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Pressures on seeding lines influencing cotton emergence and initial growth

Pressões sobre as linhas de semeadura influenciando a emergência e o crescimento inicial de algodão

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RESUMO

A força que é aplicada sobre a unidade semeadora pode influenciar a emergência das plântulas de algodão, podendo resultar em decréscimo no desenvolvimento e potencial produtivo da planta. Assim, o trabalho teve por objetivo avaliar o efeito de diferentes pressões exercidas sobre as linhas de semeadura do algodoeiro na emergência e crescimento inicial das plantas. Foi utilizado o delineamento em blocos casualizados com oito tratamentos e três repetições, totalizando 24 parcelas. Os tratamentos foram constituídos das pressões, manual 16, 45 e 120 kg, automático leve, padrão e pesado, automático personalizado 36 e 59 kg. Foi avaliado a emergência de plântulas aos 5; 6; 7 e 8° dia após semeadura, número total de planta emergida no 8° dia, número de sementes expostas, altura de plantas com 20 e 25 dias após semeadura e comprimento de raiz principal com 15 dias após semeadura. Na emergência mais rápida, aos 5 dias após a semeadura, o sistema de pressão manual 16 e 45 kg obtiveram maior número de plantas emergidas, superando em 44,6% o sistema automático padrão do equipamento, no entanto, o uso de 16 kg também resultou em maior número de sementes expostas. O uso de sistema de pressão automático na semeadura não foi favorável a emergência das plântulas de algodão, sendo os sistemas manuais mais adequados. Não se obteve diferença na altura de planta 25 dias após semeadura e comprimento de raiz 15 dias após semeadura, em relação aos diferentes sistemas de pressão utilizados.

KEY WORDS: *Gossypium hirsutum L.; forças descendentes; semeadura de precisão.*

ABSTRACT

The force applied to the seeding unit can influence the emergence of cotton seedlings, which may result in a decrease in the development and productive potential of the plant. Thus, the work aimed to evaluate the effect of different pressures exerted on cotton sowing lines on the emergence and initial growth of plants. A randomized block design was used with eight treatments and three replications, totaling 24 plots. The treatments consisted of pressures, manual 16, 45, and 120 kg, light automatic, standard and heavy, personalized automatic 36 and 59 kg. Seedling emergence was evaluated at 5; 6; 7th and 8th days after sowing, the total number of plants that emerged on the 8th day, the number of exposed seeds, plant height 20 and 25 days after sowing, and main root length 15 days after sowing. In the fastest emergence, 5 days after sowing, the 16 and 45 kg manual pressure system obtained a greater number of emerged plants, surpassing the equipment's standard automatic system by 44.6%, however, the use of 16 kg also resulted in a greater number of exposed seeds. The use of an automatic pressure system during sowing was not favorable to the emergence of cotton seedlings, with manual systems being more appropriate. There was no difference in plant height 25 days after sowing and root length 15 days after sowing, about the different pressure systems used.

KEYWORDS: *Gossypium hirsutum L.; downforce, precison seeding.*

INTRODUCTION

In recent years, Brazil has remained among the top five global cotton producers, alongside countries like China, India, the United States, and Pakistan, ranking first in productivity (ABRAPA 2023). Today, Brazil is a cotton exporter, and cotton cultivation has increased in recent harvests, with a projected growth of 18.7% between 2012 and 2024 (SAATH & FACHINELLO 2018). In the 2022/2023 season, cotton was cultivated on 1.66 million hectares, yielding 3.15 million tons of lint cotton, with an average productivity of 1893 kg ha^{-1} (CONAB 2023).

Among the various steps required for proper cotton management, planting is one of the most critical phases, as it's essential for seedling establishment in the field. During planting, consider the choice of planting method (conventional or no-till), pressure applied to the row and compaction wheels, and seed drill calibration (OLIVEIRA 2021). The selection of the planting mechanism, seed depth placement, and distribution uniformity are influenced by the downforce applied to the planting rows (SHARDA et al. 2017, BRUNE et al. 2018, BADUA et al. 2021).

The seed should be planted at a depth of 3 to 5 cm, depending on soil texture and water absorption capacity (ARAUJO 2017). Delayed seedling emergence can result from poor seed placement in the furrow or improper furrow formation, leading to seeds being too shallow or too deep, which harms the crop (OLIVEIRA 2021). Therefore, proper furrow formation and good soil conditioning around the seed ensure efficient water absorption and oxygen availability, promoting the development of fine roots (MODOLO et al. 2011, JING et al. 2020, OLIVEIRA 2021). Excessive downward pressure during planting can create surface crusting, hindering seedling emergence (MODOLO et al. 2008, VIRK et al. 2020). This applied force on the compacting wheels causes mechanical resistance to soil penetration, resulting in furrow wall compaction, which negatively impacts plant emergence and growth (WAY et al. 2018, JING et al. 2020).

Various force control systems are being developed to manage planting pressure across diverse soil textures. These aim to prevent seed placement at suboptimal depths, which can delay emergence and reduce crop yields (BRUNE et al. 2018). Vertical forces applied to planting units help maintain seeds at desired depths and prevent furrow wall compaction (BADUA et al. 2021).

The optimal pressure for promoting successful germination and subsequently influencing the plant's productive potential, either enhancing or reducing it, has not yet been determined. This study aimed to assess how varying pressures applied to cotton planting rows affect seedling emergence and early plant growth.

MATERIAL AND METHODS

The experiment was carried out in Chapadão do Sul, Mato Grosso do Sul state, Brazil, at coordinates 18°50'38.58" South latitude, 52°31'15.77" West longitude, at an elevation of 816 meters above sea level. The experimental area's soil was classified as a Dystrophic Red Latosol (SANTOS et al. 2018), and the region's climate is tropical humid, with annual rainfall of 1,850 mm, and temperatures ranging from 13 to 28 °C (CUNHA et al. 2013).

The experimental design used randomized blocks with eight treatments and three replications, for a total of 24 plots. The treatments consisted of various pressures applied to the lines: manual 16, 45, and 120 kg; automatic light, standard, and heavy; and custom automatic 36 and 59 kg.

The experimental plots consisted of four cotton rows, each five meters long, spaced 0.90 meters apart. The experiment used FiberMax's FM 944GL, a medium-cycle cotton variety (160-180 days), with 250 kg/ha^{-1} of MAP fertilizer (10-46-00) applied at sowing.

Planting was done using a John Deere tractor and mechanized seed drill with 15 rows, spaced 0.90 m apart. Each planting unit was fitted with Precision Planting's DeltaForce® hydraulic downforce system. The system employs hydraulic oil pressure from the tractor's hydraulic system, which is directed by a valve to pistons connected to the seeding units.

The tractor's onboard computer controls this hydraulic system, allowing the operator to choose between automatic, custom automatic, and manual modes. The automatic mode comes preset with initial values: light automatic at 23 kg, standard automatic at 45 kg, and heavy automatic at 68 kg. It adjusts the force according to each seeding unit's needs, varying between these values. The custom automatic mode operates within the range of the standard automatic settings, activating when the load demand doesn't reach the preset threshold in the automatic mode. In manual systems, the operator determines and applies a constant force to the unit.

Cotton planting occurred on December 27, 2022, and evaluations began on the fifth day after sowing (January 1, 2023), starting with emergence assessment. Colored zip ties were used to distinguish emergence days. At 5, 6, 7, and 8 days after sowing (DAS), the number of emerged plants was counted (NP5, NP6, NP7, and NP8), marked with black, white, red, and yellow colors in this order, respectively, and the total number of plants on the 8th day (NT8) was recorded. Plant height at 20 and 25 DAS (ALT 20 and ALT 25), main root length at 15 DAS (CR15) , and the number of exposed seeds (NES) were also evaluated.

Fifteen plants from each treatment, five from each replication, were collected to measure plant height and root length. A scale ruler was used to measure plant size and root length. The seed exposure assessment was conducted on the fifth day after planting.

The collected data underwent variance analysis, and means were compared using the Scott-Knott test at a 5% probability level, employing Sisvar software (FERREIRA 2019).

RESULTS AND DISCUSSION

There was an effect of the treatments on all the variables studied, except for plant height at 25 DAS (ALT25) and root length at 15 DAS (CR15) (Table 1). These results indicate that the weight applied to the sowing line influences the germination of cotton seeds. According to VIRK et al. (2021) the downward vertical load applied to the seeding line plays a fundamental role in maintaining a stable and consistent seed deposition depth.

Table 1. Analysis of variance of the characteristics evaluated in the experiment.

FV	GL	Residue Mean Square				
		NP5	NP6	NP7	NP8	NT8
Repetition	2	0,000104	0,009479	0,005417	0,000729	0,020937
Treatments	7	0,876414**	0,720818**	0,069509**	0,017560*	0,551414**
Error	14	0,0210057	0,008408	0,004107	0,004658	0,047485
CV (%)		4,06	4,92	10,87	15,90	3,38
Overall average		3,57	1,86	0,59	0,43	6,46
		NSE	ALT20	ALT25	CR15	
Repetition	2	0,000417	3,782,917	2,490,417	0,040417	
Treatments	7	0,079628**	5,130238*	2.599940ns	0.919762ns	
Error	14	0,001726	1,372,917	1,584,226	0,342798	
CV (%)		22,41	12,07	10,53	10,20	
Overall average		0,18	9,71	11,95	5,74	

NP5, NP6, NP7 and NP8 = number of plants at 5, 6, 7 and 8 days after sowing, respectively. NT8 = total number of plants on the 8th day after sowing. NSE = number of seeds exposed. ALT20 and ALT25 = plant height at 20 and 25 days after sowing, respectively. CR15 = root length at 15 days after sowing. **, * and ns = significant at 1% and 5% and not significant by the F test.

The manual pressure systems of 45 kg (M45) and 16 kg (M16) resulted in the highest number of emerged plants on the 5th day after sowing, representing a 44.6% increase compared to the standard automatic system (SAS) (Fig. 1A). Precision mechanized planting aims to place seeds at the desired depth and spacing with accuracy and precision (LIU et al. 2017, YIN et al. 2018) many aspects still require refinement, since optimal crop performance isn't consistently achieved. Downward forces affect soil's mechanical resistance to penetration and compact furrow walls, potentially reducing crop emergence and growth (WAY et al. 2018, JING et al. 2020).

Excessive downward pressure can lead to soil overcompaction, hindering seed penetration, root development, and corn emergence consistency (SHI et al. 2014). ALVES et al. (2014) found that shallower planting depths expose seeds to greater environmental fluctuations, resulting in weaker and underdeveloped plants. According to CORTEZ et al. (2005) the use of vertical loads exceeding 200 N on seeding units reduced cotton plant emergence speed and percentage, while lighter loads of 100 N or moderate loads of 150 N proved more beneficial for seedling early development.

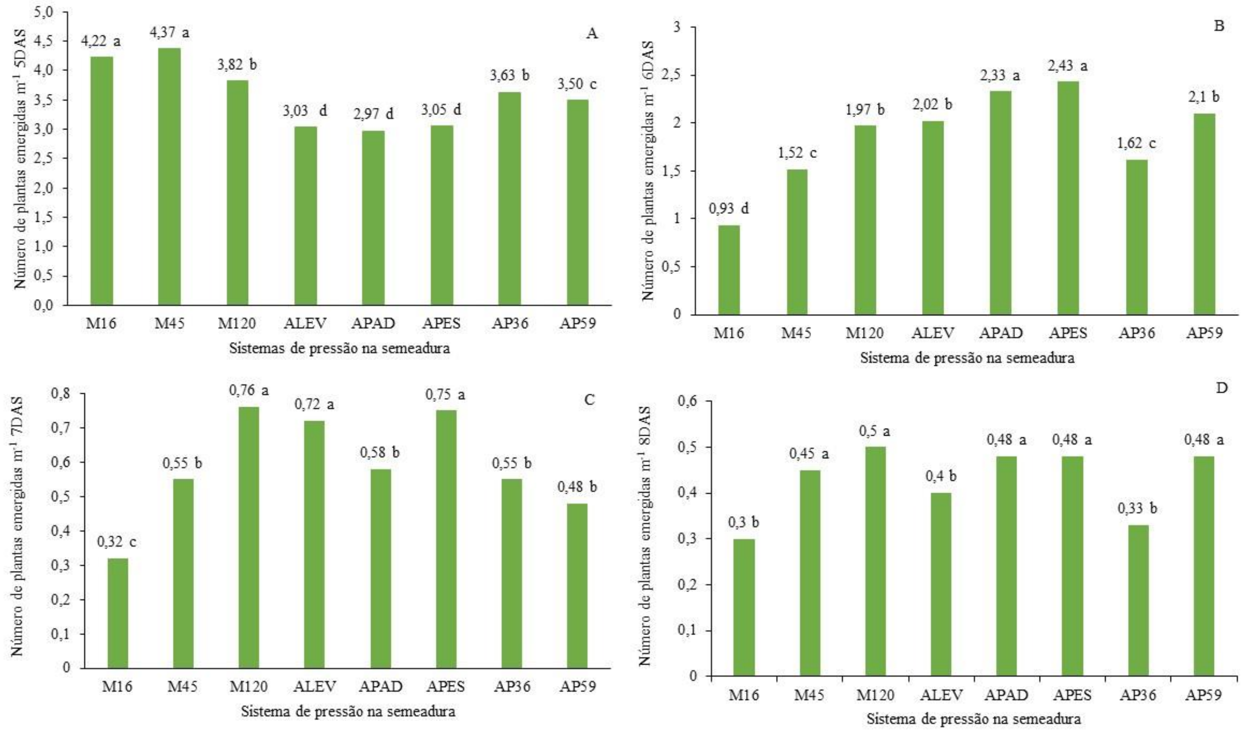

Figure 1. Number of plants emerged on the 5th (A), 6th (B), 7th (C) and 8th (D) day after sowing as a function of the different pressure systems during sowing. M16: manual 16 kg, M45: manual 45 kg, M120: manual 120 kg, ALEV: light automatic, APAD: standard automatic, APES: heavy automatic, AP36: custom automatic 36 kg, AP59: custom automatic 59 kg.

On the 6th day (NP6), manual planting with 16 kg (M16) (Figure 1B) resulted in fewer emerged plants (60.92%) compared to heavy automatic (HAS) and standard automatic (SAS) systems. This may have occurred due to the same phenomenon observed by MODOLO et al. (2007), who observed lower emergence rates in lighter loads due to air pockets forming above the seed, preventing proper soil-seed contact.

On the 7th day after sowing, an increase in emerged plants was observed in the higher-pressure systems, manual 120 kg (M120) and heavy automatic (HAS), as well as in the light automatic system (LAS). These systems resulted in 49.19% more emerged plants compared to the other pressure systems (Fig. 1C). This can happen when excessive pressure is applied during furrow creation at planting time, leading to soil surface crusting and delayed seedling emergence (MODOLO et al. 2008).

Eight days after sowing, it was observed that the pressures - manual 120 kg (M120), manual 45 kg (M45), standard automatic (SAS), heavy automatic (HAS), and custom automatic 59 kg (AP59) - resulted in the highest numbers of emerged plants (Fig. 1D). This likely happened because of increased pressure on the seeding units, resulting in excessively deep planting that stressed the seeds and delayed seedling emergence (DIÉDHIOU et al. 2021), and according to Teixeira et al. (2018) seed planting depth significantly impacts plant emergence. In this regard, GAO et al. (2020) as planting depth increases, seed placement accuracy at the optimal depth decreases.

On the eighth day, the total number of emerged plants was tallied, revealing that the manual 120 kg, manual 45 kg, heavy automatic, and custom automatic 59 kg systems recorded the highest final plant emergence counts (Fig. 2). Although the manual system excelled in performance, yielding a high number of emerged plants, ZHOU et al. (2023) showed that proper downforce can mitigate the impact of machine speed during planting and soil compaction. Automated pressure systems prevent excessive soil compaction in the seed furrow, ensuring seeds are placed at the correct depth. Unlike what GROTTA et al. observed (2007), who found that soybean plant emergence was not affected by planting depth or vertical load applied along the seeding line. While BERNARDES et al. (2023) shallower seed placement resulted in faster corn emergence.

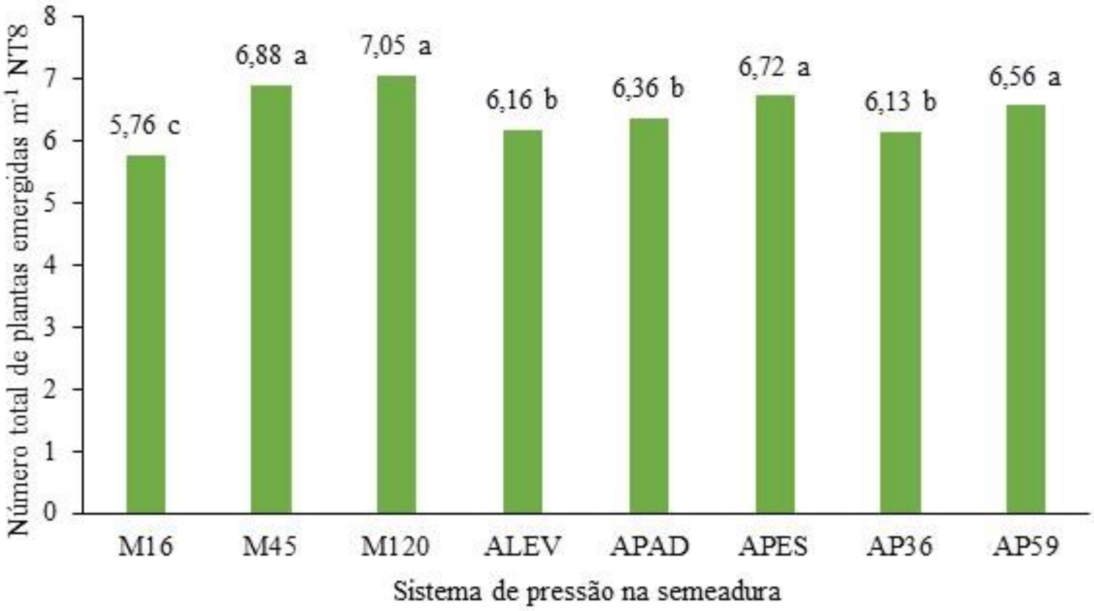

Figure 2. Total number of plants emerged up to the 8th day after sowing (NT8) as a function of the different pressure systems during sowing. M16: manual 16 kg, M45: manual 45 kg, M120: manual 120 kg, ALEV: light automatic, APAD: standard automatic, APES: heavy automatic, AP36: custom automatic 36 kg, AP59: custom automatic 59 kg.

The assessment of exposed seeds on the fifth day after planting revealed that the manual 16 kg (M16) and light automatic (LAS) pressure systems achieved the highest average of exposed seeds, at 88.63%, compared to the standard automatic system (SAS). This likely occurred due to insufficient pressure in the seeding system, resulting in inadequate seed coverage (Fig. 3).

Plant height measurements at 20 days after sowing (H20) showed that manual pressure systems of 16 kg (M16) and 120 kg (M120), light automatic (LAUTO), heavy automatic (HAUTO), and custom automatic 36 kg (CA36) systems achieved the greatest plant heights. The 120 kg manual system (M120) stood out, with plants 41.68% taller than those in the standard automatic system (SAS) (Fig 4).

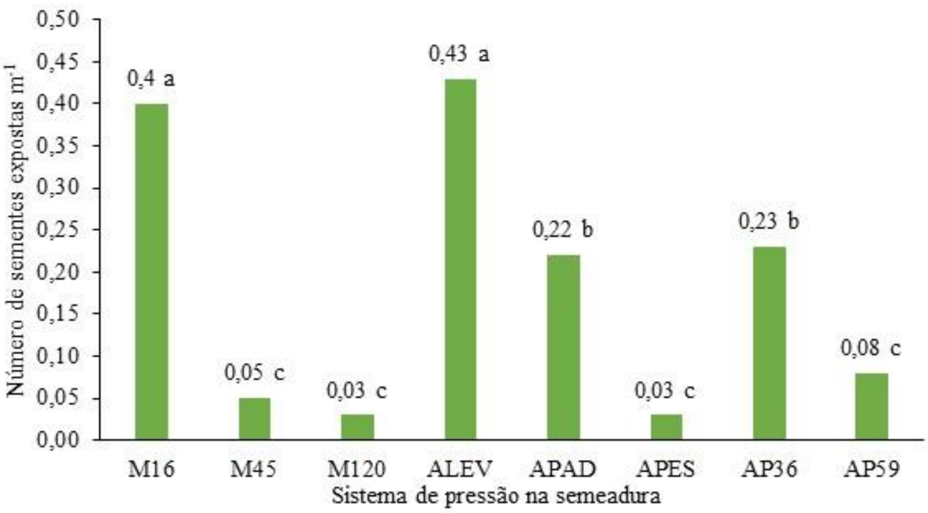

Figure 3. Number of seeds exposed in relation to pressure systems during sowing. M16: manual 16 kg, M45: manual 45 kg, M120: manual 120 kg, ALEV: light automatic, APAD: standard automatic, APES: heavy automatic, AP36: custom automatic 36 kg, AP59: custom automatic 59 kg.

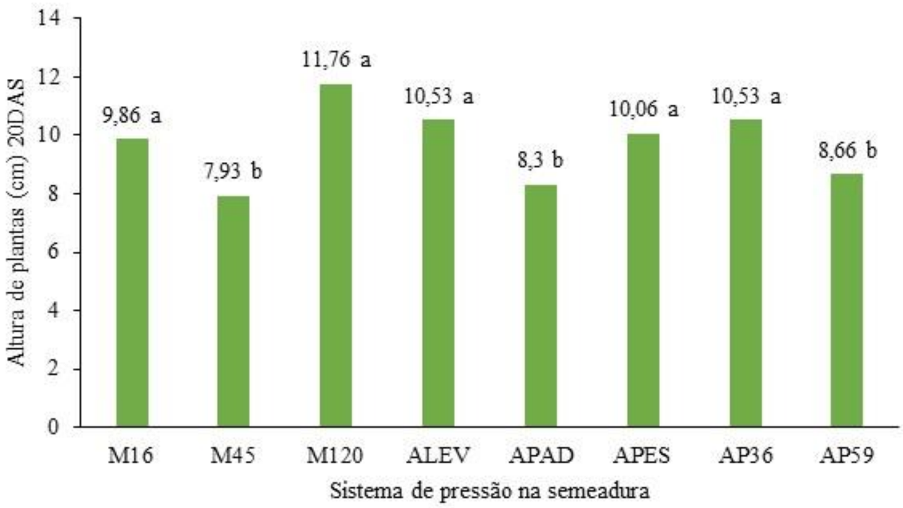

Figure 4. Plant height at 20 days after sowing (20DAS) in relation to pressure systems at sowing. M16: manual 16 kg, M45: manual 45 kg, M120: manual 120 kg, ALEV: light automatic, APAD: standard automatic, APES: heavy automatic, AP36: custom automatic 36 kg, AP59: custom automatic 59 kg.

Under high pressure conditions, plants tend to grow larger and have a higher final stand count, potentially influencing their overall height (MODOLO et al. 2011) it was also observed in this study for the total number of plants on the eighth day, where manual pressure of 120 kg (M120) resulted in the highest final plant stand. Unlike the findings of LABEGALINI et al. (2016) observed reduced plant height development, linked to more compacted soils that inhibit root system growth, thus affecting nutrient and water uptake.

25 days after planting, statistical analysis showed no significant difference in plant height across various seeding pressure systems (Figure 5). This may be due to plants equalizing as they grow under favorable environmental conditions, with their final form being genetically determined (CORTEZ et al. 2009).

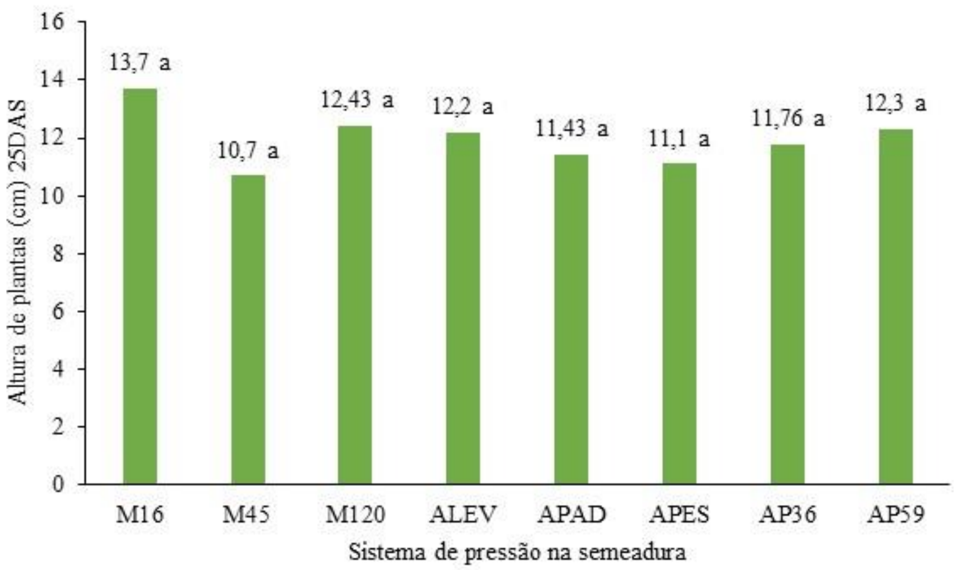

Figure 5. Plant height at 25 days after sowing (25DAS) in relation to pressure systems at sowing. M16: manual 16 kg, M45: manual 45 kg, M120: manual 120 kg, ALEV: light automatic, APAD: standard automatic, APES: heavy automatic, AP36: custom automatic 36 kg, AP59: custom automatic 59 kg.

Root length measurements taken 15 days after sowing showed that the light automatic pressure (LAP) and standard automatic pressure (SAP) systems yielded lower values compared to other pressure systems (Figure 6).

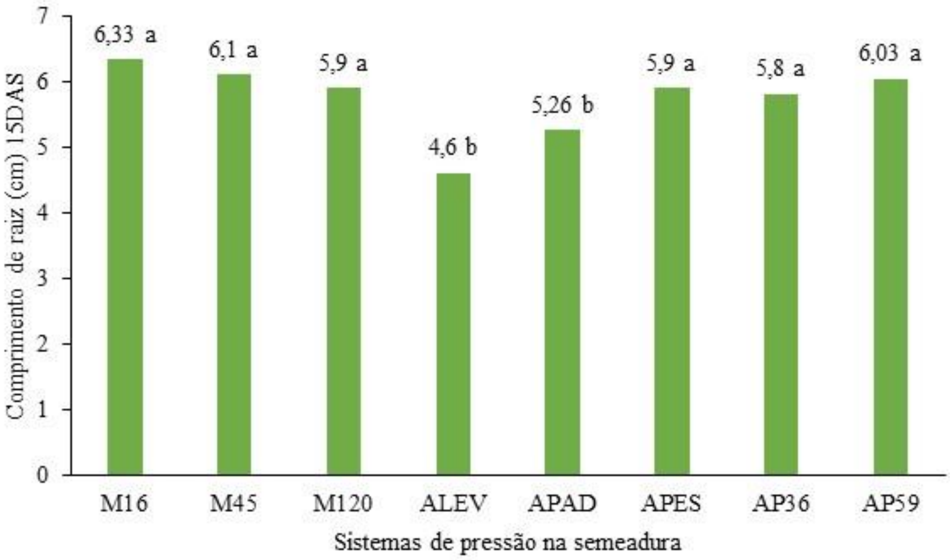

Figure 6. Root length 15 days after sowing (15DAS) in relation to seeding pressure systems. M16: Manual 16 kg, M45: Manual 45 kg, M120: Manual 120 kg, LAS: Light automatic, APS Standard automatic, HAS: Heavy-duty automatic, AP36 Custom automatic 36 kg, AP59 Custom automatic 59 kg.

Evaluation of soybean and corn root systems and soil physical properties by VALADÃO et al. (2015) observed that at the highest level of soil penetration resistance, changes occurred in the distribution of the root system. Silva et al. (2014) noted an increase in root density in the upper soil layer as compaction increased, preventing roots from penetrating deeper.

CONCLUSION

O uso de sistema de pressão automático na semeadura não foi favorável a emergência das plântulas de algodão, sendo os sistemas manuais mais adequados.

The 16 and 45 kg manual pressure systems yielded the highest number of emerged seedlings on the 5th day after sowing; however, the 16 kg manual system resulted in the most exposed seeds.

The manual pressure system at 120 kg yielded the highest number of total emerged seedlings on the 8th day after sowing, also achieving the greatest plant height 20 days after sowing.

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