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Research Article
Root Characteristics of Sugarcane Cuttings Derived from Different Stalk Parts and their Relationships with Plant Growth

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Abstract

Background and Objective: Seedling uniformity is an important factor in crop growth. In sugarcane cultivation, the position of the cutting impacts cane emergence and biomass accumulation. Therefore, the objective of this study was to evaluate shoot and root traits of sugarcane cuttings derived from different stalk portions and their relationships with above-ground parts. **Materials and Methods:** A 3×3 factorial randomized complete block design with four replications was used. The different stalk parts, namely bottom, middle and top, represented factor A, while factor B was represented by three different commercial sugarcane cultivars available in Thailand, namely KK3, LK92-11 and K88-92. Emergence was observed daily from planting up to 45 DAP. Cane height and stem diameter were measured at 3-day intervals from 21-45 DAP. Shoot dry weight, root length, root average diameter, root volume and root surface area were measured at 45 DAP. **Results:** Cuttings from different stalk parts differed in emergence date, with cuttings from the higher parts showing a good performance in shoot dry weight and rooting traits, similar to cuttings from the middle part. The three cultivars differed in terms of root and shoot traits and showed a correlation between germination date and rooting traits. Shoot traits and rooting traits were positively correlated. **Conclusion:** To obtain uniform seedling growth, cuttings should be taken from the same position.

Key words: Emergence, cane sett position, uniform seedling, root length, root surface area

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Almost all sugarcane production systems worldwide are rainfed and drought stress is a major limiting factor. Therefore, understanding the root characteristics is a key factor in mitigating drought in sugarcane[1] and it is necessary to investigate. Water deficit can affect sett emergence, growth and yield of sugarcane[2] and improving root performance in the early growth stages might increase resistance to dehydration[1]. However, rooting traits largely vary and differences in sugarcane seedling stands may affect root and above-ground expressions, leading to varying results.

The variations in sugarcane seedlings are due to a different germination of diverse bud setts. Different buds derived from different stalk sett parts such as bottom, middle and top parts result in variations in seedling stands and sprouting rates[3]. Clements[4], Das[5] and Worku[6] found higher germination percentage in cuttings taken from the upper portion and the time required for sprouting was also much shorter when compared to cuttings taken from the middle and lower portions. Similarly, Kakde[7] reported that older buds of a stalk showed a relatively slow sprouting rate. Alvarez and Planar[8] found that sprouting, number of tillers and number of stalks were highest in setts taken from the middle and upper portions of cane. According to the recommendations for farmers, the middle and top portions of stalk sugarcane should be used in plantings[9]. However, the root responses of the sprouts, according to the bud position, are not well understood and so far, information about the traits of different sugarcane cultivars with varying bud positions and the relationships with shoot characteristics is scarce.

In this sense, a better understanding of root characteristics of sugarcane seedlings derived from different stalk portions and their relationship with above ground growth could facilitate the selection of suitable bud positions on the stalk sett, contributing to the uniformity of sugarcane seedlings. The objective of this study was therefore to evaluate shoot and root traits of sugarcane seedlings derived from different stalk portions and their relationship with above ground growth.

MATERIALS AND METHODS

Experimental details: The greenhouse experiment was conducted from April-May 2014 at the Field Crop Research Station of Khon Kaen University, Khon Kaen, Thailand (lat 16°28′ N, long 102°48′ E, 200 m above sea level). A 3×3 factorial, randomized complete block design with four replications was used. Different bud portions such as bottom middle and top of stalk sett were assigned as factor A, while factor B was represented by three commercial sugarcane cultivars commonly used in Thailand, namely KK3, LK92-11 and K88-92. These genotypes have previously been used as check cultivars in numerous yield trails in Thailand.

The plants were grown in pots with equal amounts of soil. In the first year, canes of each cultivar were cut at 12 months in the field and each stalk was separated into three parts (bottom, middle and top part) via total bud numbers of each stalk divided by 3. A center bud in each portion was representatively selected and then planted in a pot. Water was applied at soil field capacity (11% soil moisture content) at planting and irrigation was performed daily throughout the experimental period.

Data collection

Emergence date and growth traits: Cane emergence started at 14 days after planting (DAP) and daily observations were done until 45 DAP. Cane height was measured from the soil surface level to the leaf tip at 3rd day intervals from 21-45 DAP, while stem diameter was determined using a vernier caliper. Shoots, including stems and leaves were collected for each pot at 45 DAP for fresh weight determination via oven-drying at 80°C for 48 h or until constant weight.

Rooting traits: Root samples were collected at 45 DAP and washed in round bottom sieves with a mesh size of 0.5 mm^2, following the recommendations of Bohm[10]. The samples were rinsed with tap water to remove the soil and subsequently, root length, average diameter, volume and surface area were determined via the WinRHIZO program (WinRHIZO program (WinRHIZO Pro (s) V. 2004a by Regent Instruments Inc.)[1,11-13].

Statistical analysis: All statistical analyses were conducted using Statistix8. The measured data were subjected to two-way analysis of variance (two-way ANOVA) as factorial in randomized complete block design. Comparison among genotypes for all parameters was based on the least significant difference (LSD) test[14]. Simple correlation analysis was used to determine the relationships between shoot traits and root characteristics.

RESULTS AND DISCUSSION

Cane emergence: Cuttings from the top and middle bud portions of the three genotypes showed a faster cane

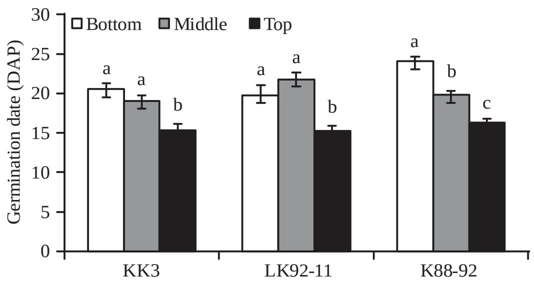

Fig. 1: Mean germination date (DAP) sugarcane cuttings from different node positions (bottom, middle, top) from the sugarcane cultivars KK3, LK92-11 and K88-92
Vertical bars shown standard error difference of means and mean value with the same letters of each cultivar are not significantly different by LSD at $p<0.05$

emergence than those from the bottom portion. The cultivars KK3 and LK92-11 showed no significant differences in emergence date between middle and bottom cuttings. Middle and bottom bud cuttings of K88-92 significantly differed, with cuttings from the middle part showing a faster emergence than those from the bottom part (Fig. 1). Germination is an important factor in successful sugarcane production and a high germination rate provides a high population per area, supporting a high amount of millable cane[15,16].

Sprouting performance was also related to the number of tillers and stalks per area and was high in cuttings taken from middle and top portions of the stalk[4-9]. Also, previous studies reported that bud age was related to sprouting capacity and older buds, at the lower stalk parts, showed a low sprouting capacity, which was most likely a result of the drying up of the scales[5-7,9]. Substances for growth regulation play an important role in the emergence of sugarcane setts[16]. Auxin concentrations are high in the top parts of the stalk, inhibiting the growth of lateral buds[16].

Growth and shoot dry weight performance: At 18 DAP, stem height between cuttings from different stalk parts did not differ in cultivar LK92-11, whereas KK3 and K88-92 showed a greater stem height of cuttings from the top part compared to those from the middle and bottom parts. However, after 18 DAP, cuttings from the middle portion showed a greater height increase in LK92-11 and K88-92, with similar values compared to the top cuttings. Cultivar KK3 showed a clear difference among the three portions during 24-40 DAP, although seedling height from top cuttings was not significantly different compared to that from middle cuttings at 45 DAP. From 24-45 DAP, in all three cultivars, cuttings derived from the bottom part were of lower height than those from the two middle and top parts (Fig. 2a-c). All seedlings derived from different bud stalk portions did not differ in shoot diameter for all measurement dates, except at 18 DAP, where shoot diameter was lower for cuttings from the bottom part compared to those from the middle and top parts for K88-92 (Fig. 2d-f). Shoot dry weight of three cultivars at 45 DAP differed significantly between cutting height, with cuttings from the top part showing higher values compared to those taken from the middle and bottom parts (Fig. 3).

Biomass accumulation in sugarcane was related to the period from emergence to maturity and to growth rate[16]. Cuttings derived from the top portion showed the most rapid cane emergence and, consequently, the highest shoot dry weight and stem height. In contrast, a previous study of Sime[9] found that the mean height of cuttings from the bottom part was rather higher than middle and top portions, which might be due to genetic variation. Favorable growing conditions might have facilitated higher stalk length and stalk diameter, which resulted in higher weight and there seemed to be a positive correlation between stalk length and weight and between, stalk diameter and weight as indicated in a previous study[17].

Root performance: The cultivars KK3 and LK92-11 showed a high root performance of cuttings taken from the middle and top portions, namely high root length, root surface area, root volume and root diameter when compared to cuttings from the bottom part. The root traits of K88-92, derived from different node positions, varied considerably; cuttings from the top part showed a higher root length, root average diameter, root surface area and root volume compared to those from the middle and bottom parts, respectively (Fig. 4a-d).

A good root growth performance at the formative stage is crucial to resist droughts at the early stages. In the subtropics, sugarcane seedlings were subjected to water shortage over a period of 2-4 months after planting[1], affecting cane emergence, growth and yield[2]. Good emergence and root performance at the formative stage are important for the growth and development throughout the life cycle[16,18].

Relationship between root and shoot parts: Correlation coefficients between germination date and rooting traits, i.e., root length, root surface area, root average diameter and root volume were significantly negative, with values of -0.72, -0.75, -0.76 and -0.78, respectively (Fig. 5a-d). The relationship between shoot dry weight and rooting traits (root length, root surface area, root average diameter and root volume) was

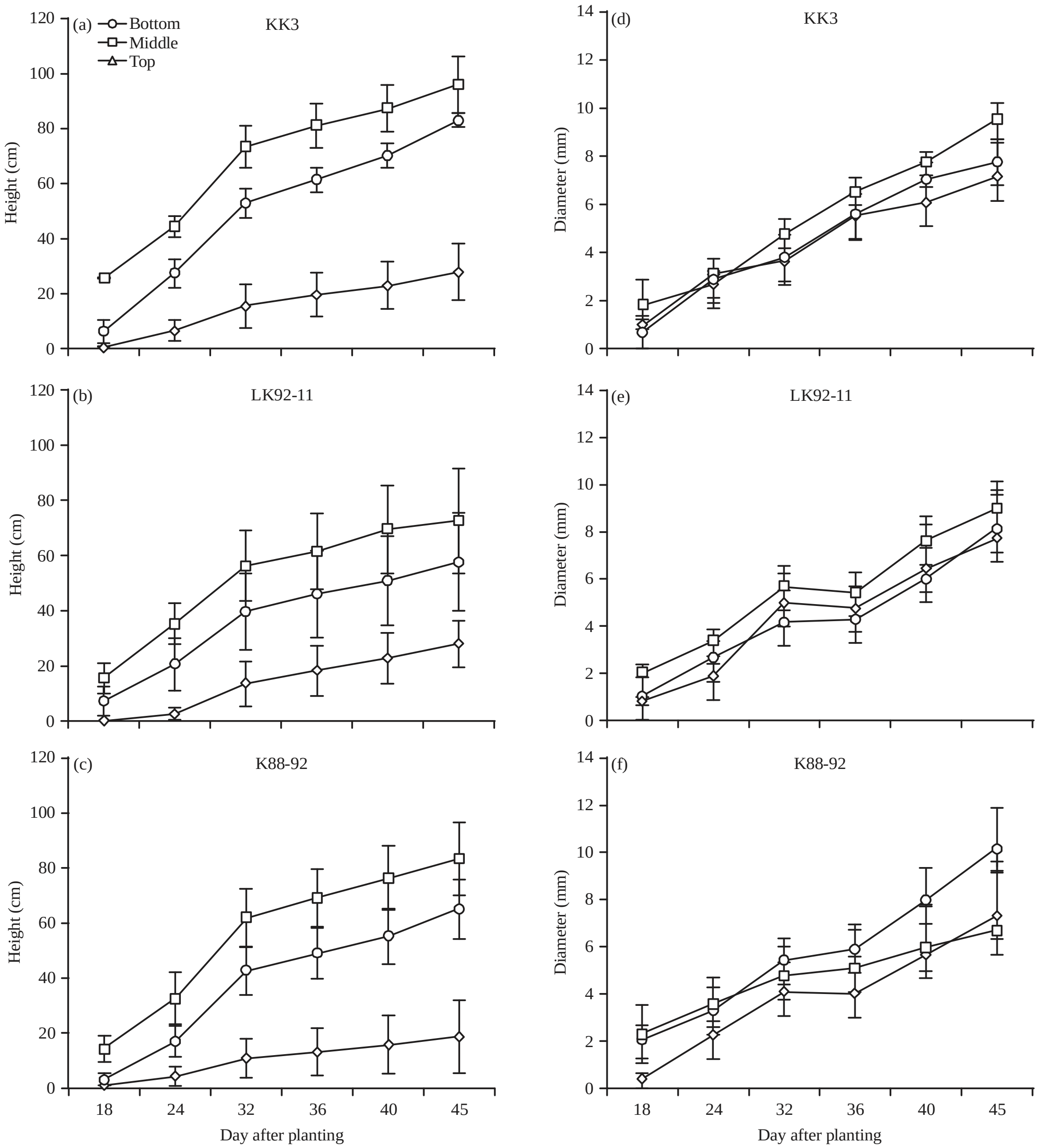

Fig. 2(a-f): (a, b and c) Stalk height and (d, e and f) diameter of cuttings from three different parts of the stalk (bottom, middle and top) from three sugarcane cultivars (KK3, LK92-11 and K88-92)

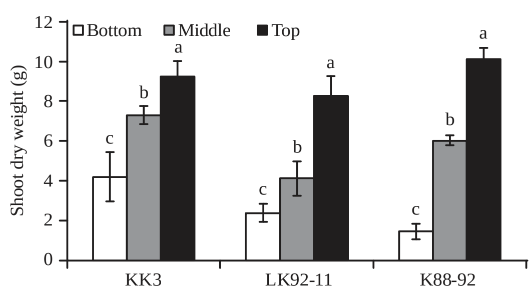

Fig. 3: Shoot dry weight of cuttings obtained from different node positions (bottom, middle and top) from the three sugarcane cultivars KK3, LK92-11 and K88-92

Vertical bars shown standard error difference of means and mean value with the same letters of each cultivar significantly different by LSD at $p<0.05$ after are not

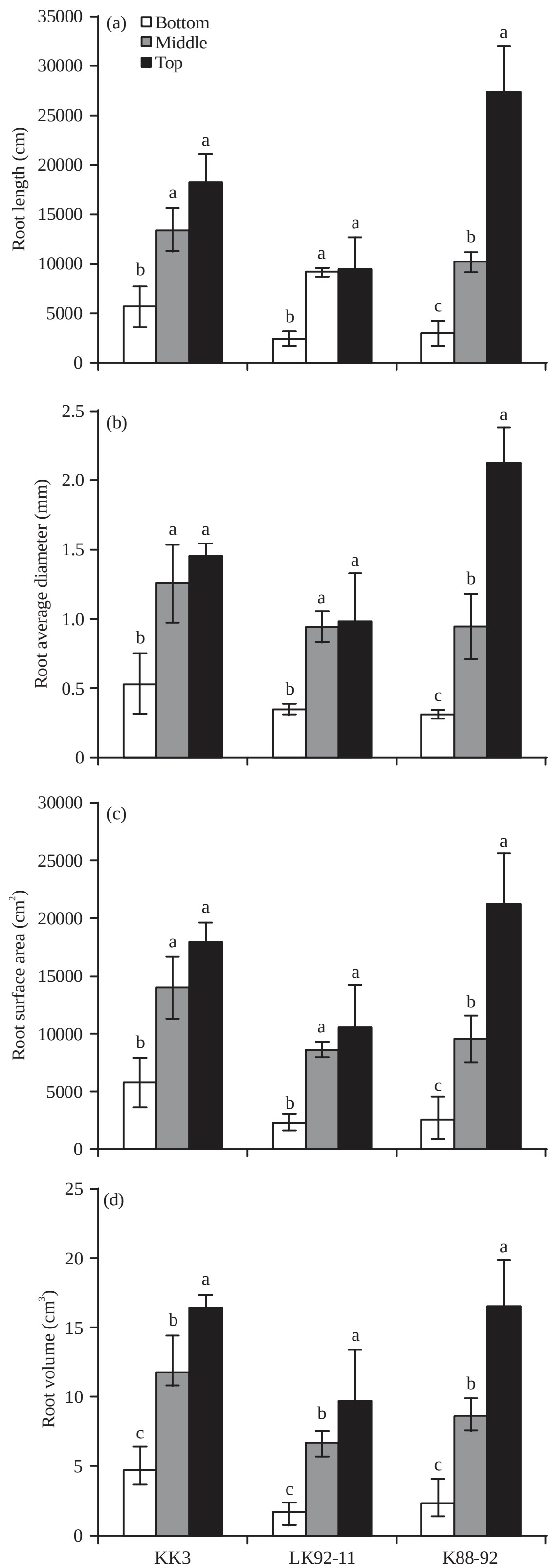

Fig. 4(a-d): Rooting traits, i.e. (a) Root length, (b) Root average diameter, (c) Root surface area and (d) Root volume in cuttings from three sugarcane cultivars (KK3, LK92-11 and K88-92) obtained from different node positions (bottom, middle and top)

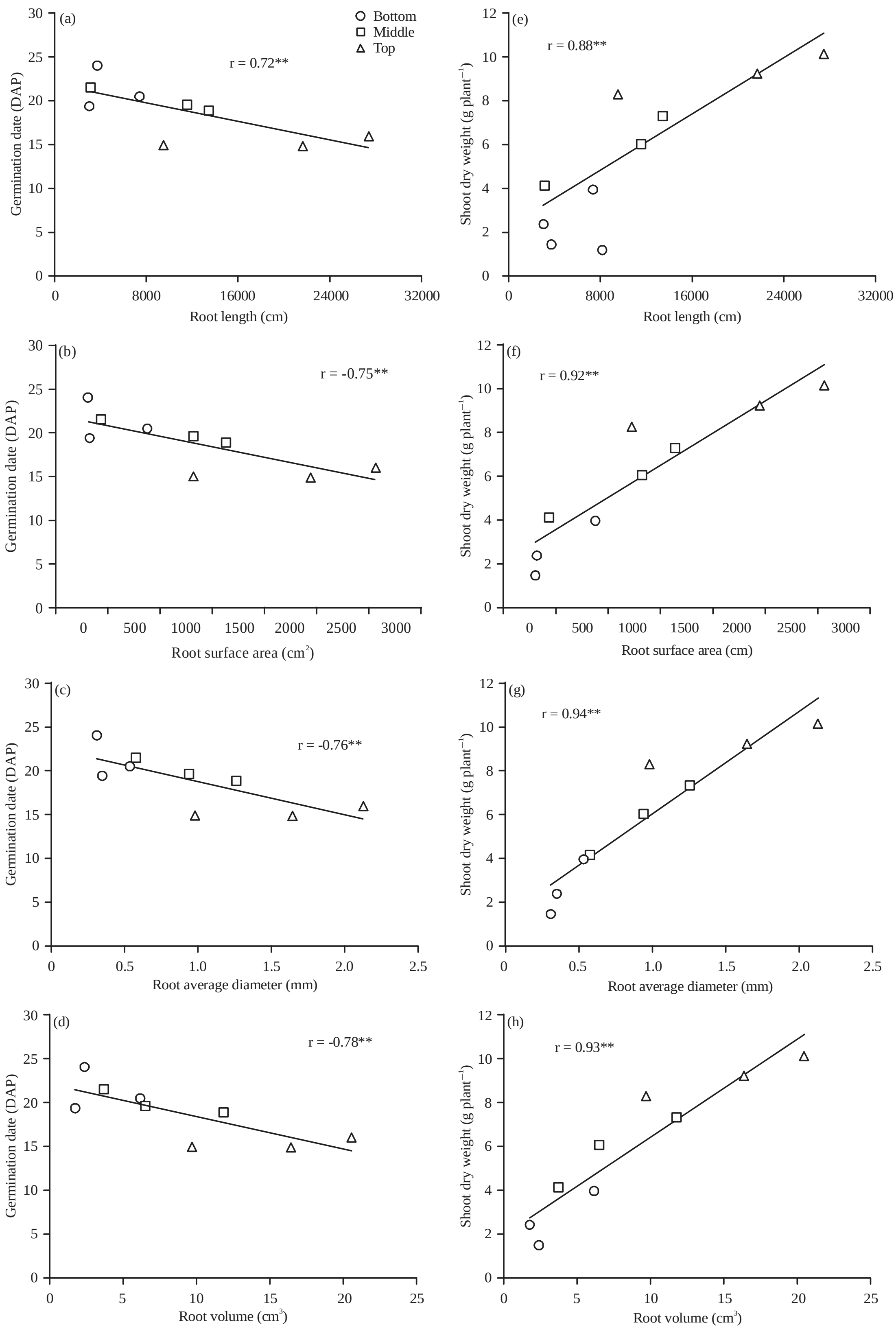

Fig. 5(a-h): Relationships between germination date (DAP) and rooting traits, i.e., (a) Root length, (b) Root surface area, (c) Root average diameter, (d) root volume and (e-h) Relationships between shoot dry weight (g/plant) and rooting traits in cuttings from three sugarcane cultivars taken from different node positions (bottom, middle and top; n = 36)[16]

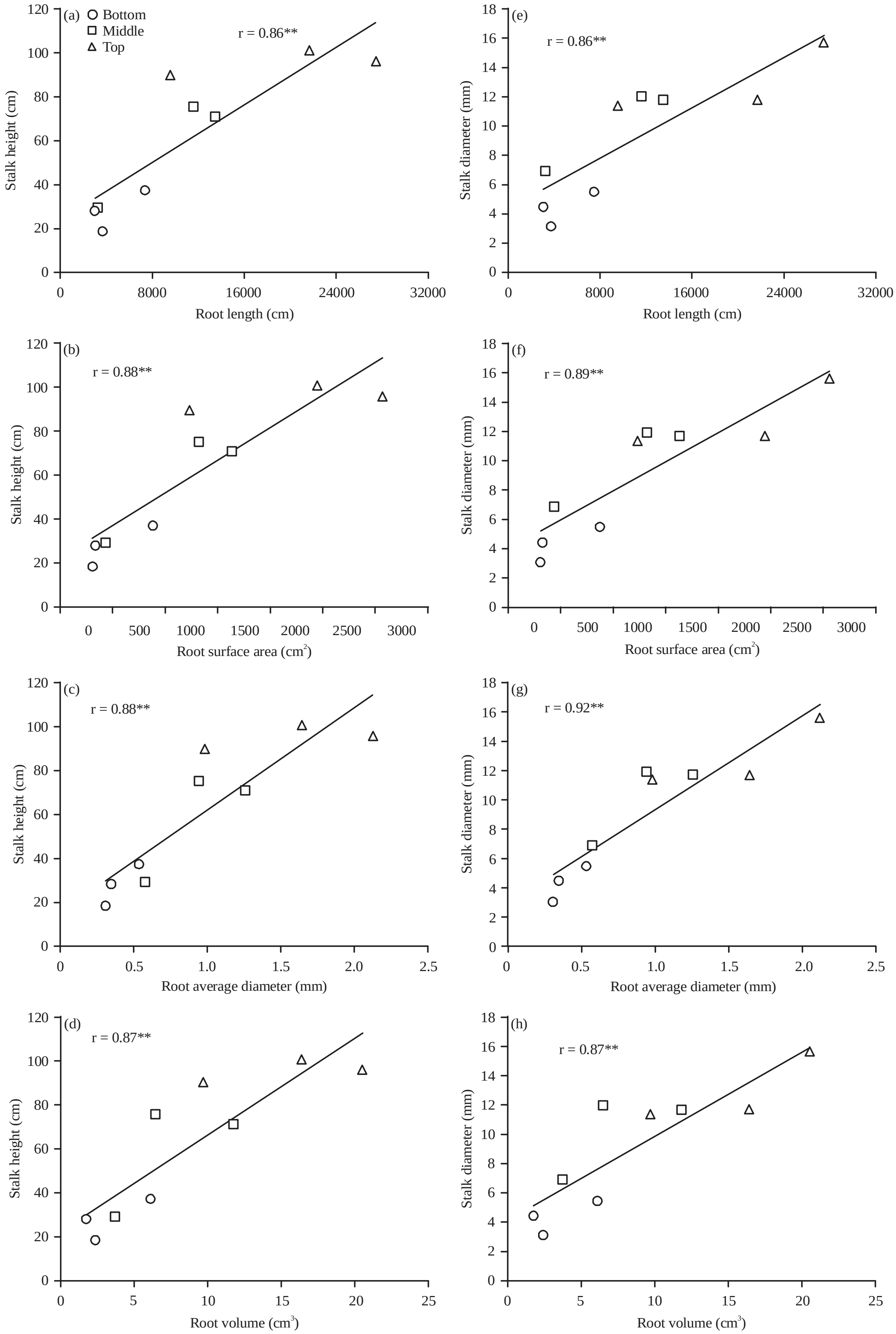

Fig. 6(a-h): Relationships between stalk height and rooting traits, i.e. (a) Root length, (b) Root surface area, (c) Root average diameter, (d) Root volume and (e-h): Relationships between stalk diameter and rooting traits in cuttings from three sugarcane cultivars taken from significantly positive (Fig. 5e-h), with correlation coefficients of 0.88, 0.92, 0.94 and 0.93, respectively. In addition, the correlation coefficients between above-ground traits, such as stalk height (Fig. 6a-d) and diameter (Fig. 6e-h) and rooting traits were significantly positive. Rapid germination contributed to a higher root formation, as indicated by the relationship between germination date and rooting traits. Consequently, the relationship between shoot and rooting traits with different sett portions was positive, indicating that a large root system facilitates shoot development.

In sugarcane, there was a positive correlation between shoot and root growth[1,18-20] and between root length and leaf[21]. The root promotes the activity and function of the shoot[20]. Cuttings from the top part of the stalk, with younger buds are characterized by rapid germination compared to cuttings with older buds, resulting in a larger root system. Such a system is more suitable for nutrient and water uptake, thereby facilitating sugarcane shoot growth[1].

CONCLUSION

This study concluded that the cuttings from different stalk parts differed significantly in terms of cane emergence, with cuttings from the top part showing the fastest emergence and higher shoot dry weight and root characteristics, similar to the values obtained for cuttings from the middle part. That can be beneficial for sugarcane research work, cuttings should be taken from the same position to obtain uniform seedling growth.

SIGNIFICANT STATEMENT

This study discover that the cuttings from different stalk parts differed significantly in terms o f cane emergence, shoot and root traits. Previously researchers reported that different buds derived from different stalk sett parts such as bottom, middle and top parts result in variations in seedling stands and sprouting rates. However, the root responses of the sprouts, according to the bud position, are not well understood and the relationships with shoot characteristics is scarce. The results of this study suggested that cuttings should be taken from the same position to obtain uniform seedling growth, for research work.

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