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BEET SEEDLING EMERGENCE IN FUNCTION OF SOWING DEPTH AND SYSTEM

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ABSTRACT - Seedling emergence rates of two beet cultivars were determined in two sowing systems, at different sowing depths and periods in the Central Southern region of Paraná State, Brazil. Two experiments were carried out (no till and trays) in a randomized block design in a split-split-plot scheme in time, considering the nine sowing dates as plot and the subplot consisted of a 2x3 factorial including two cultivars (Maravilha and Chata do Egito) at three sowing depths (2, 4 and 6 cm). The split-split-plot was formed by four emergence periods (7, 14, 21 and 28 days after sowing). The germination speed was calculated based on the germination emergence. Due to the climate of the region, it was observed that the highest emergence rate occurred up to 14 days after sowing and the superiority of the tray system was evident. The 2 cm seeding depth cm resulted in the highest emergence rate in both systems. The Maravilha cultivar performed best in the tray system, regardless of the sowing date and depth. Field emergence was positively correlated to temperature and was identified as one of the factors responsible for lower seedling emergence rates under low temperatures.
Key words: *Beta vulgaris*, sowing period, temperature.

EMERGÊNCIA DE PLÂNTULAS DE BETERRABA EM FUNÇÃO DA PROFUNDIDADE E DO SISTEMA DE SEMEADURA

RESUMO - Foram determinadas as taxas de emergência de plântulas de duas cultivares de beterraba em função de diferentes sistemas de semeadura, em diferentes profundidades e épocas de semeadura, na região Centro-Sul do Paraná, Brasil. Para tanto, foram conduzidos dois experimentos (semeadura direta no solo e em bandejas) no delineamento de blocos casualizados, em esquema de parcelas sub-subdivididas no tempo, considerando-se as nove épocas de semeadura como parcela e na subparcela um esquema fatorial 2x3, compreendendo duas cultivares (Maravilha e Chata do Egito) em três profundidades de semeadura (2, 4 e 6 cm). As sub-subparcelas foram constituídas por quatro épocas de avaliação de emergência (7, 14, 21 e 28 dias após a semeadura). Com base na emergência, foi calculado o índice de velocidade de germinação. Em função das condições climáticas da região, observou-se que a maior taxa de emergência ocorreu até 14 dias após a semeadura, destacando-se a superioridade do sistema em bandejas. A profundidade de semeadura de 2 cm proporcionou, nos dois sistemas, a maior emergência de plântulas. A cultivar Maravilha apresentou o melhor desempenho no sistema de bandejas, indiferente da época e profundidade de semeadura. A emergência no campo foi positivamente correlacionada à temperatura, sendo apontada como um dos fatores responsáveis pela menor emergência de plântulas sob baixas temperaturas.
Palavras-chave: *Beta vulgaris*, época de semeadura, temperatura.

INTRODUCTION

In Brazil, sugar beet growing intensified greatly with European and Asian immigration. Over the past decade it could be seen a steady increase in demand of this vegetable, both for use in canning and for fresh consumption (SOUZA et al., 2003).

Inadequate emergence is one of the main factors that accounts for low crop productivity (SMITH et al., 1990; ECHER et al., 2007), which is why the period between sowing and seedling emergence is one of the critical phases of the crop cycle. Seed germination is affected by a series of intrinsic and extrinsic conditions

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that are essential for the process to proceed normally (CARVALHO; NAKAGAWA, 2000).

Reduced beetroot glomerule germination may be due to the presence of water soluble inhibiting substances and barriers that decrease oxygen and water penetration to the embryo (HADLEY; FORDHAM, 2003). The beet grows preferably in cold season or in regions with tropical climate, being tolerant to frost. Better quality tubers are formed when the plant is grown at temperatures between 16 and 20 °C. Currently, although the beet crop is adapted to different environmental conditions, yield is reduced by up to 50% when it is grown in summer time. Weather conditions with high temperature and higher humidity favored the occurrence of diseases and pests and tuberous roots start to show undesirable internal color, with lighter concentric rings, and the taste is changed, becoming less sweet (PUIATTI; FINGER, 2005).

The summer production, despite achieving high prices in the market, is more problematic, particularly by greater susceptibility to fungal diseases of foliage and incidence of pests at high temperature periods (FILGUEIRA, 2000).

Other factors should also be taken to guarantee good establishment of the crop in field such as sowing depth and method. Sowing at improper depth could delay seedling emergence making them susceptible to parasite attack (FORCELLA et al., 2000). Depth varies from one to a maximum of 6 cm values depending on the cultivar and soil type (PUIATTI; FINGER, 2005). Allied to this and aiming for greater crop yield, Kenter et al. (2006) reported the importance of combining proper depth with water availability and mean daily temperatures around 18 °C during the summer.

Regarding sowing method, beetroot is usually cropped by no till system but it can also be transplanted (FILGUEIRA, 2008). However, these methods provide disuniform stands depending on the germination and the stress caused by transplantation. The seedlings in seedbeds are formed when bare root are transplanted, without lumps around, being very sensitive to environmental conditions, as well as damage caused to the root system and contamination by pathogens (SOUZA; FERREIRA, 1997 apud ECHER et al., 2007).

On the other hand, seedlings produced on trays present healthy root development, guaranteeing greater uniformity of the plants in the field but with later production compared to no till (SOUZA; FERREIRA, 1997).

Seedlings produced on 128-, 200-, and 288-cell trays presented greater emergence than seedlings produced in the no till system (HORTA et al., 2001). The same authors further observed that among the trays used, the 128-cell trays where more efficacious in seedling production because they provided superior performance for the number of leaves and canopy fresh matter weight, but they had no effect on root development. Similar results were reported by Echer et al. (2007), but in this case greater root development was observed. The superiority of the tray system compared to the no till system to greater control of spacing or predetermined plant population, with selected and uniformly sized seedlings and fewer health problems due to the absence of pests and pathogens in the substrate (HORTA et al., 2001).

However, in both techniques, little knowledge there about the influence of sowing depth and date on seedling emergence. Thus, the objective of the present study was to determine the seedling emergence of two beetroot cultivars in no till and tray cropping systems at different sowing depths and dates.

MATERIALS AND METHODS

Two experiments were carried out from June to October, 2007, in Guarapuava, PR, Brazil. The climate of the region according to Köppen classification is Cfb (wet mesothermic subtropical) with no dry season, cool summers and mild winters. The approximate altitude is 1.100 m, with 1.944 mm mean annual rainfall, 12.7 °C annual mean minimum temperature, 23.5 °C maximum mean annual temperature and 77.9 % relative air humidity (THOMAZ; VESTENA, 2003).

The first experiment was set up in 200-cell polyethylene trays with substrate (Plantmax®). Each plot consisted of eight tray cells containing one seeds each that were kept in a greenhouse with two 10-minute microspary irrigations per day. The environment was controlled and the temperature was kept between 22 and 25 °C.

The second experiment was set up in the field, simultaneously with the tray experiment, using the no till planting system, on a soil classified as typical clay textured LATOSSOIL BROWN Dystrophic (EMBRAPA, 2006). The treatment of direct sowing in the field was conducted on the same day of seeding in trays. The area used was characterized by the intensive cultivation of vegetables for several years. The sowing of the crop was directly made on the site, using trencher online and incorporating compost in the planting line. The Maravilha cultivars and Chata Egito were used because they are commonly grown in the region by beet growers. The ground cover contained remaining maize straw from the previous crop. The Cultivars Chata do Egito belongs to the company Feltrin Sementes and the Maravilha belongs to the company Isla Sementes, the seeds were harvested and had mostly a single embryo. Plots of 1 m^2 were used with 0.20 m between-row spacing and density of 20 glomerules per linear meter, in a total of 100 glomerules per plot. The beds were spray-irrigated for 15 minutes once a day at 4 pm. Fertilization was carried out based on the soil analysis using 800 kg ha^{-1} of the NPK 04-14-08 formula at planting and about 10 t ha^{-1} of cattle manure three days before planting. These practices were necessary even considering that the crop would not be conducted to the end of the cycle, so that all the soil conditions of a traditional cultivation were established to better simulate the real conditions.

The experiments were carried out in a complete randomized block design with four replications in the field and six replications in the trays, in a split-plit-plot in time scheme, considering nine sowing dates as plots and in the split plots consisted of a 2x3 scheme with two cultivars (Maravilha and Chata do Egito) at three sowing depths (2, 4 and 6 cm). The split-split plots consisted of four emergence assessment periods (7, 14, 21 and 28 days after sowing - D.A.S.).

The seedlings were considered emerged when they were approximately 3 cm tall, when the first two leaves were opening. The germination speed index (GSI) was determined, indicated as a test that assesses the seed vigor, based on the principle that the faster the seed germinates and emerges, the greater is its vigor (NAKAGAWA, 1999). For this the GSI was calculated based on sowing emergence according to the formula proposed by Maguire (1962), where GSI = $G_1/N_1 + G_2/N_2 + ... + G_n/N_n$, where: GSI is the germination speed index, G_1, G_2 and G_n is the number of normal seedlings calculated in the first, second and last counting, and N_1, N_2 and N_n is the number of days after implanting the test.

The maximum and minimum temperatures were obtained daily from the meteorological station at the State University of Central Western Paraná, and their mean was adopted as the environmental temperature (Figure 1).

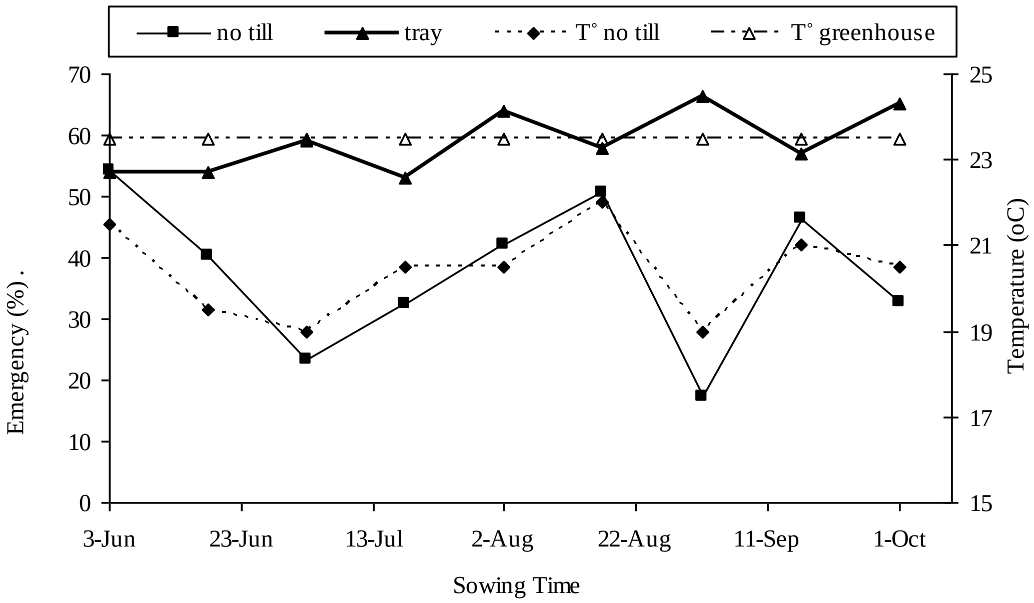

FIGURE 1 - Mean daily temperature and beetroot seedling emergence in the no till and tray sowing systems, in nine sowing dates.

The data obtained from counting the emerged seedlings in both the experiments were submitted to joint analysis of variance and the means were compared by the Scott-Knott test ($p<0.05$). Pearson correlations were studied between the mean environmental temperature and seedling emergence on the nine sowing dates.

RESULTS AND DISCUSSION

The variation analysis of mean square values assessed the emergence of seedlings, taking into account the interactions between the main factors cultivar (Maravilha and Chata Egito), sowing dates (7 14, 21 and 28 days) and the depth of seeding (2, 4, 6 cm) respectively showing the standard error of each interaction (Table 1).

The analysis of variance of the data obtained in the tray sowing system showed that there was significant difference among the factors assessed and their interactions. However, in the no till sowing system, the variable “cultivar” and the “cultivar vs depth” interaction were not significant.

The shallowest sowing depth resulted in a greater number of emerged seedlings, in both the no till and tray sowing systems, different from the others (Figure 2). The results obtained in the present study corroborated the recommendations by Filgueira (2008) and were in line with those currently practiced (DURR et al., 2000; SESTER et al., 2005; SILVA; VIEIRA, 2006; GRANGEIRO et al., 2007), that is, 1 to 2 cm depth. Forcella et al. (2000) reported that as depth increased the germination rate decreased, due to lower temperature during the day and even because of the death of seedlings in pre-emergence due to pest attack. Another factor related to less emergence due to depth can be attributed to the cultivar genotype, where seedlings with good emergence have a hypocotyl greater than 2 cm long (DURR et al., 2000). This fact helps to explain the greater emergence presented at the 2 cm depth, because greater depths require greater hypocotyls. Sester et al. (2005) reported that a longer hypocotyl may be the result of selection based on broad genetic variability but this characteristic is little seen because the sowing depth is seldom greater than 5 cm.

When the cultivars were compared at the different sowing depths, the Maravilha cultivar presented greater emergence in the tray system, unlike the Chata do Egito cultivar at all the depths. The same fact was observed for sowing period, where the Maravilha cultivar was superior in all the assessment periods. On the other hand, when the cropping was in the field, there was no statistical difference between the cultivars for sowing date (Table 2).

TABLE 1. The variation analysis of mean square values (Q.M.) assessed the emergence of seedlings, taking into account the interactions between the main factors cultivar (Maravilha and Chata Egito), sowing dates (7 14, 21 and 28 days) and the depth of seeding (2, 4, 6 cm) respectively showing the standard error of each interaction.

Principal Interactions	G.L.	Q.M.
Sowing x Cultivar (Chata do Egito)	8	6593.48
Sowing x Cultivar (Maravilha)	8	9093.62
Cultivar x Sowing (06/03/07)	1	372.09
Cultivar x Sowing (06/18/07)	1	356.51
Cultivar x Sowing (07/03/07)	1	15.04
Cultivar x Sowing (07/18/07)	1	195.51
Cultivar x Sowing (08/02/07)	1	508.76
Cultivar x Sowing (08/17/07)	1	5704.17
Cultivar x Sowing (09/01/07)	1	104.17
Cultivar x Sowing (09/16/07)	1	21.09
Cultivar x Sowing (10/01/07)	1	888.17
Standard Error	1.61	
Cultivars x Epoch (7 days)	1	5300.46
Cultivars x Epoch (14 days)	1	28.17
Cultivars x Epoch (21 days)	1	880.07
Cultivars x Epoch (28 days)	1	495.04
Epoch x Cultivar (Chata do Egito)	3	36501.51
Epoch x Cultivar (Maravilha)	3	17117.43
Standard Error	1.07	
Epoch x Depth (2 cm)	3	18378.91
Epoch x Depth (4 cm)	3	17793.77
Epoch x Depth (6 cm)	3	15407.36
Depth x Epoch (7 days)	2	1534.26
Depth x Epoch (14 days)	2	2964.50
Depth x Epoch (21 days)	2	2343.89
Depth x Epoch (28 days)	2	2061.29
Standard Error	1.31	
Error Total	790	123.79

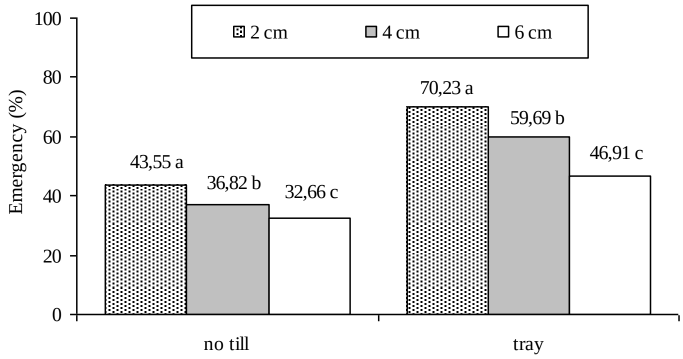

FIGURE 2 - Beetroot seedling emergence in no till and tray sowing systems in function of three sowing depths. Means of the same sowing systems, followed by the same lower case letter did not differ statistically by the Scott-Knott test ($p<0.05$).

TABLE 2. Rate of seedling emergence of two beetroot cultivars in function of nine sowing dates (06/03/07 to 10/01/07), in two sowing systems (no till and tray).

Sowing	No till		Tray	
	Chata do Egito	Maravilha	Chata do Egito	Maravilha
06/03/07	52.29 aA	56.23 aA	46.18 bB	61.8 Ca
06/18/07	42.23 cA	38.37 cA	46.35 bB	61.28 Ca
07/03/07	23.58 eA	22.79 fA	46.35 bB	71.53 BA
07/18/07	30.92 dA	33.77 dA	42.71 bB	63.54 Ca
08/02/07	44.48 cA	39.87 cB	55.38 aB	72.74 BA
08/17/07	42.81 cB	58.23 aA	46.53 bB	69.27 BA
09/01/07	16.19 fA	18.27 gA	59.37 aB	73.26 BA
09/16/07	46.83 bA	45.9 bA	54.17 aB	59.89 Ca
10/01/07	35.73 dA	29.65 eB	51.56 bB	78.99 AA

Means of the same sowing date, followed by the same uppercase letter on the line for each cultivar and lower case letter in the column, did not differ statistically by the Scott-Knott test at 5% probability.

When the emergence obtained in the field and in the trays was compared (Table 2) for each cultivar, a 33.9% increase was observed in the number of seedlings for the Chata do Egito cultivar and 78.5% for the Maravilha cultivar. In the field, emergence was directly affected by the environmental temperature (Figure 1), where the lowest percentage of emerged seedlings was observed in the cooler periods, that was from July 3 to September 1, with emergences of 23.19% and 17.23%, respectively (Table 3). The mean temperature recorded in these two periods was 18 °C, below the conditions considered ideal for beetroot glomerule germination that according to Swiader et al. (1992) are between 20 and 24 °C. The Pearson test showed that there was a positive and significant correlation between seedling emergence in the field and mean environmental temperature (86%), where the increase of the latter resulted, according to Carvalho and Nakagawa (2000), in greater water absorption with a significant increase in germination. Considering the tray sowing method, there was no correlation between temperature and emergence because in this case the temperature was controlled (average 23 °C) and did not vary in the different cropping periods (Figure 1).

TABLE 3. Rate of beetroot seedling emergence in the no till sowing system in function of nine sowing dates (06/03/07 to 01/10/07) and three depths (2, 4 and 6 cm).

Sowing	Depth (cm)		
	2	4	6
06/03/07	52.41 bA	57.47 aA	52.90 aA
06/18/07	42.19 cA	43.47 cA	35.25 cB
07/03/07	28.66 dA	22.31 eB	18.59 eB
07/18/07	39.31 cA	33.00 dB	24.72 dC
08/02/07	45.59 cA	41.78 cA	39.16 bA
08/17/07	59.34 aA	48.09 bB	44.12 bB
09/01/07	26.66 dA	12.03 fB	13.00 fB
09/16/07	51.28 bA	47.06 bA	40.75 bB
10/01/07	46.50 cA	26.12 eB	25.44 dB

Means of the same sowing date, followed by the same uppercase letter on the line for each cultivar and lower case letter in the column, did not differ statistically by the Scott-Knott test at 5% probability.

The effects of temperature on the no till system were also observed at the different depths (Table 3). In the period when the lowest temperature was observed (September 1st), emergence was 26.66% at the 2 cm depth, contrasting with the 59.34% observed in the period with the highest temperature, an increase of 122.58% in the number of plants. The same fact was observed at the 4 and 6 cm depths regarding the second high temperature period

(June 3) with increases of, respectively, 377.72% and 306.92% in the number of plants. The increases observed at the greater depths ratified the importance of temperature on beetroot seedling emergence. Durr and Boiffin (1995) also observed a strong influence of temperature on beetroot seedling emergence. However, Scott and Jaggard (1993) observed greater influence of solar radiation on seedling emergence. Kenter et al. (2006) reported that in the fall, the predominant factor in beetroot development was temperature and, as the radiation intensity decreased, it become limiting. Studies have been carried out under controlled conditions to quantify the influence of temperature, solar radiation and water quantity on the growth and initial development of the beetroot (ABDOLLAHIAN-NOGHABI; FROUD-WILLIAMS, 1998) and under field conditions (SCHITTENHELM, 1999) where temperature was shown as the main factor responsible for glomerule germination and consequently, seedling emergence. Richard et al. (1995) also reported the importance of temperature on the initial development of beetroot seedlings, but even with variations of up to 10 °C, significant differences were not observed in the emergence.

In the two sowing methods assessed, emergence was similar at 7 D.A.S., with emergence of 14.78% in the field and 14.66% in the trays. However, at 14 D.A.S., superiority was observed in the yield in trays, with 66.86% emergence, greater than the 47.25% emergence in the field. This difference was maintained at 21 and 28 D.A.S., with significant increase in the cropping in trays and reduced stand in the field at 28 D.A.S. (Table 4). The greatest GSI was observed in the tray sowing system (13.28) that was greater than the GSI in no till (9.21). The Maravilha cultivar presented the best GSI (15.86) in the tray system and the Chata do Egito cultivar the lowest GSI (8.62) in the no till system. The increase in the GSI was an indication of good yield due to the greater vigor of the plants in the field (NAKAGAWA, 1999).

TABLE 4. Rate of seedling emergence of two beetroot cultivars in function of four assessment periods (7, 14, 21 and 28 D.A.S.) and two cropping systems (no till and tray).

D.A.S.	No till		Tray	
	Chata do Egito	Maravilha	Chata do Egito	Maravilha
7	9.82 cB	19.73 dA	7.87 dB	21.45 cA
14	46.89 AA	47.61 aA	54.32 cB	79.40 bA
21	48.56 AA	44.53 bB	66.51 bB	84.79 aA
28	43.64 BA	40.61 cB	70.68 aB	86.50 aA

Means of the same sowing date, followed by the same uppercase letter on the line for each cultivar and lower case letter in the column, did not differ statistically by the Scott-Knott test at 5% probability.

The decrease in stand observed at 28 days in the no till system was attributed to greater difficulty in carrying out the crop treatments, especially at the initial phase of the crop development. Similarly, according to Horta et al. (2001), it is important to also consider the formation of a crust on the soil surface and lack of uniformity in the sowing bed, factors that commonly reduce seedling quality in no till. However, the seedling irregularity can also be found in seedling transplant where, according to Mckee (1981), this fact occurs in function of the extent of injury caused to the root system, the polant physiological conditions and variations in the intensity and duration of shock after transplant.

Although reports have indicated a delay in the beetroot crop cycle with seedling transplant compared to no till (MCKEE, 1981; SOUZA; FERREIRA, 1997; FILGUEIRA, 2008), that is theoretically the greatest disadvantage of the tray system, Horta et al. (2001) observed delay of only 9 to 13 days in the cycle in seedlings produced in 200- and 288-cell trays, respectively. It is important to ratify that although seedling transplant prolongs the crop cycle, this practice raises productivity and quality and reduces the quantity of seed spent (FILGUEIRA, 2008). Another possibility to increase earliness in transplanted seedlings is mineral supplementation at the initial phase of development (HORTA et al., 2001).

CONCLUSION

The sowing at the 2 cm depth resulted in greater plant emergence in the two sowing systems. The superiority in the seedling production by the tray system compared to the no till system was expressed between 7 and 14 D.A.S.

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