of cucumber, *Cucumis sativus* L. cv. Dina, was investigated. The experiment was carried out in greenhouse with day and night temperature of 25° and 18°C. The gel forming conditioner was added to the top 10 cm of the pots. Increasing gel conditioner rate in the growth media has resulted in rapid germination. The addition of gel conditioner increased the early growth of the seedlings. Control plants had significantly lower leaf number than the treated plants but significantly higher average leaf area. At the end of the experiment, 75 days after sowing, no significant treatments effects were observed on plant height, or on shoot fresh and dry matter weights. Relative water content (RWC), Water use efficiency (WUE) and total yield were significantly increased with addition of gel conditioner.

Cucumber is one of the main vegetable crops grown in Saudi Arabia, especially under protected cultivation. Cucumber production has increased from 70 thousand tons in 1986 to 98 thousand tons in 1990. Almost 59% of the crop is produced under protected cultivation (Ministry of Agriculture and Water 1990). Cucumber growth can be affected by many factors, such as soil moisture content. Constant supply of moisture is necessary during the life of the plant, especially during flowering and fruiting (Loomis 1977).

Keywords: *Cucumis sativus;* soil conditioner; seeds germination; growth; RWC; WUE.

The scarcity of water is a limiting factor for agriculture specially under desert conditions. With an improved water use efficiency (WUE) limited amount of available water can be used more effectively by plants. Soil conditioners such as super-absorbant materials may potentially improve plant access to water. Soil conditioners reduce evaporation and increase soil available water (Al-Omran *et al.* 1987). Their application improves soil physical properties (Miller 1979, Johnson 1984, Al-Omran *et al.* 1987, Wallace and Wallace 1986a), and increases soil swelling and decreases infiltration rate (Miller 1979). Bres and Weston (1993) found a linear increase in water retention by the growth media with gel application.

The addition of soil conditioner to the growth media increased seed germination and early growth of the plants (Cook and Nelson 1986). Seed germination and seedling growth of tomato, cotton, lettuce and wheat were increased with the addition of gel conditioner (Wallace and Wallace 1986b, c; Verplancke *et al.* 1990).

However, other studies showed that water-soluble polymer did not affect plant growth (Ingram and Yeager 1987, Wang 1989). Recently, Bres and Weston (1993) examined the effect of hydrosource and Agri-gel incorporated at different levels in a growth medium containing 1 part peat: 1 part perlite: 1 part vermiculite on the growth of tomato seedlings. They found that seedling growth was not affected by the gel application.

Plant response to gel conditioner might be, relatd to the gel type (Wang and Gregg 1990), rate of application (Al-Harbi *et al.* 1994) and irrigation water quality (Johnson 1984). The objective of this study was to determine the effect of soil conditioner (Broad leaf P4) on seed germination and the growth of cucumber plants.

Materials and Methods

A surface soil sample (0-20 cm) was collected from the Experimental Research Station at Dierab, Saudi Arabia. The soil contained 77% sand, 12% silt and 11% clay. It contained very low organic matter (0.75%), high $CaCO_3$ (28%), a low amount of soluble salts (EC_e = 0.76 dSm^{-1}) and very low SAR value (0.81). The soil is classified as a calcareous sandy loam (torripasment). The soil was air dried and passed through a 2 mm sieve.

The gel-forming conditioner bought from the local market and used was Broad leaf P4*, manufactured by Agricultural Polymer Ltd, UK, with a grain size of 0.5-1.5 mm. The soil conditioner was applied to the soil at five rates: 0.0 (control), 0.2, 0.4, 0.6, and 0.8% (on a dry weight basis). The corresponding amounts of soil conditioner were thoroughly hand-mixed with air dried soil. Subsamples were taken from each treatment to determine the moisture content at 0.01 MPa (Field capacity) using a pressure plate apparatus (Black 1965).

The soil was placed in plastic pot, 23 cm in diameter and 30 cm in height, to bulk density of 1.5 g/cm^3. The treated soils with the appropriate rate of soil conditioner were mixed with the top 10 cm of soil in the pots and 5 cm from soil surface to the edge of the pots was left for soil expansion. The pots were placed in greenhouse at 25 ± 3°C day and 18 ± 3°C night time temperatures. The treatments were replicated five times and the experiment was carried in completely randomized design (CRD).

Before sowing cucumber seeds (*Cucumis sativus* L.), all treatments were irrigated using tap water (EC = 0.4 dS m^{-1}, SAR = 0.9) to field capacity of each treatment. The amount of irrigation water to reach the field capacity was 2091 cm^3 for control, 2538 cm^3 for 0.2%, 3060 cm^3 for 0.4%, 3722 cm^3 for 0.6% and 4493 cm^3 for 0.8% of soil conditioner rate. Twenty four hours after wetting the pots to field capacity, five seeds of cucumber were sown in each pot at a depth of 2 cm. Seed germination was recorded daily and seed germination index was calculated as follows:

$$GI = \frac{\Sigma T_i N_i}{S}$$

Where T_i is the number of days after sowing, N_i is the number of seeds germinated on day i, and S is the total number of seeds planted (Scott *et al.* 1984).

At the second true leaf stage the seedlings were thinned to one seedling per pot. Afterward, all treatments were irrigated every 3 days with a fixed amount of tap water. The total amount of irrigation water for each pot during growing period (75 days) was 19500 cm^3 plus the initial amount of irrigation at field capacity for each treatment. The amount of water added during the growing season was calculated to ensure that no drainage water were collected from the pots. A fixed amount of nutrient solution was added to each pot (Collin and Jensen 1983). The retained water in the soil at harvest was 825 cm^3 for control, 1100 cm^3 for 0.2%, 1310 cm^3 for 0.4%, 1750 cm^3 for 0.6% and 1950 cm^3 for 0.8% soil conditioner rate.

* The use of trade name is for the information and convenience of the reader. Such use does not constitute an official endorsement of the product.

Changes in plant height and stem diameter were measured four weeks after sowing over a 10-day period. Leaf expansion was measured non-destructively four weeks after germination as described by Ismail (1989). The estimated leaf area (LA) was calculated based on a series of leaf breadth measurements using a regression equation of:

$$LA = 0.1828 * LB^{2.4284}$$

Where LA is estimated leaf area (cm^2), LB is leaf breadth (cm). ($n = 30$, $R^2 = 0.9878$). Relative water content (RWC), was measured in the plants seven weeks after sowing; it was calculated as follows:

$$RWC = \frac{FW - DW}{TW - DW} * 100$$

Where FW is fresh weight, DW is dry weight and TW is turgor weight.

Water use efficiency (WUE) was calculated as follows:

$$WUE = \frac{\text{total yield (mg)}}{\text{evapotranspiration } (cm^3)}$$

At the end of the experiment, plant height, fresh and dry weight of the aerial parts were measured. Leaf area measurement was carried out on a sample of five leaves from each plant. Fruit number per plant and total fruit weight per plant were determined.

Results and Discussion

Cucumber seed germination started five days after sowing. Results presented in Fig. 1 and in Table 1, indicate a shorter germination time with the addition of soil conditioner. Germination index (GI) was significantly decreased at the 0.2% conditioner rate compared to the control. Increasing gel conditioner rate to 0.4, and 0.6 slightly reduced the GI but the difference was not significant. Rapid seed germination could be attributed to the positive effect of gel conditioner addition which is reported to increase the available water (Al-Omran *et al.* 1987) and improve soil texture (Wallace and Wallace 1986a). Wallace and Wallace (1986b) also

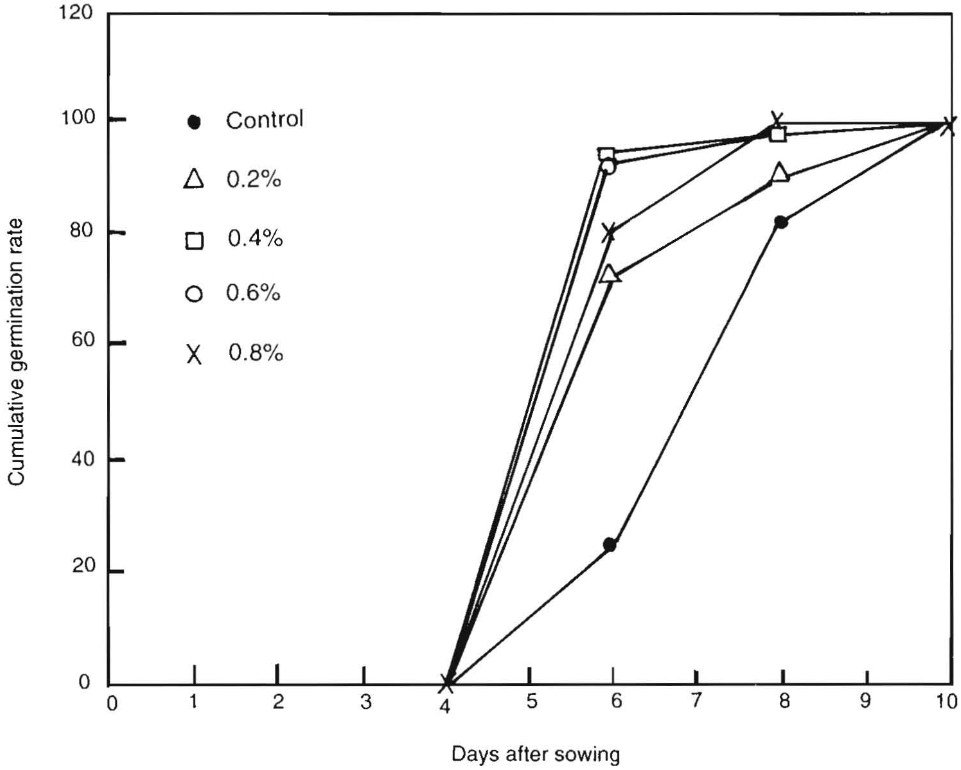

Fig. 1. Effect of soil conditions, percentage on cumulative seed germination rate.

reported an increase in earliness of seed germination of lettuce and cotton with addition of combined dry and solution of polyacrylamide (PAM). Cook and Nelson (1986) found that PAM solution improved seed germination compared to granular PAM application. Seven days from sowing in the present experiment, 100% of the seeds germinated for all treatments.

Our results show a progressive increase in the early growth of the stem and leaves with increasing gel conditioner rate in the growth medium. This is indicated by the changes in plant height, stem diameter and leaf area (Figs. 2 a, b and 3). The application of soil conditioner of 0.4 and 0.6% gel significantly increased RWC of the plants compared to the other treatments (Table 1). Further increase in the conditioner rate to 0.8% did not affect the RWC of the plants.

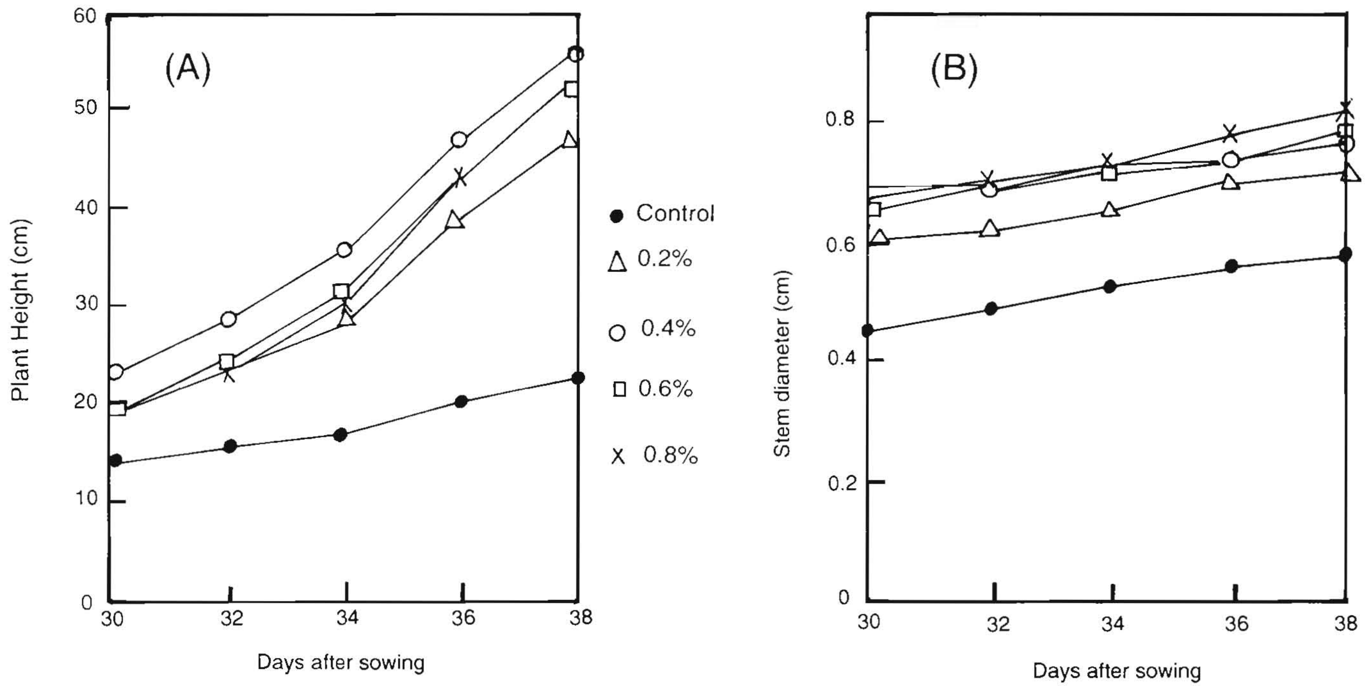

Fig. 2. Changes in plant height (A) and stem diameter (B) as influenced by soil conditioner rate.

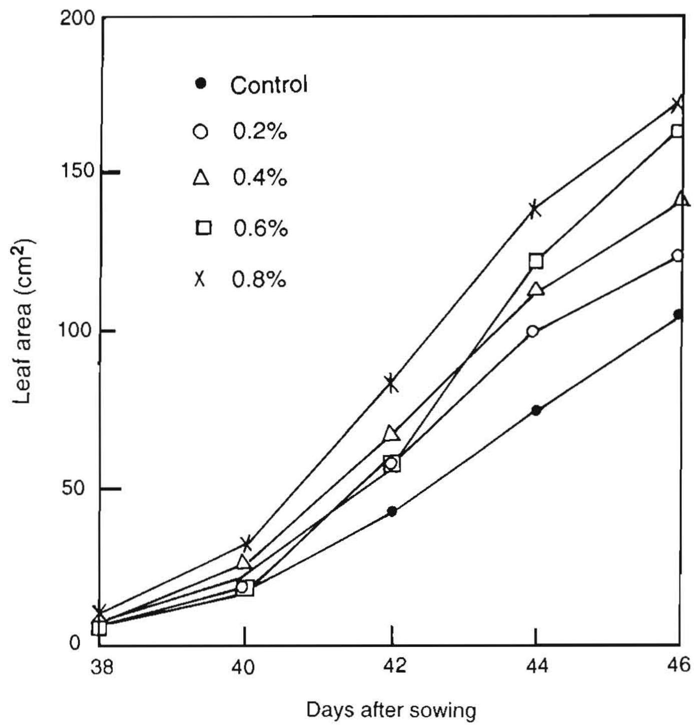

Fig. 3. Changes in leaf are as influenced by soil conditioner rate.

Table 1. Effect of soil conditioner rate on seed germination index (GI) and relative water content (RWC)

Soil conditioner rate	GI	RWC (%)
Control	6.8 a	84. 79b
0.2%	6.6 ab	87.42 ab
0.4 %	6.0 abc	88.47 a
0.6%	5.8 bc	89.39 a
0.8%	5.6 c	87.03 ab

* Means followed by the same letter within a column are not significantly different at the 5% level as determined by the least significant difference.

Table 2. Effect of the soil conditioner rate on the means of plant height, leaf number, leaf area, shoot fresh and dry weight and dry weight percentage at the end of the experiment

Soil conditioner rate	**Plant height (cm)**	**Leaf number (1/p)**	**Leaf area (cm^2)**	**Shoot weight**		
				FW (g/p)	**DW (g/p)**	**DW %**
Control	182.5 b	24.75 b	260.45 a	233.79 a	24.65 a	10.67 b
0.2%	206.25 ab	30.75 a	216.67 b	236.87 a	26.79 a	11.40 ab
0.4 %	227.5 a	28.75 a	200.27 b	218.61 a	26.07 a	11.92 a
0.6%	181.25 b	27.75 ab	210.87 b	222.83 a	23.83 a	10.67 b
0.8%	211.25 ab	29.00 a	211.51 b	220.95 a	24.35 a	10.90 b

* Means followed by the same letter within a column are not significantly different at the 5% level as determined by least singificant difference.

At the end of the experiment, no significant differences were observed between the treatments for plant height and fresh and dry weight of the shoots (Table 2). The highest leaf area was recorded in control plants while 0.2% treatment plants gave a higher leaf number, which resulted in slightly higher shoot fresh and dry weight but the difference was not significant. These results are in agreement with the results reported by Wang, (1989) on tropical ornamental plants. Also Bres and Waston (1993) reported that fresh and dry weights of tomato seedlings were not affected by adding hydrogel to the growth media when the water supply limitation was removed as a confounding factor. Fertilizer solution and salts dissolved in irrigation water might limit the benefits of gel conditioner, as reported by Johnson (1984) who found that polyacrylamide gel hydration was inhibited more than 75% by a saline water (EC = 3.2 dS m^{-1}). Also Bowman *et al.* (1990) reported that gels (hydrophilic polyacrylamide gels) exclude salts from the absorbed water which led to an increase in the salt concentration in the external solution. They concluded that, in the presence of fertilizer salts, gel amendment had a little or no significant effect on the physical properties of the growth medium.

Table 3. Effect of the soil conditioner rate on the total fruit number per plant, fruit weight (g/p) and water use efficiency (WUE)

Soil conditioner rate	Fruit number (f/p)	Total fruit weight (g/p)	WUE
Control	5.25 a	253.5 b	12.21 b
0.2 %	6.25 a	403.42 ba	19.27 ba
0.4 %	7.5 a	503.87 a	23.71 a
0.6 %	7.25 a	537.70 a	24.98 a
0.8 %	7.5 a	540.07 a	24.50 a

* Means followed by the same letter within a column are not significantly different at the 5% level as determined by the least significant difference.

Water use efficiency (WUE) expressed on total yield basis is presented in Table 3. Generally, the results showed that WUE was significantly increased with increasing soil conditioner rates compared to that for the control, with the exception of the 0.2% soil conditioner rate. However, the differences in WUE between the soil conditioner rates were not significant. Similar results were found in our earlier study on tomato (Al-Harbi *et al.* 1994). El-Kommes *et al.* (1989) also reported an increase in WUE with addition of soil conditioner (Boligrow) at the rate of 0.25%, and a further increase in soil conditioner rate reduced the WUE. Table 3 also shows that the fruit number per plant was not affected significantly by the addition of soil conditioner. However, total yield per plant was rapidly increased with increasing soil conditioner rate in the growth medium but the differences between effects of soil conditioner rates were not significant.

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References

Al-Harbi, A.R., Al-Omran, A.M., Wahdan, H. and **Shalaby, A.A.** (1994) Impact of irrigation regime and addition of a soil conditioner on tomato seedling growth. *Arid Soil Research and Rehabilitation,* **8:** 285-290.

Al-Omran, A.M., Mustafa, A. and **Shalaby, A.A.** (1987) Intermittent evaporation from soil columns as affected by a gel-forming conditioner. *Soil Sci. Soc. Am. J.,* **51:** 1593-1599.

Black, C.A. (1965) *Methods of Soil Analysis,* Parts 1 and 2. American Society of Agronomy, Maddison, WI.

Bowman, D.C., Evans, R.Y. and **Paul, J.L.** (1990) Fertilizer salts reduce hydration of polyacrylamide gels and affect physical properties of gel-amended container media. *J. Am. Soc. Hortic. Sci.,* **115:** 382-386.

Bres, W. and **Weston, L.A.** (1993) Influence of gel additives on nitrate, ammonium and water retention and tomato growth in a soilless medium. *Hort. Sci.,* **28:** 1005-1007.

Collin, W.L. and **Jensen, M.H.** (1983) Hydroponics. A 1983 technology overview. The environmental research laboratory. University of Arizona, *Tucson.,* 119 p.

Cook, D.F. and **Nelson, S.D.** (1986) Effect of polyacrylamide on seedling emergence in crust-forming soils. *Soil Sci.,* **141:** 328-333.

El-Kommos, F., Dahroug, A.A. and **Nour El-Din, Y.** (1989) Evaporation, water use efficiency and dry matter of wheat as affected by some soil conditioners and different soil moisture levels. *Egypt. J. Soil Sci.,* **29:** 387-400.

Ingram, D.L. and **Yeager, T.H.** (1987) Effect of irrigation frequency and water-absorbing polymer amendment on ligustrum growth and moisture retention by a container medium. J. *Environ. Hortic.,* **5:** 19-21.

Ismail, M.R. (1989) *The effect of salinity and vapour pressure deficit on the growth of tomatoes (Lycopersicon esculentum).* Ph.D. University of London, Faculty of Science.

Johnson, M.S. (1984) Effect of soluble salts on water absorption by gel-forming soil conditioner. *J. Sci. Food Agric.,* **35:** 1063-1066.

Loomis, E.L. (1977) Water consumption of cucumber during vegetative and reproductive stages of growth. *J. Amer. Soc. Horti. Sci.,* **102:** 124-127.

Miller, D.E. (1979) Effect of H-SPAN on water retained by soils after irrigation. *Soil Sci. Soc. Am. J.,* **43:** 628-629.

Ministry of Agriculture and Water (1990) *Agriculture statistical year book.* Seventh volume.

Scott, S.J., Jones, R.A. and **Williams, W.A.** (1984) Review of data analysis methods for seed germination. *Crop. Sci.,* **24:** 1192-1199.

Verplancke, H., De Boodt, M. and **Al-Jloud, A.A.** (1990) Effect of synthetic polymers on water use efficiency for crop production on sandy soils in Saudi Arabia. *Soil Tech.,* **3:** 45-55.

Wallace, A. and **Wallace, G.A.** (1986a) Effect of very low rate of synthetic soil conditioners on soils. *Soil Sci.,* **141:** 324-327.

Wallace, A. and **Wallace, G.A.** (1986b) The effect of soil conditioners on emergence and growth of tomato, cotton and lettuce seedling. *Soil Sci.*, **141:** 313-316.

Wallace, A. and **Wallace, G.A.** (1986c) Enhancement of coal fly ash by a polyacrylamide soil conditioner on growth of wheat. *Soil Sci.*, **141:** 387-389.

Wang, Y. (1989) Medium and hydrogel affect production and wilting of tropical ornamental plants. *Hort. Sci.*, **24:** 941-944.

Wang, Y. and **Gregg, L.L.** (1990) Hydrophilic polymers- Their response to soil amendments and effect on properties of soilless potting mix. *J. Am. Soc. Hortic. Sci.*, **115:** 943-946.

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تأثير معدلات التربة على إنبات البذور والنمو لنباتات الخيار (*Cucumis sativus* L.)

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ص .ب (٢٤٦٠)- الرياض- ١١٤٥١ - المملكة العربية السعودية

درس تأثير اضافة معدلات مختلفة من محسن التربة (Broad leaf P4)على إنبات البذور ونمو نباتات الخيار (صنف دينا) . استخدمت خمس معدلات من محسن التربة (صفر ، ٢ ,٠ ، ٤ ,٠ ، ٦ ,٠ ، ٨ ,٠٪ أضيفت على أساس الوزن الجاف للتربة) . وقد استخدمت تربة جيرية طميية رملية تحتوي على ٧٧ ٪ رمل ، ١٢٪ سلت و ١١٪ طين . كما احتوت التربة على ٧٥ ,٠٪ من المادة العضوية و٢٨٪ كربونات كالسيوم $CaCo_3$ ومعامل توصيل كهربي ٨٦ ,٠ ديسمن/ م ونسبة ادمصاص الصوديوم (SAR) ٨١ ,٠ .

تمت اضافة محسن التربة الى الطبقة السطحية (١٠ سم) من التربة داخل القصارى . حيث تم خلط الكمية المناسبة من محسن التربة مع التربة المجففة هوائياً وقد تم تقدير السعة الحقلية عند ١ ,٠ بار شد مائي للتربة المستخدمة .

نفذت التجربة في تصميم عشوائي كامل (CRD) باستخدام خمس مكررات . وضعت القصارى داخل بيت محمي وتم ضبط درجة الحرارة على ٢٥ْ م نهاراً و١٨ْ م ليلا . قبل زراعة البذور تم ري القصارى الى سعتها الحقلية . وكانت كمية المياه المستخدمة للوصول الى السعة الحقلية ٢٠١٩ سم٣ للتربة الغير معاملة ، ٢٥٣٨ سم٣ للمعاملة ٢ ,٠٪ ، ٣٠٦٠ سم٣ للمعاملة ٤ ,٠٪ ، ٣٧٢٢ سم٣ للمعاملة ٦ ,٠٪ و٤٤٩٣ سم٣ للمعاملة ٨ ,٠٪ من محسن التربة . أدت زيادة محسن التربة الى الاسراع في إنبات البذور كما أدت الى زيادة النمو الخضري للبادرات . أظهرت النتائج انخفاضاً معنوياً في عدد الأورق للنباتات الغير معاملة مقارنة بالنباتات المعاملة بينما كان معدل المساحة الورقية أعلى في النباتات الغير معاملة . في نهاية التجربة ، بعد ٧٥ يوماً من الزراعة ، لم يظهرتأثير معنوي للمعاملات على طول النبات أو على الوزن الخضري والجاف للبادرات . كما أظهرت النتائج زيادة معنوية في محتوى الماء النسبي وكفاءة استخدام المياه وكذلك المحصول الكلي بزيادة معدل محسن التربة في بيئة النمو .