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Changes in Germination and Primarily Growth of Three Cultivars of Tomato Under Diatomite and Soil Materials in Auto-Irrigation System

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Abstract

In order to evaluate the effects of different materials on germination and growth of tomato (*Solanum lycopersicum L.*) cultivars under negative pressure hydraulic auto-irrigation systems, an experiment was conducted in National Engineering Research Center for Intelligent Agricultural Equipments, Beijing, China. Three cultivars of tomato (Jiafen No-18, Jiahong No-5, and Jiahong No-4) as main plots, and three materials, including: 100% soil, 50% diatomite + 50% soil, and 100% diatomite as sub plots, were evaluated in a split plot based on randomized complete block design with three replications in a green house. Cultivar effect was significant on total germination percentage, speed of germination, radicle length, coleoptiles length, fresh leaf weight and fresh coleoptiles weight were significance. The influence of material on total germination percentage, speed of germination, mean germination time, coefficient of velocity germination, radicle length, coleoptiles length and fresh leaf weight were meaningful. The highest total germination percentage (74.99%), coefficient of velocity germination (0.57), coleoptile length (6.00 cm), fresh leaf weight (0.31 g), fresh coleoptile weight (0.30 g), dry leaf weight (0.019 g) and dry coleoptile weight (0.017 g) was observed in Jiafen No-18. However, Jiahong No. 4 had the maximum speed of germination. While maximum values of total germination percentage, speed of germination, mean germination time was related to 100% soil. Application of 50% soil + 50% diatomite obtained the highest radicle length, coleoptile length, fresh leaf weight, fresh coleoptile length and dry leaf weight. It seems that application of 50% soil + 50% diatomite, and Jiafen No. 18 is appropriate under the negative pressure hydraulic auto-irrigation system.

Keywords: coleoptile, diatomite, germination, primarily growth, radicle, tomato

1. Introduction

The production of tomato (*Solanum lycopersicum L.*) has increased worldwide at about 40% during the last 10 years, and greenhouse cultivation had become economically important for all year round Tomato (Yarra et al., 2012; Schwarz et al., 2013; He et al., 2009), which consumed all over the world (Rai et al., 2013). Tomato is an important source of vitamins and minerals in the human diet (Fujimura et al., 2013). Since germination is the first stage in the vegetative growth of plants, an important and sensitive stage in plant life cycle, and a key process in the emergence of plants (Villiers et al., 1994; Yasari et al., 2013). Poor seed germination is a common phenomenon which causes a great concern for vegetable growers (Peyvast et al., 2010; Naderidarbaghshahi & Jalalizand, 2013). Delayed and reduced germination and seedling emergence cause non-uniform stand establishment and seedlings subject to soil-borne pathogens (Piri et al., 2009). The germination ability and germination percentage of crops is of fundamental importance, influencing the viability of the plants developing from the grains. Seed vigor can be defined as the ability of the seed to germinate and become established under less than optimal conditions, or to survive a series of environmental stresses during germination (Balla et al., 2012). Diatomite (DE) is a sedimentary rock primarily composed of the fossilized remnants of unicellular fresh water plants known as Diatoms (Danil de Namor et al., 2012; Aksakal et al., 2013). It is mainly comprised of SiO_2 with small concentration of Fe_2O_3, Al_2O_3, MgO, CaO and organic matters (Wang et al., 2012). Diatomite is a siliceous sedimentary rock with a porous structure, low density, high surface area and excellent thermal resistance, and it is readily available and environmentally friendly as well (Huang et al., 2012). One of the most important conditions required for germination and emergence is the presence of satisfactory environmental factors, especially favorable

temperatures and water supplies (Nonogaki et al., 2010). The present work aimed to determine changes in the germination ability of different cultivars of tomato under different materials in direct seeding under negative pressure hydraulic auto-irrigation system.

2. Materials and Methods

Diatomite and three varieties of tomato were obtained from National Engineering Research Center for Intelligent Agricultural Equipments, Beijing, China. Three cultivars of tomato (Jiafen No-18, Jiahong No-5, and Jiahong No-4) in main plots, and three materials, including: 100% soil, 50% diatomite + 50% soil, and 100% diatomite in sub plots, were evaluated in a split plot experiment based on a randomized complete block design(CRBD) with three replications in a green house at National Engineering Research Center for Intelligent Agricultural Equipments, Beijing, China (40o10/ N, 116o27/E) in 2013. For 100% soil and 100% diatomite, 5.12 kg soil and 2.2 kg diatomite were used, respectively. 50 seeds per pots were planted. Germination speed (GR), mean germination time to complete germination (MTG), and coefficient of velocity of germination (CVG) were measured with equations 1, 2 and 3, respectively.

$$\mathrm{GR} = \sum_{n=1}^{n} \frac{\mathrm{Si}}{\mathrm{D}} \mathrm{i} \tag{1}$$

Si: the number of germinated seeds, Di: the number of days until counting date, n: numbers of counting and GR: speed of germination on the basis of number of days.

$$MTG = \sum \frac{\mathrm{NiDi}}{\mathrm{N}} \tag{2}$$

N: total seed number, Ni: number of germinated seed per day, and Di: the number of required days for germination.

$$CVG = \frac{1}{\mathrm{MTG}} \tag{3}$$

Germinated seeds were carried out by using three replicates of 50 seeds and other seeds were cultured to determine seedling dry matter. Radicle and coleoptile of germinated seeds were measured for length and weight. To this purpose, 10 seeds were chosen randomly, within those germinated first. The selected seedlings were oven-dried for 48 hr at 65^{o}C for dry weight (DW) measurement. The negative hydraulic pressure controlled auto-irrigator was used in this experiment (Xue et al., 2005). The device is composed of a water-supplying tube (WS), negative pressure controlling system (NPC_s), water-supplying micro-porous ceramic plate (CP) and soil containing pot. The NPC_s contains a water-reserving tube (WR), air inlet (Al) and pressure adjusting pipe (PAR). The WS is connected to the CP, which was installed at the base of soil-containing experimental pots. The position of the WS was higher than the upper margin of the CP; thus water infiltrated slowly from the CP into the soil-containing pot. Due to gravity, the water pressure in the cavity of the CP reduced with increasing height of PAP (h_1) and remained constant for a particular height. Analysis of variance (ANOVA) was used to determine the significant differences. The Multiple Range Test of Duncan performed the separation means. All statistics were performed with MSTAT-C program (version 2.10).

3. Results and Discussion

Cultivar effect on total germination percentage, speed of germination, radcile length, coleoptiles length, fresh leaf weight and fresh coleoptile weight was significant. However, mean germination time, coefficient of velocity germination, dry leaf weight and dry coleoptile weight were not significantly affected by cultivar. The influence of material on total germination percentage, speed of germination, mean germination time, coefficient of velocity germination, radicle length, coleoptile length and fresh leaf weight was meaningful. Total germination percentage, speed of germination, coefficient of velocity germination, fresh leaf weight and dry coleoptiles weight were markedly affected by interaction between cultivar and material. But, the interaction between cultivar and material had not significant influence on mean germination time, radicle length, coleoptiles length, fresh coleoptile weight and dry leaf weight (Table 1).

Table 1. Analysis of variance for experimental characteristics

S.O.V	d.f.	Total germination percentage	Speed of germination	Mean germination time	Coefficient of velocity germination	Radicle length	Coleoptile length	Fresh leaf weight	Fresh coleoptile weight	Dry leaf weight	Dry coleoptile weight
Replication	2	0.0001	109.76ns	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001
Cultivar (C)	2	635.668*	134.52*	0.052	0.002	0.043*	18.670*	0.097*	0.220*	0.0002	0.001
Error (a)	4	0.0001	18.839	0.0002	0.0002	0.0001	0.0002	0.0002	0.0002	0.0001**	0.0002
Material (M)	2	7545.16**	1166.951**	4.430*	0.492**	0.583*	6.070*	0.017**	0.003	0.0002	0.0001
C×M	4	37.826**	117.230**	0.048	0.001**	0.763	2.450	0.003**	0.011	0.002	0.0001**
Error (b)	12	0.0001	8.434	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002

*and** mean significant at P=0.05 and P=0.01 level, respectively in f-test. NS= Not Significant.

Table 2. Mean comparison for total germination percentage (%), speed of germination, mean germination time, coefficient of velocity germination, radicle length (cm), coleoptile length (cm), fresh leaf weight (g), fresh coleoptile weight (g), dry leaf weight (g), and dry coleoptile weight (g)

Treatment	Total germination percentage	Speed of germination	Mean germination time	Coefficient of velocity germination	Radicle length	Coleoptile length	Fresh leaf weight	Fresh coleoptile weight	Dry leaf weight	Dry coleoptile weight
Cultivar(C)										
Jiafen No.18 (C1)	74.99a	19.55b	1.88a	0.57a	2.00b	6.00a	0.31a	0.30a	0.019a	0.017a
Jiahong No.5 (C2)	62.82b	24.01ab	2.03a	0.55a	2.10a	3.16c	0.11c	0.08c	0.011a	0.003a
Jiahong No.4 (C3)	58.86c	27.25a	2.03a	0.55a	1.96c	5.03b	0.25b	0.17b	0.019a	0.012a
Material(M)										
100% soil (M1)	84.78a	34.39a	2.59a	0.38c	1.80c	4.83b	0.22b	0.17a	0.015a	0.011a
50% soil + 50% diatomite (M2)	79.63b	24.72b	2.12b	0.46b	2.30a	5.50a	0.27a	0.19a	0.019a	0.010a
100% diatomite (M3)	32.25c	11.70c	1.21c	0.82a	1.96b	3.86c	0.18c	0.18a	0.016a	0.012a
C×M										
C1M1	98.12a	25.27bc	2.34c	0.42c	1.70g	7.00a	0.32b	0.30ab	0.020a	0.020a

Common letters within each column do not differ significantly.

The highest total germination percentage was related to Jianfen No-18 (74.99%), which had significant difference with other cultivars. The maximum total germination percentage was related to usage of 100% soil in pots (84.78%), and the minimum was obtained by 100% diatomite. The highest total germination percentage was related to Jiafen No-18 and 100% soil interaction. Seed germination performance is very important for successful productions of crops (Rahimi, 2013). Although, the maximum speed of germination was related to Jiahong No-4, it had just significant difference with Jiafen No-18. The speed of germination was significantly decreased from 100% soil to 100% diatomite. Moreover, the highest speed of germination was obtained for interaction of Jiahong No-4 and 100% soil (46.24). There were not any significant differences in mean germination time among cultivars. The maximum and the minimum mean germination time, which had significant differences with each other, were belonged to application of 100% soil (2.59) and 100% diatomite (1.21). Interaction between Jiahong No-4 and

100% soil had obtained the highest mean germination time. Seedling stand establishment is a sensitive stage in the process of plant production. Uniformity and percentage of seedling emergence in direct planting may greatly influence the yield and quality of crops (Yasari et al., 2013). In spite the fact that, the maximum coefficient of velocity germination was obtained for Jiafen No-18, it had no significant differences with all other cultivars. Application of 100% diatomite had obtained the highest value of coefficient of velocity germination, which had significant differences with other treatments. Furthermore, interaction between Jiafen No-18 and 100% diatomite had obtained the maximum value of this treatment. Improper application or application rate of diatomite can have negative influence on seed germination. The highest radicle length was related to Jiahong No-5, which had meaningful difference with two other cultivars. Usage of 50% diatomite + 50% soil also obtained the maximum radicle length (2.30 cm). The maximum value of radicle length, which was 2.80 cm, was shown in interaction between Jiahong No.4 and application of 50% soil + 50% of diatomite. Jiafen No-18 had obtained the maximum coleoptile length, which had meaningful difference with other cultivars. Application of 50% soil and 50% diatomite, which had obtained the maximum coleoptile length, had significant differences with other treatments. The highest value of coleoptile length was related to Jiafen No-18 and 100% soil (7.00 cm). The maximum fresh leaf weight was shown in Jiafen No-18, followed by Jiahong No-4 and Jiahong No-5, respectively. The highest value of fresh leaf weight, which was 0.27 g, obtained in usage of 50% soil + 50% diatomite, which had significant difference with other treatments. Interaction between Jiafen No-18 and 50% soil + 50% diatomite obtained the highest fresh leaf weight (0.38 g). The maximum fresh coleoptiles weight was related to Jiafen No-18, followed by Jiahong No-4 and Jiahong No-5, respectively. There are not any significant differences in fresh coleoptiles weight between different materials. Interaction between Jiafen No-18 and 50% soil + 50% diatomite had obtained the maximum fresh coleoptile weight. The lowest dry leaf weight was obtained for Jiahong No-5, which had no significant differences with other cultivars. There was also no significant difference in dry leaf weight among different materials. Interaction between Jiahong No-4 and 50% soil + 50% diatomite was obtained the maximum dry leaf weight (0.022g). Although, the maximum dry coleoptile weight was obtained for Jiafen No-18 (0.017 g), and 100% diatomite (0.012 g), there were not any significant differences among treatments. Interaction between Jiafen No-18 and usage of 100% soil was obtained the maximum dry coleoptile weight (0.020 g), which had significant differences with other treatments.

4. Conclusion

The highest total germination percentage, coefficient of velocity germination, coleoptile length, fresh leaf weight, fresh coleoptile weight, dry leaf weight and dry coleoptile weight were observed in Jiafen No-18. However, Jiahong No-4 obtained the maximum speed of germination. The maximum values of total germination percentage, speed of germination, and mean germination time were related to 100% soil. Application of 50% soil + 50% diatomite had obtained the highest radicle length, coleoptile length, fresh leaf weight, fresh coleoptile length and dry leaf weight. It can be concluded that application 50% soil and 50% diatomite, and Jiafen No-18 has a great potential seed germination under negative hydraulic pressure auto-irrigation system.

The unique physical and chemical properties of diatomite in terms of high permeability, very fine particle size, high porosity, chemical inertness, low thermal conductivity,ease of accessibility and cost effective of Diatomite has not been fully explore in respect seeds germination.

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