RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume 60 Issue 11: 1753-1759 (November 2026)

Agronomic Performance of Kersting's Groundnut under Variable Plant Spacing and Fertilizer Types in Western Burkina Faso

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ABSTRACT

Background: Kersting's groundnut is an important source of protein, minerals and vitamins. However, traditional agronomic practices constrain their productivity. The study aimed to identify the optimal plant density and fertilizers types to enhance cultivation and yield of this legume.

Methods: Trial was laid out in a factorial design with three replications, focusing on two plant densities based on intra-row × inter-row D1 (20 cm × 40 cm) and D2 (30 cm × 40 cm) corresponding to 125000 and 83333 plants/ha respectively and three fertilization levels including F0 (no fertilizer), F1 (100 kg/ha of NPK (14-23-14) and F3 (a mixture of 50kg/ha NPK and 2 t/ha organic fertilizer). Ten Kersting's groundnut cultivars, obtained through participatory selection the previous year at the same experimental site in Bama (Western Burkina Faso), were tested. Measured traits included plant height, leaf size, flowering days, grain yield and 100-seed weight.

Result: Flowering date, plant height, grain yield and 100-seed weight were significantly affected by plant density, fertilizers types and their interactions. The application of 100 kg/ha NPK under the narrow spacing (20 cm × 40 cm: intra-row × inter-row) induced early flowering. This narrow spacing combined with low soil fertilization, proved optimal for maximizing both plant height (37.4 cm) and grain yield (2 t/ha). Cultivars Hou28, Ler21 and Ken12 achieved the highest performance, each exceeding a grain yield of 2 t/ha. The wider spacing (30 cm × 40 cm: intra-row × inter-row) was more effective for increasing 100-seed weight. Fertilization with 100 kg/ha of NPK alone or the combination of 50 kg/ha NPK and 2 tons/ha compost appeared unsuitable for maximizing kersting's groundnut production in this specific soil context. Kersting's groundnut remains a resilient crop and the identified high-yielding cultivars Hou28, Ler21 and Ken12 could represent promising parental lines for future hybridization and breeding programs.

Key words: Fertilizers, Grain yield, Kersting's groundnut, Plant density.

INTRODUCTION

Kersting's groundnut [*Macrotyloma geocarpum* (Harms) Maréchal and Baudet] is an annual, subterranean leguminous crop native to West Africa (Pasquet *et al*., 2002). Its seeds are morphologically similar to those of the cowpea (*Vigna unguiculata*). While, the plant itself resembles Bambara groundnut (*Vigna subterranea)* and peanut (*Arachis hypogaea*).

The seeds are widely consumed, providing high protein (22%), essential amino acids (Ayenan and Ezin, 2016; Ikujenlola *et al*., 2022) and minerals such as iron, zinc, calcium and magnesium (Oyetayo and Ajayi, 2005). Beyond its nutritional qualities, Kersting's groundnut (KG) plays a therapeutic role, particularly in the prevention of heart disease and the regulation of blood sugar levels in diabetics (Adekola *et al*., 2024). From an agronomic perspective, it promotes soil fertility through atmospheric nitrogen fixation, which is estimated at between 40 and 75% (Mohammed *et al*., 2024). Despite this immense potential, this climate-resilient crop remains highly marginalized and is classified as an "orphan," "underutilized," or "neglected" crop at both global and regional levels (Ayenan and Ezin, 2016), although historically cultivated across West Africa primarily in Togo, Benin, Nigeria, Ghana and Burkina Faso (Pasquet *et al*., 2002). Its national production in Burkina Faso has critically dwindled over the past few decades, putting the crop at a severe risk of genetic erosion and extinction. Currently, its cultivation is restricted in the western region of the country, where annual rainfall exceeds 900 mm (Waongo *et al*., 2024).

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How to cite this article: Gnankambary, K., Batiéno, B.J., Sawadogo, P. and Thiombiano, C. (2026). Agronomic Performance of Kersting's Groundnut under Variable Plant Spacing and Fertilizer Types in Western Burkina Faso. *Indian Journal of Agricultural Research.* **60(11):** 1753-1759. doi: 10.18805/IJARe.AF-1078.

Submitted: 20-06-2026 **Accepted:** 14-09-2026 **Online:** 06-10-2026

Production occurs on micro-plots (less than 0.25 ha) or as field borders intercropped with major cereals like sorghum or maize. Furthermore, official national agricultural reports over the past years makes no mention of Kersting's groundnut production in Burkina Faso. Several factors including low yields, labor-intensive cultivation practices and a weak market presence caused its cultivation abandon in favor of other legumes, such as cowpea, peanut, soybean and Bambara groundnut. Recent observations have revealed a lack of knowledge of this culture by the younger generation, even within areas where it is still traditionally produced. This ongoing decline is heavily reinforced by traditional, unoptimized agronomic practices (Assogba *et al*., 2015). Indeed, this legume is grown using traditional random planting (not planted in rows) without suitable fertilizer application. This lack of management contributes to lower mean yields between 124 and 178 kg/ha (Bampuori *et al*., 2007) and rarely exceeding 500 kg/ha (Duke *et al*., 1977). In contrast, several studies reported that a high planting density increases crop yield (Desmae *et al*., 2022; Iseki *et al*., 2023) and a combination of organic manure and mineral fertilizer optimizes production (Kouelo *et al*., 2015). According to Zamukulu *et al*. (2023), the optimum plant density integrated with the suitable fertilizer improves both soil chemical properties and crop productivity. However, determining these parameters for Kersting's groundnut remains challenging, as very few studies have recommended agronomic practices to optimize its yield in Burkina Faso. To address this knowledge gap, the present study aimed to identify the optimum spacing and suitable fertilization type to enhance the grain yield of Kersting's groundnut cultivars, thereby promoting their wide adoption by farmers.

MATERIALS AND METHODS

The experimental trials were conducted at Bama in the Western Region of Burkina Faso during the 2025 cropping seasons. Bama is located in the South Sudanian agro-ecological zone at the following geographic coordinates: 11°23.310′ north latitude, 004°21.274′ west longitude, at an altitude of 320 m. The climate is characterized by two alternating seasons: A rainy season from June to September and a dry season from October to May. During the trial, the rainy season recorded a total rainfall of 1257.5 mm with significant daily variations recorded by the local meteorological station (Fig 1). The trial was a factorial design focusing on intra-row × inter-row spacing D1 (20 cm × 40 cm, corresponding to 125000 plants/ha) and D2 (30 cm × 40 cm, corresponding to 83333 plants/ha), fertilization levels F0 (no fertilizer), F1 [100 kg/ha of NPK (14-23-14)] and F2 (mixture NPK 50 kg/ha + 2 t/ha of organic fertilizer) and Kersting's groundnut cultivars, all distributed in split plot design with three replications. Fertilizer treatments were assigned in the main plots, while planting densities were allocated to the sub plots. The ten cultivars were distributed within the plots, resulting in six blocks of ten plots per replication. Each plot consisted of 4 rows of 4 m. The ten cultivars used (Ken10, Ken11, Hou30, Ken14, Ler24, Ler23, Ken13, Hou28, Ken12 and Ler21) were obtained through participatory selection in the same experiment site during the previous year. The compost was mixed with soil thoroughly at the time of final land preparation before sowing on 28 June 2025 and the NPK at two weeks after sowing. Weeding was done twice, at two weeks after sowing and followed by ridging at pre-flowering. Initial topsoil samples (0-15 cm depth) were collected before sowing and analyzed by the Soil Science Laboratory. The chemical soil characteristics were total-N:0.53 g/kg, total-P: 890 mg/kg, total-K:1650 mg/k and pH of 5.01. Soil samples were also collected after crop harvest to determine post-experimental N, P, K and pH levels.

Five plants were randomly selected from each plot for data collection including plant height, leaf length (LL) and width (LW) expressed in cm at 45 DAS (Days after sowing). The date for first flowering (FFD) and 50% flowering (50Fl) was determined by counting the number of days from sowing to flowering. Dried seeds harvested from each plot

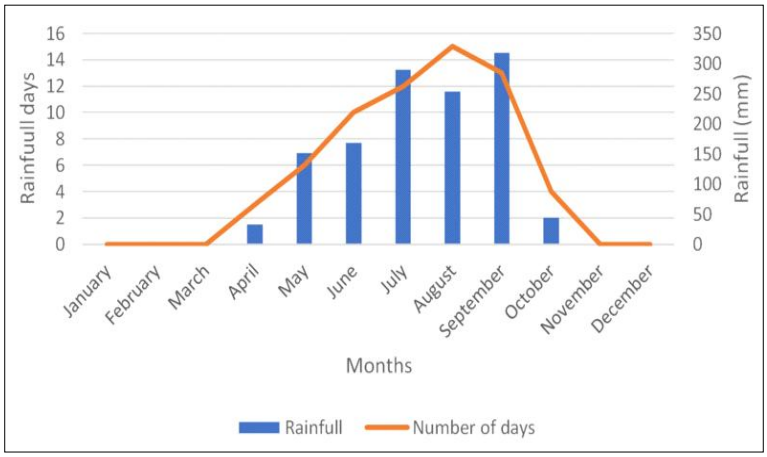


Fig 1: Monthly rainfall at bama 2025.

were weighed using a precision balance and grain yield was extrapolated and expressed in kg/ha. The 100-seed weight (HSW) was determined by counting one hundred cleaned seeds.

Data collected were entered using Microsoft Excel 2016 and analysis was performed using R 4.2.0 software. Restricted maximum likelihood (REML) mixed model analysis was used to assess statistical differences among treatments at a significance level of α= 0.05. Plant spacing, fertilizers and cultivars were considered as fixed effects and replications as random effects. Means separation was performed with Tukey's HSD Test.

RESULTS AND DISCUSSION

Treatment impact on growth parameters

The results of plant height (PH), leaf length (LL) and width (LW) of Kersting's groundnut subjected to different fertilization managements and plant densities are presented in Table 1. Both plant density and fertilizer application significantly affected plant growth, revealing a significant interaction between the two factors. The narrower spacing of 20 cm × 40 cm (intra-row × inter-row) produced the maximum plant height (35.5 cm), however the shortest (34.7 cm) resulted from the wider spacing of 30 cm × 40 cm (intra-row × inter-row). Similar findings were also reported by Iddrisu *et al*. (2024) in Groundnuts (*Arachis hypogaea* L.). The plant height in the control plot (without fertilizer input) outperforming that in the fertilized plot. Interaction effect between spacing and fertilizers showed a significant variation on plant height. The maximum plant height was achieved in the control plot (without fertilizer input) under the narrower spacing (20 cm × 40 cm), Whereas the lowest plant heigh resulted from the wider spacing (30 cm × 40 cm) with the combined NPK-compost application (Fig 2). These height differences reflect varying degrees of competition for light resources. Indeed, dense populations compete for light by prioritizing stem elongation over lateral development. Regarding leaf development, neither planting density nor fertilizer type had a statistically significant effect. Consequently, the observed variations in leaf size among cultivars may be primarily genetic. Cultivar Ler21 exhibited the largest leaf surface area (8.39 cm × 5.72 cm), followed by Hou28 (8.06 × 5.33 cm^2), whereas Ken10 recorded the smallest (7.64 × 5.06 cm^2).

Table 1: Growth parameters of ten KG genotypes under various plant spacing and fertilizers.

Study factors	PH (cm)	LL (cm)	LW (cm)
Prob. Cultivars	0.054554.	0.0004603***	0.00033***
Prob. Fertilizer	0.000724***	0.2899309	0.08513.
Prob. Density	0.043382*	0.7999899	0.75335
Prob. Cultivars: Fertilizer	0.186155	0.8458244	0.71070
Prob. Cultivars: Density	0.681721	0.8346244	0.59578
Prob. Fertilizer: Density	8.895e-06***	0.0590766.	0.09460.
Prob. Cultivars: Fertilizer: Density	0.805746	0.5330141	0.48881
Cultivars			
Ken10	35.1±0.66ab	7.64±0.10a	5.06±0.11a
Ken11	35.3±0.61ab	7.78±0.10a	5.39±0.11ab
Hou30	35.6±0.61ab	7.94±0.10ab	5.28±0.11abc
Ken14	35.4±0.61ab	7.94±0.10ab	5.22±0.11ab
Ler24	33.6±0.61b	8.00±0.10ab	5.39±0.11abc
Ler23	34.8±0.61ab	8.06±0.10ab	5.33±0.11abc
Ken13	35.1±0.61ab	8.06±0.10ab	5.44±0.11abc
Hou28	36.8±0.61a	8.11±0.10ab	5.78±0.11c
Ken12	34.9±0.61ab	8.11±0.10ab	5.28±0.11abc
Ler21	34.5±0.61ab	8.39±0.10b	5.72±0.11bc
Fertilizers			
F0	36.1±0.36a	7.93±0.06	5.32±0.06
F1	34.4±0.36b	8.06±0.06	5.50±0.06
F2	34.8±0.36b	8.02±0.06	5.35±0.06
Density			
D1	35.5±0.30a	8.01±0.05	5.40±0.25
D2	34.7±0.30b	7.99±0.05	5.38±0.25

Legend: PH: Plant height; LL: Leaf length; LW: Leaf width. Different letters within the same column indicate statistically significant differences at p= 0.05 significance level. the symbols "*", "***"and "." indicates significance at the p<0.05, p<0.001 and p<0.1 levels, respectively.

Treatment impact on flowering and yield parameters

The result showed no significant difference among the ten cultivars regarding flowering parameters. However, the date 50% flowering was significantly affected by fertilizer types, unlike the first flower date (Table 2). The mixture of 50 kg/ha NPK (14-23-14) and 2 t/ha compost prolonged the vegetative phase, delaying the flowering (54.7 DAS). Specifically, the application of 100 kg/ha NPK stimulated and shortened the flowering time (53 days after sowing). Similar result has been reported by Kouelo (2015). The early maturity trait is particularly advantageous for drought escape strategy and would be beneficial for

Table 2: Yield components of ten KG genotypes under various plant spacing and fertilizers.

Study factors	FFD (DAS)	50 Fl (DAS)	Yield (T/ha)	HSW (g)
Prob. Genotype	0.32679	0.3985	0.048051*	0.51896
Prob. Fertilizer	0.06417.	6.157e-06***	< 2.2e-16***	0.01421*
Prob. Density	0.73409	0.9125	6.096e-11***	0.93858
Prob. Genotype: Fertilizer	0.42721	0.2563	0.982272	0.86964
Prob. Genotype: Density	0.72837	0.9205	0.003487**	0.80241
Prob. Fertilizer: Density	0.99136	0.7121	0.196845	0.04551*
Prob. Genotype: Fertilizer: Density	0.66554	0.9850	0.140476	0.63371
Genotypes				
Ken10	50.1±0.48	54.1±0.36	1.65±0.19	15.7±0.39
Ken11	49.8±0.45	53.8±0.33	1.62±0.19	16.2±0.36
Hou30	50.5±0.45	54.5±0.33	1.48±0.19	16.0±0.36
Ken14	49.5±0.46	53.9±0.34	1.48±0.19	15.8±0.37
Ler24	50.1±0.46	54.0±0.34	1.50±0.20	15.8±0.37
Ler23	50.3±0.45	54.4±0.33	1.57±0.19	16.1±0.37
Ken13	50.1±0.45	54.4±0.33	1.38±0.19	16.1±0.36
Hou28	49.4±0.45	53.7±0.33	1.91±0.19	16.3±0.36
Ken12	49.8±0.45	54.2±0.33	1.85±0.19	16.7±0.36
Ler21	50.and2±0.45	54.2±0.33	1.76±0.19	15.8±0.36
Fertilizers				
F0	50.0±0.36	54.00±0.24a	2.12±0.16b	16.4±0.25b
F1	49.7±0.36	53.7±0.24a	1.31±0.16a	16.2±0.25ab
F2	50.3±0.36	54.7±0.24b	1.43±0.16a	15.6±0.25a
Density				
D1	49.9 ±0.34	54.1±0.22	1.88±0.16a	16.1±0.22
D2	50.0±0.34	54.1±0.22	1.36±0.16b	16.0±0.23

Legend: FFD: First flowering Day; 50% Fl: 50% flowering; HSW: Hundred seed weight. Different letters within the same column indicate statistically significant differences at p= 0.05 significance level. the symbols "*", "***"and "." indicates significance at the p<0.05, p<0.001 and p<0.1 levels, respectively.

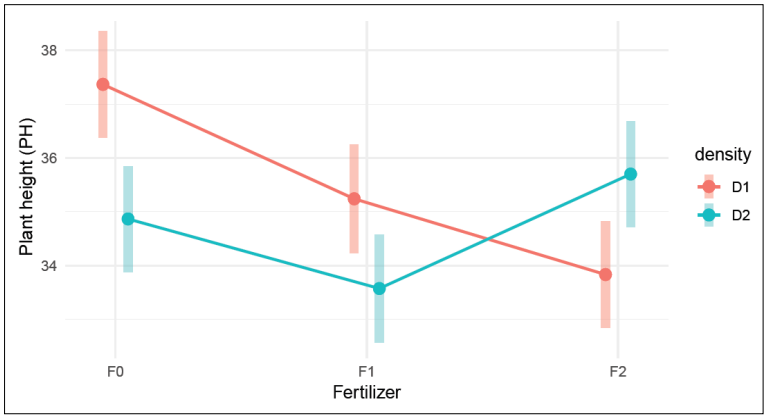


Fig 2: Plant height variation with the interaction between plant density and fertilizer types.

Kersting's groundnut cultivation in areas with limited rainfall. Furthermore, plant spacing showed no significant impact on either the date of first flower or the date to 50% flowering. Regarding seed yield, the analysis of variance revealed a significant difference among the ten KG cultivars; however, Tukey's HSD test failed to separate the means significantly. Moreover, grain yield was significantly affected by both fertilization and planting density, with a significant genotype × density interaction (Table 2). The highest grain yield (2.12 t/ha) was obtained in the control plot (unfertilized) followed by the NPK-compost mixture (1.43 t/ha) and the NPK alone (1.31 t/ha). This indicates that the initial soil nutrient status of the study area was sufficient to provide an optimal environment for Kersting's groundnut production. Indeed, pre-sowing soil analysis confirmed relatively high levels of total nitrogen (0.5 g/kg), phosphorus (890 mg/kg) and potassium (1650 mg/kg). Exceeding these nutrient levels through fertilization inputs decreased the production of Kersting's groundnut. According to Liu *et al*. (2023), applying NPK fertilizer (100 kg/ha) or a combination of 50 kg/ha NPK and 2 t/ha compost increases soil N, P and K availability (Table 3). In this study, such excessive nutrient availability likely disrupted the plants' physiological balance. According to (Singh, 2005), N applications decreased the number of nodules formed during early growth stages of legumes. Similar findings were reported by Pampana *et al*. (2018) for Chickpea (*Cicer arietinum* L.) and white lupin (*Lupinus albus* L.), where the authors attributed the yield decrease to high soil nitrogen levels. In contrast, our results contrast with those of Kouelo *et al*. (2015) who observed KG yield increases using 100 kg/ha of NPK (15-15-15) alone or combined with 2 t/ha of organic manure, as well as (Hasan *et al*., 2021), who reported that increasing N and P fertilizers increased the vegetative growth and yield of Bambara groundnut. This discrepancy is likely due to variations in the baseline soil fertility of the experimental sites or the specific NPK formulations used. Although KG can be cultivated successfully without fertiization under high-fertility conditions, continuous cultivation without fertilizer will eventually deplete soil nutrients. Therefore, the judicious use of organic and inorganic inputs remains essential to maintain long-term soil health and ensure sustainable agriculture. In addition, providing an NPK formulation adapted to the production of Kersting groundnuts would optimize crop yields.

Planting density significantly affected the grain yield of Kersting's groundnut (KG). A density spacing of 20 cm × 40 cm proved to be optimal, maximizing the grain yield of KG cultivars at 1880 kg/ha, with cultivars Hou28, Ler21 and Ken12 performing best, exceeding 2t/ha (Fig 3). These results align with Bampuori (2007), who identified an intra-row spacing of 20 cm and an inter-row spacing of 30 cm as ideal for KG cultivation. Previous studies revealing the benefits of reduced plant spacing to maximize yield have been reported by Akpalu *et al*. (2012) in *Vigna subterranea*, Iddrisu *et al*. (2024) in *Arachis hypogaea*, by Ishikawa *et al*. (2022) and Iseki *et al*. (2023) in *Vigna unguiculata*. However, these results contradict Essel *et al*. (2024), who reported a higher grain yield (3566 kg/ha) for Bambara groundnuts under wide spacing (20 cm × 50 cm)

Table 3: Soil nitrogen, phosphorus and potassium of the study areas.

Total nutrient	Soil before sowing	Soil after crop harvesting		
		Control	100 kg/haNPK	mixture (NPK-compost)
Nitrogen (g/kg)	0.53	0.31	1.00	0.69
Phosphorus (mg/kg)	890	643	1006	933
Potassium (mg/kg)	1650	1430	2200	1870
H water (P/V:1/2.5)	5.01	5.25	5.29	5.46

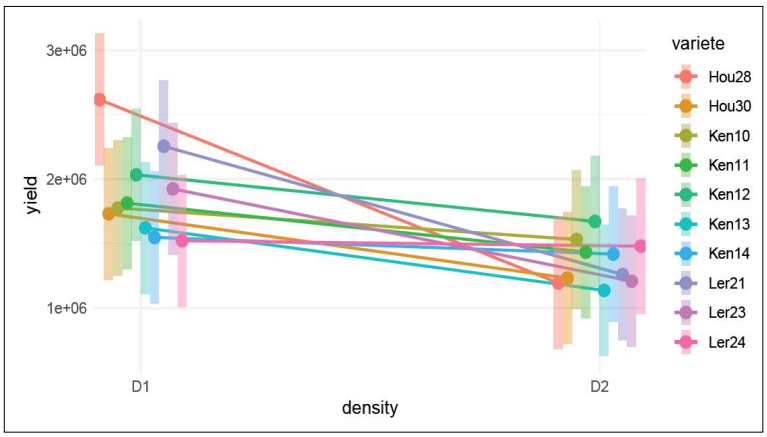


Fig 3: Yield variation with the interaction between the genotypes and density.

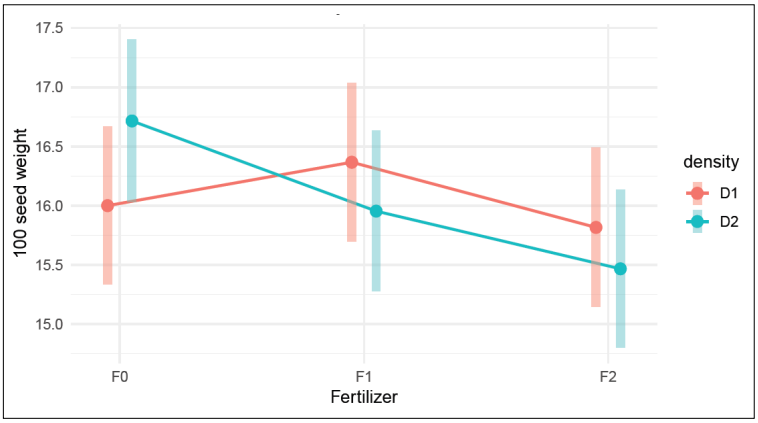


Fig 4: Hundred seed weight variation, with the interaction between the density and fertilizer types application.

than the 1,884 kg/ha recorded under reduced spacing (20 cm × 40 cm). The high yield at high density is mainly attributed to genotypic factors (Wells *et al*., 1993), more efficient resource utilization, (water, nutrients and light) and high photosynthetic activities (Huang *et al*., 2025).

Analysis of the 100-seed weight (HSW) revealed significant effects of fertilizer types, as well as a significant interaction between fertilization and plant density (Table 2). The highest 100 seed weight exceeding 16.5 g, was obtained in the unfertilized control plot. The significant interaction between fertilization and plant density shown that the wider spacing (30 cm × 40 cm) maximized the higher HSW (Fig 4).

These findings indicate that Kersting's groundnut requires minimal fertilization for grain production positioning it as a highly resilient crop. Consequently, minimizing nitrogen fertilization is recommended to maximize symbiotic nitrogen fixation and to achieve high and stable yields, thereby reducing production costs (Ayilara *et al*., 2022). According to Huang *et al*. (2025), reducing nitrogen fertilizers inputs while optimizing symbiotic nitrogen fixation not only increases yield but also save environment limiting leaching losses and greenhouse gas emissions.

CONCLUSION

This study revealed that plant density and fertilizer significantly influence plant height, 100-seeds weight and grain yield of Kersting's groundnut (KG). A planting spacing of 20 cm (intra-row) × 40 cm (inter-row), supported by adequate fertility (particularly nitrogen, phosphorus and potassium), demonstrated the potential to maximize grain yield. Among the tested material, cultivars Hou28, Ler21 and Ken12 were the highest yielding, each exceeding 2 t/ha. Conversely, the wide spacing of 30 cm (intra-row) × 40 cm (inter-row) combined with adequate fertilization proved optimal specifically for achieving a high 100-seed weight. NPK 100 kg/ha promoted an early flowering. Neither 100 kg/ha NPK (14-23-14) alone nor the combination of 50 kg/ha NPK and 2 t/ha compost resulted in the highest grain yield. This confirms that balanced fertilization remains crucial for Kersting's groundnut to reach its full nitrogen-fixation potential and ensure stable yields without inducing nutrient toxicity. Developing specific fertilizer formulas that precisely define these optimal nutrient efficiencies would provide a suitable technology to boost production. Future research should validate these findings across diverse agro-ecological zones to facilitate wider adoption and improve yields nationwide. Hou28, Ler21 and Ken12 identified as high yielding could be promising parents for future hybridization and breeding programs.

ACKNOWLEDGEMENT

The present study was supported by the Fonds National de la Recherche et de l'Innovation pour le Developpement (FONRID).

Disclaimers

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Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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