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Effects of Plant Density and Row Spacing on Yield and Yield Components of Peanut (*Arachis hypogaea* L.) on the Coastal Sandy Land Area in Nghe An Province, Vietnam

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ABSTRACT

Background: Understanding the effects of different plant densities and row spacing on yield and yield components of peanut L14 is essential for designing and adjusting management practices to improve yield.

Methods: Five planting densities were tested in Randomized Complete Block Design with three replications in 2019 spring crop on the coastal sandy land area in Dien Chau district, Nghe An, Vietnam.

Result: The different density treatments affect the growth, development and yield of the peanut variety L14. With increasing plant density, the number of pod per plant, 100 pods weight, 100 seeds weight decreased, whereas plant height, leaf area index, dry matter production increased. Population yield increased with increasing plant density from the lowest density of 25 plants m^{-2} (2.78 tons ha^{-1}), reached the highest at 35 plants m^{-2} (4.53 tons ha^{-1}), then decreasing with increasing plant density. Peanut variety L14 is grown in plant densities and row spacing of 35 plants m^{-2} (25 cm × 25 cm) and 40 plants m^{-2} (25 cm × 20 cm) are most appropriate; plants grow, develop better and give a higher yield than other densities under the same conditions.

Key words: Coastal sandy land, Peanut, Plant densities, Row spacing, Yield components.

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is one of the most valuable legumes of tropical and subtropical regions (Jadon *et al*., 2018). It is also an important oil and cash crop in Vietnam and worldwide (Le *et al.,* 2019); due to the high contents of protein, oil, fatty acids, carbohydrates, vitamins and minerals, peanuts have high commercial and nutritional value. Peanuts are ideal crops in rotation systems to improve soil fertility due to their nodule roots and their ability to fix natural atmospheric nitrogen (Abady *et al*., 2019). Vietnam is the 10^{th} of more than 100 peanut growing countries in the world and the 5^{th} of 25 peanut growing countries in Asia next to India, China, Myanmar and Indonesia in terms of cultivated area (Hieu *et al*., 2011).

Peanut yield depends on the degree of management variability and practices, especially those related to row spacing. The number of crops per unit area is one of the most important determinants of a crop's yield in the field. Therefore, planting density is one of the main factors that play an important role in the growth, yield of peanuts (Annadurai *et al*., 2009; Gulluoglu *et al*., 2016).

As the number of plants per unit area increases, competition between growth resources also increased. Crop yield is determined by the efficiency with which plant populations use available environmental resources for growth (Sreelatha *et al*., 2019). Plant density and row spacing are useful management tools for maximizing crop yield by optimizing the use of resources such as light, nutrients, water and reduce soil surface evaporation (Dapaah *et al*., 2014). Peanuts' response to plant density and row spacing has been investigated in many regions of the world. It is important to understand the effects of plant density and row spacing on crop growth and variation in yield and yield components to help build efficient production options for groundnut. Therefore, the study's objective is to determine the effects of different plant densities and row spacing on morphological development, growth rate and yield of peanuts grown in coastal sandy areas.

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MATERIALS AND METHODS

Experimental design

Field experiments were carried out during the 2019 spring crop at the research area of Institute of Agriculture and Natural Resources, Vinh University in Dien Chau district, Nghe An province, Vietnam (105.30-105.45° N, 18.20-19.50° E).

This research was conducted on the peanut variety L14, which was recognized as a technically advanced variety according to Decision No. 5310 QD/BNN-KHCN, November 29, 2002.

Five planting densities: 25 (M1); 30 (M2); 35 (M3); 40 (M4) and 45 (M5) plants m^{-2} were tested in Randomized Complete Block Design with three replications (Table 1). Before sowing, 1 ton ha^{-1} of microbial organic fertilizers + 30 kg ha^{-1} N + 90 kg ha^{-1} P_2O_5 + 60 kg ha^{-1} K_2O + 500 kg ha^{-1} lime powder was applied. Mineral fertilizer rates were determined based on the nutritional requirements of peanut and soil nutrient availability.

The plot size was 7.7 m × 1.3 m = 10.01 m^2. Cultural practices, such as land preparation and pest management practices, which were by the recommendations from the Industry-standard 10-TCN 340:2006 on Groundnut Varieties-procedure to conduct tests for value of cultivation and use.

Data collection

Plant height (cm) was measured from the ground level (at the plant's base) to the top of the highest point, including the terminal leaflet using a graduated meter stick. It was recorded from 10 randomly selected plants within the net plot. The number of branches per plant was obtained by direct counting of branches from 10 randomly selected plants in each plot. LAI was estimated as (LAI = surface area of sampled leaf/ground area occupied by the sampled plants). Dry biomass (g $plant^{-1}$) was obtained after oven drying plants at 105°C until the mass is constant. The number of pods per plant was counted directly from ten sample plants of each plot (with three replications) and an average was calculated after harvesting. One hundred pods weight (g) and one hundred seeds weight (g) are obtained from a random sample of 100 pods and 100 seeds, respectively, and weighed. Shelling per cent (%) = [weight of all seeds from random sample/weight of 100 randomly selected pods]×100. In each experimental plot, data on pod yield were recorded on ten randomly selected plants harvested.

Statistical analysis

Data collected were subjected to excel and subsequently analyses using IRRISTAT statistical package.

RESULTS AND DISCUSSION

Plant height and number of branches per plant

The results from Table 2 showed that plant height ranges from 36.5 to 39.3 cm, with densities of 40 and 45 plants m^{-2} [High], plant height also tends to be higher than 25; 30; 35 plants m^{-2} [Low]. However, statistical analysis for plant density and row spacing interaction showed no significant effect on plant height. This outcome could result from soil fertility's homogeneity in the experimental area (Mvumi *et al.* 2018). L14 is a peanut with a balanced shape, strong growth, larger plant height, more leaf stems will affect the flowering and pod formation. Therefore, peanuts with a balanced plant height will create a premise for flowering, better pod formation, higher peanut yield corresponding to an optimal density.

Table 1: Treatment and descriptions of the experiment.

Treatment	Plant density (plant m^{-2})	Plant spacing	Seed $hole^{-1}$
M1	25	25 cm × 35 cm	2
M2	30	25 cm × 30 cm	2
M3	35	25 cm × 25 cm	2
M4	40	25 cm × 20 cm	2
M5	45	25 cm × 15 cm	2

Table 2: Effect of plant density and row spacing on plant height and number of branches per plant.

Treatment	Plant height (cm)	Number of branches per plant	
		Level 1 branches	Level 2 branches
M1	36.5a	4.6bc	2.1a
M2	36.8a	4.7bc	2.3a
M3	37.3a	4.9c	2.3a
M4	38.1a	4.3b	2.1a
M5	39.3a	3.7a	2.0a
CV%	5.0	6.6	9.6
LSD	3.5	0.6	0.4

Note: Different small letters in the table meant a significant difference among treatments at 0.05 level.

The number of branches per plant at different planting densities varied from 3.7 to 4.9. There was a significant difference between the number of level 1 branches per plant for the densities of 40; 45 plants m^{-2} [High] and 25; 30; 35 plants m^{-2} [Low]. Low densities have more branches per plant than high densities. Dapaah *et al.* (2014) reported that medium and low sowing densities had a slightly higher number of branches per plant than the control and high sowing densities. However, the author also found that branching in peanuts may impact positively on yield. Giayetto *et al.* (1998) found that the number of branches per plant decreased correspondingly to an increase in plant density. Existing plants developed more branches at low plant densities because of reduced competition. Similar results have been reported by other studies (Sternitzke *et al.*, 2000).

Leaf area index (LAI)

The statistical analysis for planting density and row spacing on the leaf area index in Table 3 showed that affected LAI at the flowering period (after sowing). LAI increased and was maximum during the pod formation period and decreased during harvest but no significant effect by plant density and row spacing in both of these periods. LAI tends to be higher at higher densities during the growing stages and vice versa. Our results are also consistent with previous studies; Rasekh *et al.* (2010) found that LAI was also significantly influenced by the plant density during different growth stages. Magagula *et al.* (2019) observed that the highest LAI value was 4.63-4.93, which declined to 1.93-2.47 as maturity.

Table 3: Effects of different plant density and row spacing on leaf area index and dry matter production.

Treatment	Leaf area index (m^2 leaf m^{-2} ground)			Dry matter production (g $plant^{-1}$)		
	Flowering	Pod formation	Harvesting	Flowering	Pod formation	Harvesting
M1	1.73a	4.53a	1.21a	6.13ab	23.78a	26.34ab
M2	1.77b	4.60a	1.35ab	6.05a	25.39b	28.56ab
M3	1.80c	4.76a	1.41ab	6.28ab	26.72bc	30.23ab
M4	1.81c	4.82a	1.47ab	6.51b	27.63c	32.59b
M5	1.95d	4.93a	1.58b	6.03a	23.45a	25.37a
CV%	4.9	4.3	10.0	3.2	3.2	10.0
LSD	0.2	0.4	0.3	0.4	1.6	5.6

Note: Different small letters in the table meant a significant difference among treatments at 0.05 level.

Table 4: Effects of different plant density and row spacing on yield components and yield.

Treatment	Number of pod per plant	100 pods weight (g)	100 seeds weight (g)	Shelling percent (%)	Theoretical yield (tons ha^{-1})	Net yield (tons ha^{-1})
M1	9.3d	153.4a	63.6a	76.3a	3.57a	2.78a
M2	8.7c	152.8a	63.2a	76.5a	3.99b	2.95ab
M3	8.5c	152.6a	63.1a	76.9a	4.53c	3.62b
M4	7.2b	151.8a	62.8a	76.8a	4.37c	3.37b
M5	6.1a	151.2a	62.6a	76.2a	4.15bc	3.08ab
CV%	2.3	2.5	4.9	4.1	3.6	7.7
LSD	0.3	7.1	5.8	5.8	2.8	4.5

Note: Different small letters in the table meant a significant difference among treatments at 0.05 level.

Dry matter production

Dry matter accumulation capacity of the peanut variety L14 increases with the growing stages and obtained the highest value at harvest (Table 3). At this period, dry matter accumulation was highest in M4 (40 plants m^{-2}) and lowest in M5 (45 plants m^{-2}). It can be explained that in the density M5 (45 plants m^{-2}), there will be a dispute over aerial nutrition and ground nutrition, resulting in the lack of nutrients required for the individual growth of each plant.

The differences in dry matter production among the treatments are small (Table 3). The difference in dry mass might be due to crop growth resources are efficiently used at higher plant densities and resulted in higher dry matter accumulation at optimum plant densities (Magagula *et al*. 2019). The amount of solar radiation obstructed into the canopy depends on the plant density as higher plant densities increase the canopy closure rate and increase interception of photosynthetically active radiation needed for carbohydrate production and higher biomass in the plants (Mckenzie *et al*., 1992). The change in dry matter accumulation could be due to the leaf area and leaf area index (Olanyika and Etejere, 2015).

Yield components and yield

The number of pods per plant was a significant difference in response to plant density and row spacing interaction. The differences in the number of fruit observed were probably largely due to the peanut varieties' genotype and higher availability of growth sources at lower plant densities (Gabisa *et al*., 2017). Abdullah *et al*. (2007) also reported that an increase in plant density decreased the number of pods per plant and as plant density decreased, the number of pods per plant increased. The total number of pods per plant was high in treatment with low plant densities and low in treatment containing high tree densities (Zhao *et al*. 2017).

The data showed no significant difference in the interaction between plant density and row spacing for the 100-pods weight, 100-seeds weight. This outcome is consistent with the findings of Magagula *et al*. (2019). In general, with increased plant density, the 100-pods weight and 100-seeds weight decreased; this might be due to the plants' wider spacing (Konlan *et al*., 2013). The variations in row spacing regarding 100-seed weight might be due to competition for light, water, and other essential requirements among the plants (Onat *et al*., 2016).

The shelling percentage was not affected by plant spaces and row spacing; the shelling percentage values ranged from 76.2 to 76.9% in experiment treatments. The shelling percentage depends on the genetics of the variety, farming practices and climatic and soil conditions. Similar results were reported by Nandania *et al*. (1993), the interaction of row spacing and plant density on the shelling percentage was not statistically significant.

The theoretical yield at different experiment densities ranged from 3.57 to 4.53 tons ha^{-1}. Net yield under different density treatment ranged from 2.78 to 3.62 tons ha^{-1}. In our opinion, the density of 35 plants m^{-2} (25 cm × 25 cm) and 40 plants m^{-2} (25 cm × 20 cm) are suitable for the spring crop in

Dien Chau district, with this density shows that peanut grows and develops better than other densities, give higher yield. Other studies have reported higher yield in close spaced (30 cm × 15 cm) compared to wide (50 cm × 10 cm) spaced groundnut systems (Ahmad *et al*., 2007). The higher yield from the higher plant densities is mainly due to the efficient use of water, nutrients and more importantly light (Wells *et al*., 1993). Yilmas (1999) found that the highest yield was obtained at a distance of 60 cm × 15 cm. Madkour *et al*. (1992) showed that the effect of row spacing on seed and pod yield was significant and that the row spacing of 50 cm showed higher yields, compared to 60 cm row spacing. The pod yield per hectare was increased when the row spacing decreased (increasing plant density). Studies have also shown that the essential factor for peanut cultivation practice is improving pod number per plant and pod weight based on appropriate planting density (Zhao *et al.* 2017).

CONCLUSION

In this study, the different density treatments affect the growth, development, and yield of the peanut variety L14 in the spring crop on the Dien Chau district's coastal sandy area. Peanut variety L14 is grown in plant densities, and row spacing of 35 plants m^{-2} (25 cm × 25 cm) and 40 plants m^{-2} (25 cm × 20 cm) are most appropriate; plants grow, develop better and give a higher yield than other densities under the same conditions. Planting density and row spacing are among the main factors that play an essential role in the growth, yield, and quality of peanuts. Establishing the optimum density per unit area is essential to achieving maximum yield.

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