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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Impact of Row Planters and Different Planting Arrangements on Peanut Yield and Yield Components

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Abstract

Peanut (*Arachis hypogaea* L.) is one of the most important and economical oilseeds in the tropics and subtropics, playing a crucial role in both human nutrition and soil reclamation. This study aimed to evaluate the performance of various row planters and planting arrangements for mechanized peanut cultivation in the Moghan region of Iran using a randomized complete block design with six treatments and four replications over 2020 and 2021. The main objective was to identify the optimal planter configuration to enhance peanut yield. The treatments included different planting setups: T1 and T2 used a pneumatic single-row planter with 75 cm row spacing and 12 and 17 cm between plants, respectively. T3 and T4 applied a pneumatic twin-row planter (Tarashkadeh) with 75 cm between rows and 22 and 28 cm between plants, respectively, while T5 and T6 utilized a single-row planter with reduced row spacing of 50 cm and plant spacing of 25 and 30 cm. The results indicated that T4 and T3 provided the best horizontal uniformity of seed distribution (78.93% and 78.62%, respectively) and high emergence rates (94.23% and 93.08%). The twin-row configuration (T4) increased pod yield by 12.21% and 17.70% compared to the single-row patterns (T2 and T1). The twin-row planting system significantly improved plant density and pod yield, demonstrating its effectiveness over traditional single-row planting. Based on these findings, the use of a pneumatic twin-row planter (Tarashkadeh) with 75 cm row spacing and 28 cm plant spacing is recommended for farmers in the Moghan region to optimize peanut production.

Keywords: Peanuts, Pneumatic planter, Pod yield, Twin-row cultivation

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1. Introduction

Peanut (*Arachis hypogaea* L.) is one of the most important and economical oilseeds in the tropics and subtropics. Peanut distinguishes itself as a promising oil crop, benefiting from its affiliation with the legume family. Beyond its significance in human nutrition, peanuts play a crucial role in soil reclamation, leveraging the beneficial characteristics inherent to legumes (Önemli, 2005). This crop is rich in minerals, vitamins, fatty acids, fiber, and phenolic compounds. Peanut is a thermophilic plant that needs warm, sunny weather and a frost-free growing season (Aninbon et al., 2016; Abdzad Ghohari et al., 2018). The Moghan Plain, which is in northwestern Iran, is one of the places where peanuts are grown the most. Peanut seeds are commonly used for vegetable oil production and also for other products such as snack foods and peanut butter (Çalişkan et al., 2008; Kurt et al., 2017). Peanuts are considered the 13th most important food crop in the world and the 4th most important source of edible oil (FAOSTAT, 2022). China is the largest producer as well as consumer of groundnut in the world, with 17.6 million tonnes followed by India (6.7 million tonnes), Nigeria (4.4 million tonnes), and Sudan (2.8 million tonnes) (FAOSTAT, 2022). In the Moghan plain in northwest Iran, the area where peanuts are grown has grown a lot in recent years, from about 1.000 hectares in 2016 to more than 7.000 hectares in 2019, with a total production of 30.000 tonnes. As a result, Moghan Plain is Iran's first peanut cultivation and production area (Taghinazhad, 2019). The number of plants per unit area is one of the important yield determinants of field crops. As a result, planting density is one of the most important factors influencing peanut growth, yield, and quality (Kurt et al., 2017).

High-yield and efficient agricultural production requires reasonable plant-row spacing and planting strategies (Yang et al., 2017). Plantations with appropriate row spacing are among the most critical elements affecting peanut productivity (Awal and Aktar, 2015). If the planting density exceeds the optimum level, the available environmental factors may become insufficient to support the plant adequately. Conversely, if the planting density falls below the optimum level, the plant may struggle to fully harness the benefits of environmental factors (Ferahoğlu et al., 2023). Previous research in peanuts revealed that altering plant population and row pattern can affect canopy structure and light efficiency (Gardner and Auma, 1989), crop yield, quality factors, and pest development (Lanier et al., 2004; Lassiter et al., 2016), disease incidence and management (Wehtje et al., 1994; Maas et al., 2006; Tillman et al., 2006; Nuti et al., 2008), weed management (Place et al., 2010), physiological characteristics and yield (Rasekh et al., 2010), yield and yield components (Awal and Aktar, 2015; Kurt et al., 2017), leaf function and yield (Jun et al., 2021). Gardner and Auma (1989) reported that narrowing row spacing might improve peanut crop performance in low-temperature conditions during early vegetative growth. This change in crop structure should help with the expected use of resources (like light, water, and nutrients) and growth at the same time. The size of these responses is likely to change depending on how the plant grows (Haro et al., 2022). Peanut planting patterns have been single rows 70 cm apart. Therefore, conventional crop mechanization systems cannot increase plant density per unit area (Kurt et al., 2017). Previous research has shown that planting peanuts in twin-rows rather than single-rows can increase pod yield and total sound mature kernels by up to 450 kg ha^{-1} (Baldwin et al., 2000; Beasley et al., 2000).

The twin-row pattern allows for greater spacing between individual plants, which in turn results in increased crop growth rate, enhances some market-grade attributes, reduces the occurrence of tomato spotted wilt tospovirus (TSWV) (Baldwin and Williams, 2002; Hurt et al., 2003; Tillman et al., 2006), and increases peanut pod yield (Lanier et al., 2004; Kurt et al., 2017; Yilmaz and Jordan, 2022). On the other hand, the type of planter used for planting is very important in terms of mechanical damage to the seed and uniformity of seed distribution (Celik et al., 2007; Yasir et al., 2012). According to Wehtje et al. (1994), vacuum-type planters were to be more precise and feature a better seed metering method. Kirk et al. (2013) demonstrated that although single-row mean pod yield in peanut was higher than twin-row, single-row mean harvested yield was lower but not statistically different. The traditional single-row planting of peanuts has been popular in Iran for many years, but the new twin-row method can be effective in increasing the yield and yield components of peanuts, as well as the mechanical parameters of the seeds.

The study aims to investigate and compare various row planters with distinct planting arrangements for mechanized peanut cultivation in the Moghan region of Iran. The primary objective is to identify the most effective planter that can enhance peanut yield, considering factors such as seed distribution uniformity and emerging percentage. The hypothesis suggests that specific planting patterns, particularly twin-row configurations, will lead to improved pod yield compared to traditional single-row methods. Additionally, the study aims to assess the role of planter types, hypothesizing that certain types, like vacuum-type planters, may demonstrate superior precision in seed metering.

2. Materials and Methods

2.1. Experimental procedure

This study was conducted in the experimental field of the Ardabil Agricultural and Natural Resources Research and Education Center (Moghan Agricultural Research Station), Parsabad, Northwest of Iran (N 39°39' E 48°88' N, altitude=78 m) during the two growing seasons 2020-2021 using a randomized complete block design with six treatments in four replications. According to data from the Iran Meteorological Organization (IRIMO, 2021), this location has a semi-humid and somewhat warm climate. Over the previous 30 years, the average annual precipitation has been 251 mm, with the majority falling in the autumn and early spring. The region's annual precipitation is from 72.9 mm to 523 mm. The average annual high temperature is 35°C, while the average annual minimum is 8°C. The typical yearly relative humidity is around 71%. Climatic information about the experimental location is given in *Table 1*.

Table 1. Meteorological data during the experimental years

	2020					2021				
Date	Min (C°)	Max (C°)	Avr (C°)	Prc (mm)	Re (%)	Min (C°)	Max (C°)	Avr (C°)	Prc (mm)	Re (%)
May	11.3	22.9	17.1	42.9	72.8	13.5	27.2	20.3	16.9	67.4
June	16.7	33.4	25.0	10.3	57.2	16.9	31.7	24.3	17.6	61.3
July	19.7	34.1	26.9	0.6	57.2	21.7	36.3	28.0	0.0	53.6
August	20.4	31.5	26.0	3.9	64.1	20.7	35.6	28.1	0.0	50.4
September	17.2	29.8	23.5	43.5	70.8	19.5	31.7	25.6	2.4	63.0
October	12.9	24.1	18.5	29.2	74.2	12.3	21.6	17.0	42.8	74.7
November	9.3	18.3	13.8	6.2	79.9	6.5	14.8	10.7	43.8	77.8

*Min: Minimum monthly temperature; Max: Maximum monthly temperature; Avr: Average monthly temperature; Prc: Precipitation; Re: Average Relative Humidity.

Table 2. Characteristics of row planters used in the experiment

Planter type	Number of planting units	Row spacing (cm)	Width (m)	Connection type	Cover and press wheel	Type of opener	Metering type
Pneumatic row planter with spacing of 50 cm (SP-F4- 6 row)	6	50	3	mounted	Open inner rubber	runner	Vertical plate
Pneumatic row planter with twin row (Tarashkadeh) (Sp /540 – 8 row)	2×4	75	3	mounted	Open inner rubber	runner	Vertical plate
Pneumatic row planter with spacing of 75 cm (WPHE- 4 row)	4	75	3	mounted	Open inner rubber	runner	Vertical plate

Each experimental plot had a 25×6 m dimension. The soil texture of the experimental field was clay-loam. The treatments were as follows: T1 and T2: planting by pneumatic single-row planter with spacing of 75 cm between rows and 12 and 17 cm between plants, respectively; T3 and T4: planting by pneumatic row planter with twin-row planter

(Tarashkadeh) with spacing of 75 cm between rows and 22 and 28 cm between plants, respectively; and T5 and T6: planting by pneumatic single-row planter with spacing of 50 cm between rows and 25 and 30 cm between plants, respectively. Therefore, the plant density for each treatment was as follows: T1: 11.11 plants per 1 m^2, T2: 7.84 plants per 1 m^2, T3: 12.12 plants per 1 m^2, T4: 9.52 plants per 1 m^2, T5: 8 plants per 1 m^2 and T6: 6.6 plants per 1 m^2.

The method for preparing the land, which included disk harrowing and an experimental bedder, was the same in both years. During the cropping period, furrow irrigation was conducted around 4 to 5 times. An integrated approach to weed control was adopted, utilizing a combination of mechanical intervention using a cultivator and chemical measures, specifically applying 2 liters of trifluralin per hectare of pre-emergence herbicide before planting and hand weeding.

Traits including seed damage ratio, uniformity index of horizontal and vertical distribution of seeds, planting depth, emerging percentage, effective field capacity, yield, and yield components (number of pods per plant, pod length and diameter, 100-seed weight, and plant height) were measured. Grooves, overlays, and dispensers were similar in different treatments. The specifications of the planters used are given in *Table 2*.

2.2. Plant material

The local cultivar Goli was used in this study, with an average seed rate of 70 kg ha^{-1}. The experiment was planted as a single seed in row planters.

2.3. Measurement methods

2.3.1. Seed damage ratio

The mechanical seed damage ratio was calculated using the following equation 1 formula (Taki and Asadi, 2009):

$$SDR = \frac{n}{N} \times 100 \qquad \text{(Eq.1).}$$

Where SDR: seed damage ratio, n: number of damaged and broken seeds output from the distributor and N: total number of output seeds.

2.3.2. Effective field capacity

The effective field capacity (EFC) of a planter can be computed by dividing the area finished by the actual field time in hours (Taghinazhad, 2017).

$$EFC = \frac{A}{Tt} \qquad \text{(Eq.2).}$$

Where: EFC: effective field capacity, A: area worked per hectare, Tt: total time spent per hour

2.3.3. Seed germination percentage

Seed germination percentage was calculated from the formula 3 provided by Karayel and Ozmerzi (2002):

$$PE = \frac{Ste}{n} \times 100 \qquad \text{(Eq.3).}$$

Where: PE: percentage of seed emergence; Ste: number of total emerged seedlings per meter; n: number of seeds sown per meter.

2.3.4. Horizontal uniformity of seed distribution

After all the seeds in each plot had grown, a digital measurer was used to measure the distance between plants in a parallel row at 20 random points from the middle of each plot. Then, the horizontal uniformity of seed distribution was calculated from the formula 4 and 5 that described by (Senapati et al., 1992).

$$sd_s = \sqrt{\frac{\sum_{i=1}^{n} s_i{}^2 - \frac{\left(\sum_{i=1}^{n} s_i\right)^2}{n}}{n-1}} \qquad \text{(Eq.4).}$$

$$SSE = \frac{S_a - sd_s}{S_a} \quad \text{(Eq.5).}$$

Where SSE: the amount of uniformity, S_a: the mean of the measured distances, sd_s: the standard deviation of the distances, S_i: the distance measured at point i, and n: the number of samples (measurement intervals).

2.3.5. Vertical uniformity of seed distribution (seed placement depth)

After sowing, irrigation and germination of all sown seeds, plants were randomly removed from the ground at 20 points in each plot to measure the planting depth from the location of the seed to the part of the stem that was not green due to a lack of light. The vertical uniformity of seed distribution was figured out using the Senapati et al. (1992) formula 4 and 5.

2.3.6. Yield and yield components

Randomly picking 20 plants from each plot, yield components were measured, including the number of pods per plant and the weight of 100 seeds. Other morphological characteristics, such as plant height, pod length, pod diameter, grain length, and grain diameter, were also measured. To determine the yield per hectare, 5 samples of one square meter plots were harvested. The pods were hand-collected and weighed after drying. Final yields were adjusted to 7% moisture as described by Sorensen et al. (2004) and Yilmaz and Jordan (2022).

2.4. Data analysis

Outliers were detected before variance analysis using the Grubbs test. The Anderson-Darling test verified the normality of the data. Bartlette's test was used for the assumption of homogeneity of variance. Then a combined analysis of variances was performed using STAR statistical software (IRRI, 2013). The means were compared by Tukey's HSD (Honestly Significant Difference) at the 5% probability level.

3. Results and Discussion

The combined analysis of variance showed that Year had a significant effect on seed damage ratio, whereas Treatment and Year × Treatment effects were non-significant (*Table 3*). The Year also had a non-significant effect on effective field capacity, while Treatment was significant (*Table 3*). The non-significant effects of Treatment and Year × Treatment effects on the seed damage ratio were probably due to the similarity of the vacuum distributions among the planters, so the seed damage ratio resulting from mechanical damage to the seeds was low in all row planters tested. These results were in accordance with the findings of Jabir and Alfadilb (2022) who found that similar vacuum distributions among planters can reduce seed damage ratios by providing consistent seed pick-up, uniform distribution, and improved rows performance, enhancing planting efficiency and crop yield. Significant differences in some traits observed during the experimental years could be attributed to different weather conditions. In other words, the difference in the weather conditions of the experimental years had a significant effect on seed damage ratio, horizontal uniformity of seed distribution, vertical uniformity of seed distribution and planting depth traits but did not have a significant effect on effective field capacity and germination percentage. Tillman et al. (2006) and Yilmaz and Jordan (2022) reported similar results for significant effects of the year on some traits they studied. The means comparison for effective field capacity showed that T1 and T2 treatments had the highest effective field capacity (1.11 and 1.08 hectares per hour, respectively). T5 and T6 treatments were ranked second (0.96 and 0.94 hectares per hour, respectively), and T4 and T3 were ranked third (0.79 and 0.78 hectares per hour, respectively) (Table 4). Effective field capacity in a manually operated single-row planter for groundnut seeds studied by Singh and Moses (2021) was reported at 0.081 ha h^{-1}. The results of Patil et al. (2004) study were 0.21 ha h^{-1} for sugarcane cutter planter. Singh and Singh (2017) found that the effective field capacity (output) of the sugarcane cutter planter was 0.16 ha h^{-1} and its performance was compared with the conventional method of planting. In their study, lower effective field capacity was related to the low forward speed (0.50 ms^{-1}) of the tractor. They also reported that the effective field capacity of the planter (output) varied with the field and crop parameters. Variation in field capacity due to soil properties influences effective field capacity, impacting work width, forward speed, and time lost during agricultural operations (Ottoni Filho et al. 2014). Therefore, high levels of effective field capacity led to higher efficiency. In this experiment, single-row planters were higher than double-row planters.

The combined analysis of variance showed that Year, Treatment and Year × Treatment had a significant effect on horizontal uniformity of seed distribution, whereas only Year had a significant effect on vertical uniformity of seed distribution and planting depth. The effects of Treatment and Year × Treatment on germination percentage were also significant (*Table 3*).

Table 3. Combined analysis of variance of the investigated planter's performance on peanut planting

Source of variations	Df	Seed damage ratio	Effective field capacity	Horizontal uniformity of seed distribution	Vertical uniformity of seed distribution	Germination percentage	Planting depth
Year	1	11.116^{*}	0.011^{ns}	215.688^{**}	267.907^{**}	0.262^{ns}	0.251^{*}
Replication (Year)	6	1.042	0.010	8.643	15.586	5.371	0.033
Treatment	5	0.437^{ns}	0.154^{**}	84.425^{**}	12.985^{ns}	217.301^{**}	0.033^{ns}
Year × Treatment	5	0.327^{ns}	0.005^{ns}	34.538^{**}	7.338^{ns}	35.742^{**}	0.025^{ns}
Error	30	0.348	0.008	7.350	6.416	8.103	0.062
Coefficient of Variation (%)	-	15.65	9.34	3.57	3.95	3.26	5.03

* and ** : Significant at the 5% and 1% probability levels, respectively, and ns: non-significant

The mean comparison showed that treatments T4 (78.93%) and T3 (78.62%) demonstrated the highest horizontal uniformity in seed distribution, closely followed by T1 (78.20%) and T2 (76.36%). In contrast, treatments T5 (72.34%) and T6 (71.59%) exhibited lower levels of uniformity in seed distribution (*Table 4*). Differences among treatments in terms of horizontal uniformity of seed distribution can be related to the emerging percentage of the treatments (*Table 4*). A lower emerging percentage in single-row treatments compared to twin-row treatments resulted in a lower horizontal uniformity of seed distribution. In terms of emerging percentages, maximum values belonged to T4 and T3 treatments (94.23% and 93.08%), while minimum values belonged to T5 and T6 treatments (83.16% and 81.61%) (*Table 4*). In the twin-row planting system, due to the mutual placement of two vertical planes at an angle with a certain distance, zigzag planting on the row was possible to some extent, which was not possible for single-row planting. Therefore, with this method of planting, the poor emerging caused by planting a row of peanuts on the stack has been avoided. Zhang et al. (2023) reported that the twin-row planting in peanuts offers higher daytime net carbon uptake, water-use efficiency, and potentially greater yields compared to single-row planting. Twin-row planting in peanuts boosts pod yield by maximizing plant density, improving light interception, reducing branching, and potentially lowering pest effect, making it a more efficient cultivation approach (Yilmaz and Jordan, 2022).

Table 4. Mean comparison of the investigated planter's performance on peanut planting

Treatment	Effective field capacity (ha. hr^{-1})	Horizontal uniformity of seed distribution (%)	Emerging percentage (%)
2020	0.93 a	73.88 b	78.47 a
2021	0.96 a	78.11 a	87.32 a
Treatment			
T1	1.11 a	78.20 a	87.24 b
T2	1.08 a	76.36 a	85.06 bc
T3	0.78 c	78.62 a	93.08 a
T4	0.79 c	78.93 a	94.23 a
T5	0.96 b	72.34 b	83.16 cd
T6	0.94 b	71.59 b	81.61 d

The means in each column followed by similar letter(s) are not significantly different at the 5% probability level, using the HSD Test

The combined analysis of variance showed that the Year was significant for plant height, pod number per plant, and pod yield. Treatment had a significant impact for pod number per plant, grain length, 100-grain weight, and pod yield. The Year × Treatment interaction was also significant on pod number per plant and pod yield. Plant height, pod length, pod diameter, and grain thickness were non-significant in terms of the treatments investigated (*Table 5*).

The results presented in *Table 6* reveal significant variations among the treatments in terms of the measured field parameters. The mean comparison revealed that the T2 treatment (23.75) had the highest pod number per plant, whereas there were no significant differences among the T1, T5 and T6 treatments (*Table 6*). The lowest values belonged to T3 and T4 treatments that had no significant differences with T1, T5 and T6 treatments.

Table 5. Combined analysis of variance of the investigated field parameters with different planters

Source of variations	Df	Plant height	Pod number per plant	Pod length	Pod diameter	Grain length	Grain thickness	100-grain weight	Pod yield
Year	1	11.530*	221.020**	0.000 ns	0.000 ns	0.004 ns	0.016 ns	38.324 ns	5821973.86 **
Replication (Year)	6	1.087	11.740	0.021	0.001	0.005	0.006	12.575	35042.38
Treatment	5	8.990 ns	12.780 *	0.024ns	0.009 ns	0.151**	0.015 ns	35.331**	864262.01**
Year × Treatment	5	4.006 ns	1.520*	0.020 ns	0.001 ns	0.037 ns	0.004 ns	1.490 ns	58746.10 *
Error	30	3.999	5.043	0.021	0.003	0.016	0.019	6.933	18543.99
Coefficient Of Variations (%)	-	4.33	10.06	7.20	7.67	7.72	18.86	2.53	3.26

* and ** : Significant at the 5% and 1% probability levels, respectively, and ns: non-significant

Table 6. Mean comparison of the investigated field parameters with different planters

	Pod number per plant	Grain length (cm)	100-grain weight (g)	Pod yield (kg ha^{-1})
Year				
2020	24.46 a	1.67 a	103.13 a	4521.54 a
2021	22.17 b	1.65 a	104.92 a	3825.04 b
Treatment				
T1	22.62 ab	1.89 a	106.43 a	3823.12 c
T2	23.75 a	1.69 b	103.42 bc	4078.18 b
T3	20.75 b	1.51 c	101.40 c	4515.52 a
T4	20.76 b	1.54 c	102.02 bc	4645.42 a
T5	23.00 ab	1.63 bc	104.70 ab	3976.13 b
T6	23.00 ab	1.70 b	106.16 a	4001.25 b

The means in each column followed by similar letter(s) are not significantly different at the 5% probability level, using the HSD Test.

For grain length, the highest values were recorded in the T1 (1.89 cm) and T2 (1.69 cm) treatments. Although T2 did not show significant differences from the T5 (1.63 cm) and T6 (1.70 cm) treatments, the lower grain length values were observed in T3 (1.51 cm) and T4 (1.54 cm), which were not significantly different from T5 (*Table 6*). Regarding 100-grain weight, the T1 (106.43 g) and T6 (106.16 g) treatments exhibited the highest values, while the lowest were found in T3 (101.40 g) and T4 (102.02 g). Treatments T2, T4, and T5 showed no significant differences in this parameter (*Table 6*). For pod yield, T4 (4645.42 kg ha^{-1}) and T3 (4515.52 kg ha^{-1}) treatments produced the highest yields, followed by T2 (4078.18 kg ha^{-1}), T6 (4001.25 kg ha^{-1}), and T5 (3976.13 kg ha^{-1}), which showed no significant differences from one another. The lowest pod yield was observed in the T1 treatment (3823.12 kg ha^{-1}) (*Table 6*). In terms of pod number per plant, the highest number was observed in 2020, with 24.46 pods per plant, while 2021 exhibited a lower value of 22.17 pods per plant. Among the treatments, T2 recorded the highest pod number (23.75), while T3 and T4 had the lowest values (20.75 and 20.76, respectively) (*Table 6*).

Results revealed that for T1 and T2, despite having more yield components than T3 and T4 treatments, the pod yield overall was higher in twin-row cultivation treatments compared to single-row cultivation. The reason for this result can be attributed to the presence of more plants per unit area in twin-row cultivation treatments than in single-row cultivation. Previous research has demonstrated that increased yields in twin-row planting are directly connected to more effective use of solar energy and other growth resources in narrowly spaced peanut crops, which translated into greater pod yields (Yaşlı et al., 2020).

One method for improving peanut yields without fostering excessive intra-row rivalry is to plant them in twin-rows, as described by Lassiter et al. (2016) and Mkandawire et al. (2021). Twin-row planting patterns have been found to produce higher yields than single-row planting patterns (Lanier et al., 2004).

Peanut production increases as the number of plants per unit area increases. The twin-row planting strategy allows farmers to boost plant density in the field by more than double, which is nearly unachievable with the standard single-row planting arrangement (Kurt et al., 2017). How well a plant population utilizes available environmental resources for growth is the primary determinant of crop yield. Plants benefited more from water, sunlight energy, and nutrients when there was less peanut plant density. Because of this, as the plant population declined, there was an increase in the number of pods per plant and the 100-grain weight (*Table 6*). These findings are consistent with those of Sorensen et al. (2004), Konlan et al. (2013), Dapaah et al. (2014), Kurt et al. (2017) and Mkandawire et al. (2021).

Finally, twin-row planting is a novel technology in peanut cultivation in Iran, with little study to record its influence on yield or yield characteristics. Traditionally, peanut planting patterns have consisted of single rows 75 cm apart, primarily with the local cultivar Goli. This study's findings suggest that boosting plant density per unit area by employing the twin-row planting pattern could be an efficient alternative to traditional single-row planting methods for optimizing yield.

4. Conclusions

The twin-row planting pattern exhibited superior performance with the highest horizontal uniformity of seed distribution and emerging percentage. The unique arrangement of two vertical planes at an angle, maintaining a specific distance, facilitated a zigzag planting configuration in the twin-row system, effectively avoiding the issues associated with poor emergence observed in the single-row planting method. Over the two-year study period, the twin-row pattern demonstrated an approximate 500 kg ha^{-1} increase in pod yield compared to the single-row pattern. The heightened plant density in twin-row cultivation treatments contributed to the enhanced pod yield in comparison to single-row cultivation. Consequently, it is deduced that employing a pneumatic twin-row planter (Tarashkadeh) with a spacing of 75 cm between rows and 28 cm between plants is a more preferable and recommendable approach for peanut cultivation among Moghan farmers.

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Ethical Statement

There is no need to obtain permission from the ethics committee for this study.

Conflicts of Interest

We declare that there is no conflict of interest between us as the article authors.

Authorship Contribution Statement

Concept: Taghinezhad, J.; Design: Taghinezhad, J.; Data Collection or Processing: Taghinezhad, J.; Statistical Analyses: Zeinalzadeh-Tabrizi, H.; Literature Search: Taghinezhad, J., Zeinalzadeh-Tabrizi, H.; Writing, Review and Editing: Zeinalzadeh-Tabrizi, H.

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