Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2024; 12(5): 228-234

Received: 19-08-2024
Accepted: 25-09-2024

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Influence of seeding dates and densities on the incidence and severity of groundnut rosette (*Arachis hypogaea* L.1753) in Isiro, Democratic Republic of Congo

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DOI: https://doi.org/10.22271/j.ento.2024.v12.i5c.9403

Abstract
To assess the influence of seeding dates and densities on the incidence and severity of peanut rosette, a study was carried out over two cropping seasons at Isiro. It tested the effect of four dates coupled with three seeding densities. The different sowing dates for the first growing season were March 15th, March 30th, April 15th and April 30th, 2023. While for the second season the dates were August 1st, August 15th, August 30th and September 15th, 2023. On the other hand, densities for the two cropping seasons were 250000plants/ha (20cmx20cm), 111,111plants/ha (30cm x 30cm) and 62500plants/ha (40cm x 40cm). The combination of two factors resulted in 12 treatments. The results of two trials conducted using the *Split plot* experimental set-up indicated the following average: incidence of rosette: low for early sowings at high densities (21.1% and 15.1%), very high for late sowings at low densities (94.9% and 97.7%). In terms of disease development, late sowings (second week) showed an early onset of rosette, with higher severity or symptoms (scores 4 and 5) than early sowings, which showed a late onset (fourth week), with lower severity (score 1). Dry pod yield: high for early planters (775kg/ha and 531kg/ha) and low for late planters (113.7kg/ha and 70kg/ha). Statistical analyses (ANOVA) revealed significant differences between dates, densities and interaction of two factors for rosette incidence and peanut dry pod yield (for both seasons).

Keywords: Date, density, incidence, severity, peanut

1. Introduction

Peanuts (*Arachis hypogaea*), like other legumes, are an important source of proteins, lipids and minerals that improve blood cholesterol levels [5-18]. This crop, although less exposed than other tropical legumes [17], is susceptible to various diseases and pests, against which farmers protect themselves by using tolerant or resistant varieties [8]. Among all the pests and diseases that threaten it, rosette is a major scourge, and can alone lead to significant production losses of up to 90% [3-7]. Groundnut Rosette Virus (GRV) is a species belonging to the genus *Umbravirus*, family *Tombusviridae*, native to sub-Saharan Africa. It is a single-stranded RNA virus with positive polarity. It is transmitted on plants by an insect vector, the peanut aphid (*Aphis craccivora*), which is the main vector [11-13-22].

It is rife in Haut - Uélé Province, and has been the subject of very few studies there in terms of its perverse effects on groundnut production and cultural control methods based on sowing date and density in the agro-ecological conditions of Isiro as reported in the work of Adanga *et al*. (2015) [1]; Kpengbe (2015) [9] and Murefu *et al*. (2019) [14]. The question this research attempts to answer is: Is there a sowing date and density for each cropping season which, when combined, can significantly reduce the extent of rosette and consequently improve groundnut yield in Isiro's agro-climatic conditions?

Indeed, early sowing (In relation to the return of the rains) coupled with a high sowing density in each season, reduces the incidence of rosette and improves groundnut production in the study area. Considering the importance of sowing date on the one hand, and the existence of an optimum sowing density for groundnut rosette control on the other [21], this study set out to highlight the influence of sowing date and density on the incidence and severity of groundnut rosette in the agro-ecological area of Isiro and its surroundings. This work is of practical interest to farmers in general and to the Isiro population in particular, as it provides them with the information they need to fight against groundnut rosette.

2. Environment, materials and methods

2.1. Study area

The experiment was carried out in the vicinity of the town of Isiro, in the village of Modimbo at kilometer point 4 on the south-west side of the town center. It was carried out over two seasons. The geographical coordinates of two fields sampled with the Garmin 60 GPS were 02o 44' 12" latitude North and 027o 35' 36" longitude East; at 749 m mean altitude for the first; 02o 44' 32" latitude North and 027o 35' 03" longitude East; at 753 m mean altitude for the second field. Figure 1 below shows the geographical map of the study area:

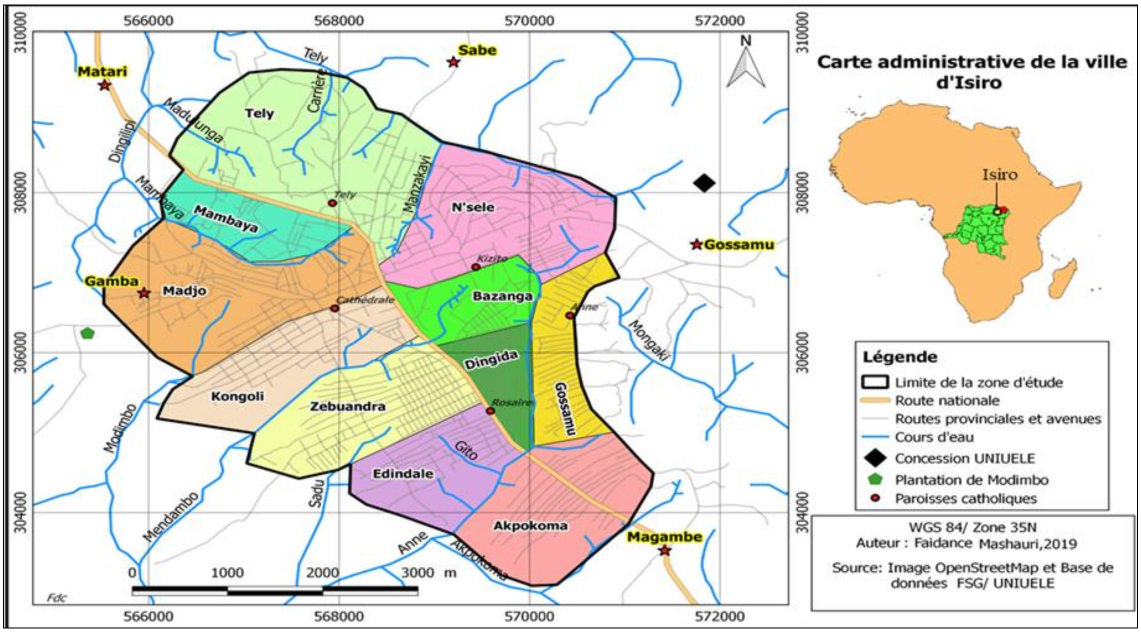

Fig 1: Map of study area [12].

Moreover, the climate of the Isiro region, according to Köppen's classification, is of type Am, which constitutes the transition between the equatorial climate (Af) and the tropical climate with a marked dry season (Aw) [15-16]. As for the soils of the two experimental fields, analysis by the soil laboratory of Faculty Institute of Agronomic Sciences of Yangambi reveals the following: pH: 5.35-5.44; Nitrogen: 0.25 - 0.90%, Carbon: 7.17 - 7.16%, Phosphorus: 0.37 - 0.31ppm (I. F.A-Yangambi Laboratory, 2024). The spontaneous vegetation in place for both fields was essentially composed of savannah species: *Setaria sphacelata; Panicum maximum; Pennisetum purpureum; Cynodon dactylon; Imperata cylindrica; Elaies guineensis, and others.*

2.2. Materials

The biological material used consisted of peanut seeds (*Arachis hypogaea* L. 1753) of the G17 variety. This is an upright variety with a vegetative cycle of around 90 days, with an average of 2 red seeds per pod. The seed used was obtained from the INERA BAMBESA station and had the qualities of a good seed (germination capacity: 98%; varietal purity: 99%).

Fig 2: Peanut seed (*Arachis hypogaea* L.1753)

The technical equipment used includes a hoe, machete, metric tape, electronic scale, rakes, Garmin 60 GPS, bags, calculator, etc.

2.3. Methods

For this study, the split-plot experimental design was adopted. The primary and secondary factors were sowing dates and densities, respectively. The design included four replications of 12 treatments each [10]. The main factor had four levels corresponding to the four sowing dates. For the first season, these were as follows: D1: sowing on March 15th, D2: sowing on March 30th, D3: sowing on April 15th and D4: sowing on April 30th, 2023. For the second season, however, the following dates were selected: D1: sowing on August 1st, D2: sowing on August 15th, D3: sowing on August 30th and D4: sowing on September 15th, 2023. In addition, for the secondary factor, three levels corresponding to three peanut sowing densities were tested for the two cropping seasons. These were d1: 250,000 plants/ha (20cm x 20cm), d2: 111,111 plants/ha (30cm x 30cm) and d3: 62500 plants/ha

(40cm x 40cm). Thus, 12 combinations or treatments were obtained and presented as follows: D1d1, D1d2, D1d3, D2d1, D2d2, D2d3, D3d1, D3d2, D3d3 and D4d1, D4d2, D4d3. Figure 3 below illustrates the experimental system for the tests:

D4			D3			D2			D1		
d1	d2	d3	d1	d2	d3	d1	d2	d3	d1	d2	d3
D3			D4			D1			D2		
d2	d3	d1	d2	d3	d1	d2	d3	d1	d2	d3	d1
D2			D1			D4			D3		
d3	d1	d2	d3	d1	d2	d3	d1	d2	d3	d1	d2
D1			D2			D3			D4		
d1	d2	d3	d1	d2	d3	d1	d2	d3	d1	d2	d3

Fig 3: Experimental system.

Plots were 2 x 5 m each. The aisles between plots and between blocks were 1m and 2m respectively. The work to open and prepare the land included demarcation, mowing, mechanized ploughing, leveling, plot preparation and planting. Sowing was carried out at a rate of one peanut seed per stake. Maintenance work consisted of weeding and ridging. Hand harvesting took place when the peanut plants showed signs of maturity. Observations focused on the following parameters: incidence of rosette; disease evolution; severity and pod yield. Rosette incidence was calculated using the following formula: I.R (%) =NI/NT X 100 (1) with I.R: Rosette incidence, N.I: Number of plants infected by rosette, N.T: Total number of plants in the plot [2]. Disease evolution or speed was determined by sampling peanut rosette attack rates in the plots every two weeks. Data on rosette severity were collected by counting leaflets showing disease symptoms while following a plot rating scale as proposed by Alahou *et al* (2021) [2]. This scale varied according to scores from 1 to 5; with 1: 0%, 2: 1 to 25%, 3: 26 to 50%, 4: 51 to 75% and 5: 76 to 100%. The pod yield data were determined by weighing the parcel production.

Raw data were processed using Microsoft Excel 2010 before being subjected to analysis of variance using Statistix 8.0. Multiple comparison of means was possible using the least significant difference test (LSD) [10].

3. Results

The mean values of the combinations of incidence and pod yield for the two seasons found in two trials are recorded in the first table.

Table 1: Mean values for incidence (%) and pod yield (kg/ha):

	D1d1	D1d2	D1d3	D2d1	D2d2	D2d3	D3d1	D3d2	D3d3	D4d1	D4d2	D4d3
Inc A	21.1	21.7	26.1	26.2	38.3	49.5	51.5	67	77.5	70.3	88.7	94.9
Inc B	21,5	22,3	28.0	15.1	43.4	54.1	43.4	78	91.8	59.8	79.0	97.7
Yld A	775	570	300	644	456	349	211	171	126	199	123	114
Yld B	528	371	206	531	233	130	278	170	90	105	80	70

Legend: Inc: Incidence Yld: yield, A: first season, B: second season

3.1. Rosette incidence Peanut rosette incidence data for the first and second seasons are plotted in Figures 4 and 5.

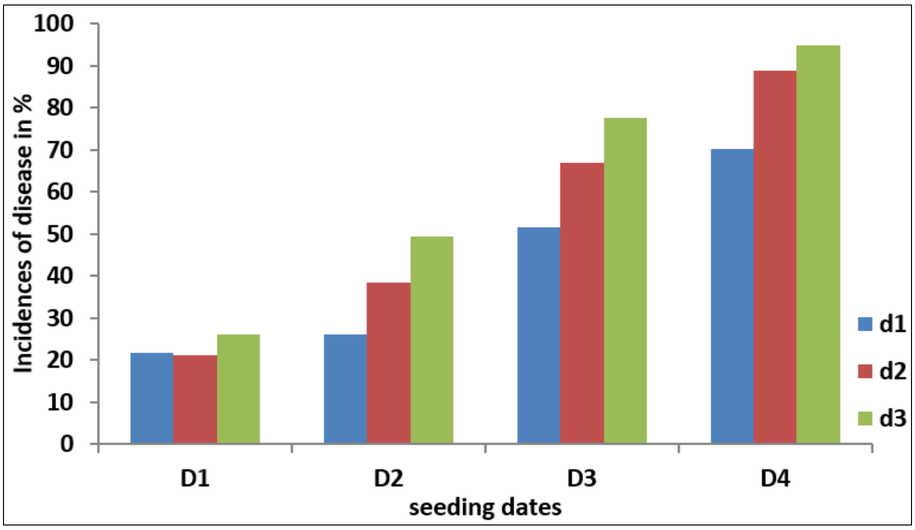

Fig 4: Incidence of peanut rosette tested in the first growing season

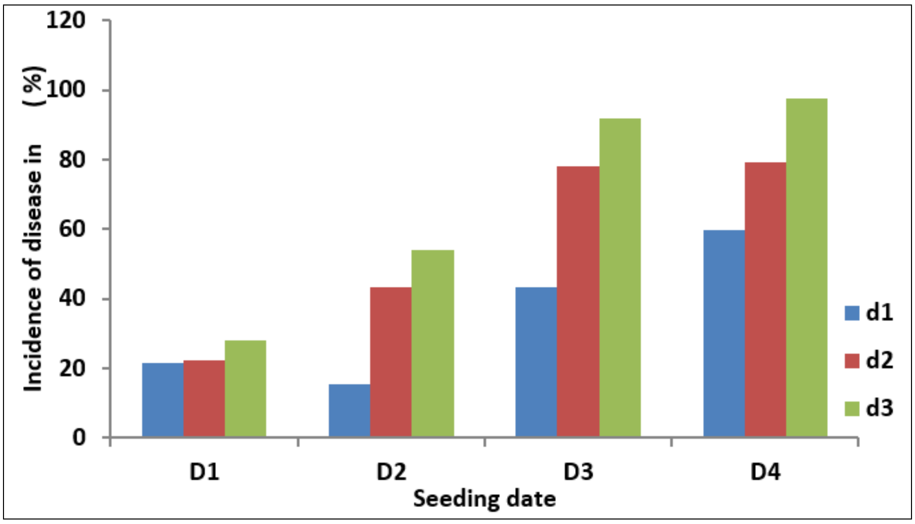

Fig 5: Incidence of peanut rosette tested in the second growing season

Examination of the above graphs shows that early planting on March 15th at a density of 111,111 plants/ha (first season) and August 1st 2023 at a high density of 250,000 plants/ha (second season) showed lower attack rates (21.1 and 21. 58%) compared with the late sowings carried out on April 30th and September 15th, 2023, all coupled with a low density of 62500plants/ha, which showed higher values (94.9 and 97.7% for both cropping seasons).

At the 5% significance level, analysis of variance revealed significant differences between dates (p=0.0000 and 0.0000), densities (p=0.0000 and 0.0000) and interaction of two factors (p=0.0132 and 0.0001) for both seasons. However, multiple comparisons by the least significant difference test for the first season (LSD = 8.97; 12.9; 18.9% for date; 4.34; 5.9 and 7.8% for density and 1.78; 2.54 and 3.66% for interaction) and the second season (LSD = 11.96; 17.19; 25.29% for date; 8.26; 11.23; 15% for density and 2.44; 3.43; 4.84% for interaction of two factors) showed similarities, significant differences, highly significant differences and very highly significant differences. The interaction observed between the two factors for both seasons indicates that the two factors interacted with each other on the incidence of peanut rosette.

3.2. Disease evolution

Figures 6 and 7 show disease trends for the two growing seasons:

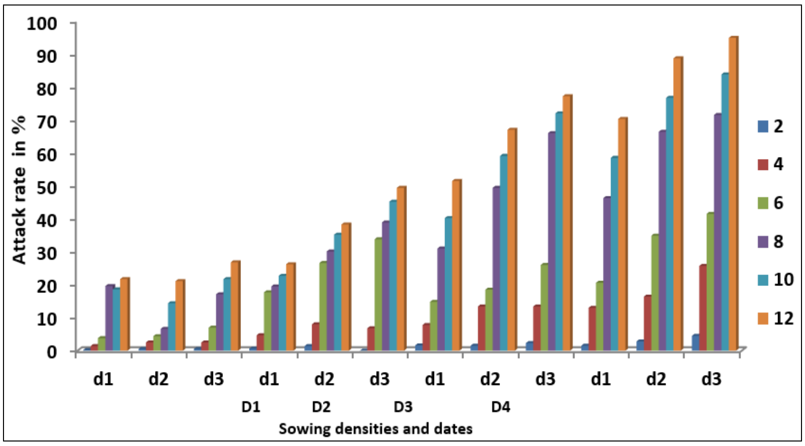

Fig 6: Evolution of peanut rosette disease for the first season

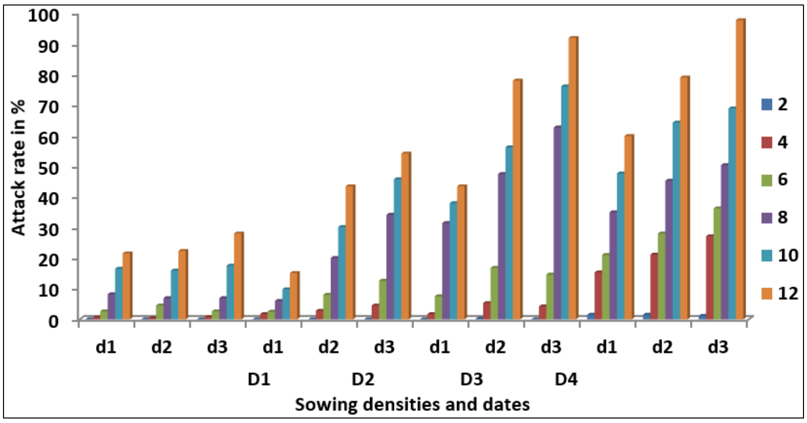

Fig 7: Evolution of peanut rosette disease for the second season, numbers 2, 4, 6, 8, 10 and 12 represent weeks.

Looking at the two figures on the evolution of rosette disease, it varied with plant age according to sowing dates, densities and their interaction. In experimental units with early sowing (March 15th and 30th; August 1st and 15th, 2023), the disease appeared late in the fourth week, whereas in plots with late sowing (April 15th and 30th; August 30th and September 15th, 2023), it appeared early in the first two weeks at any density. Furthermore, in the experimental conditions of our study, the disease reached its peak on the 84th day, for all combinations (sowing date and density).

3.3. Disease severity

The peanut rosette severity data recorded in this research have been represented in graphs 8 and 9.

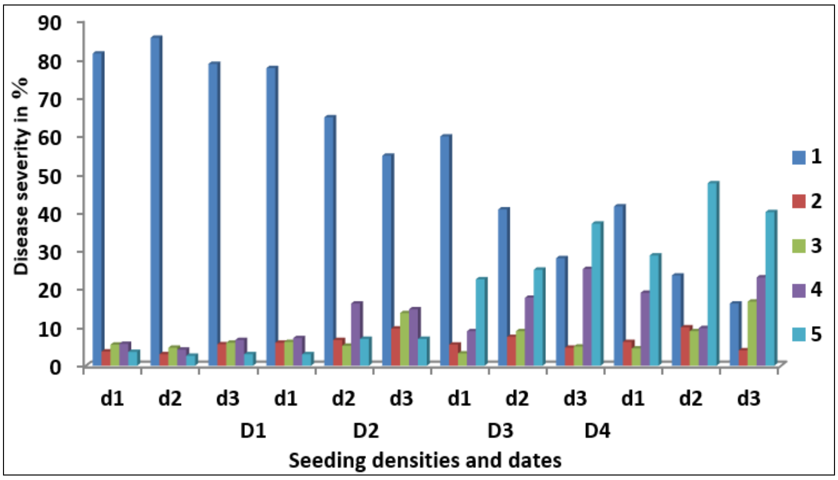

Fig8: Severity of peanut rosette disease in the first growing season

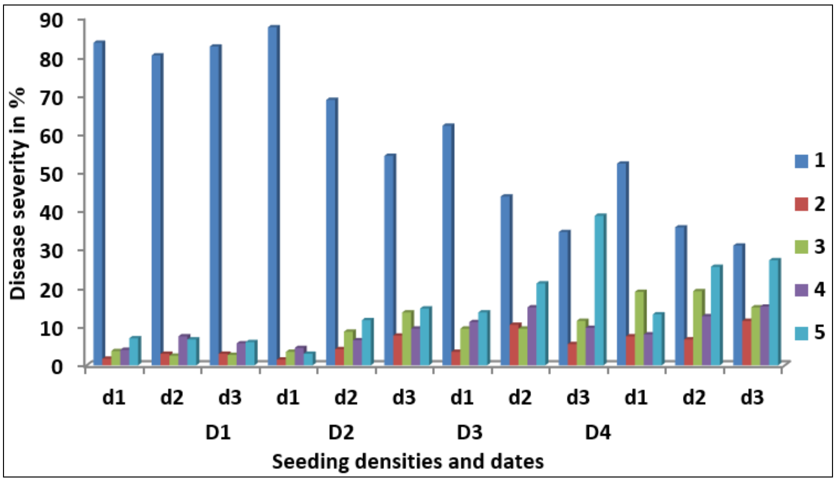

Fig 9: Severity of peanut rosette disease in the second growing season

Numbers 1, 2, 3, 4 and 5 represent the scores

Observing at the graphs of disease severity for the two cropping seasons, we noted the absence of symptoms (score 1) for the most part on plots that had been sown early (first two fortnights of the first month when the rains returned but symptoms were highly visible (scores 4 and 5) in plots where peanuts were sown late, one month after the rains returned. This situation was valid for all densities.

3.4. Yield in dry pods

The results in terms of dry pod yield in kilograms per hectare for the two seasons are shown in the graphs in figures 10 and 11.

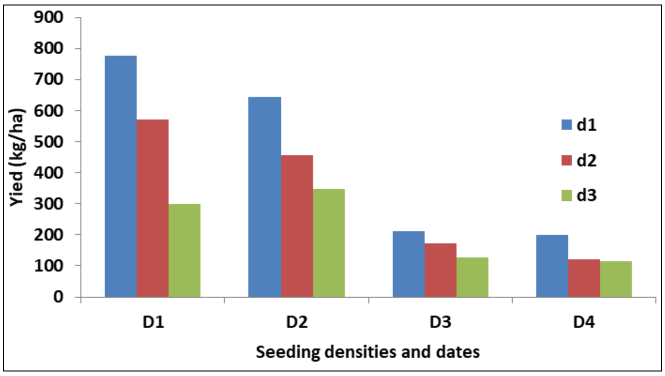

Fig 10: Yield dry pods in the first growing season

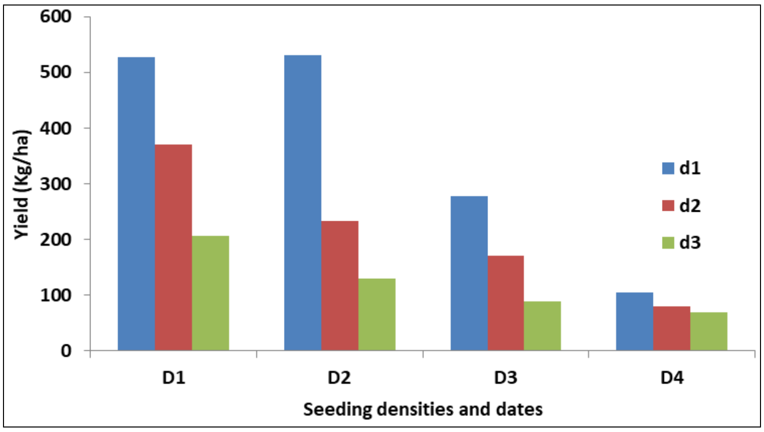

Fig 11: Yield dry pods in the second first growing season

Pod yield results recorded in our two experiments ranged from 113.7 to 775kg/ha for the first season and 70 to 531.2kg/ha for the second season. The highest values of 775kg/ha and 531.2kg/ha were obtained with the combinations of early sowing coupled with high density (sowing on March 15th, coupled with a density of 250,000 seedlings/ha for the first season and sowing on August 15th, 2023 coupled with a density of 250,000 seedlings/ha for the second cropping season). This indicates that early sowing coupled with high densities was more suitable for peanut cultivation under Isiro conditions. The averages obtained for the two seasons were 444.35 and 300.6kg/ha respectively. This indicates that the first growing season was favorable for groundnut production under Isiro conditions.

The nalysis of variance revealed significant differences between dates (p=0.0002 and 0.0000); densities (p=0.0000 and 0.0000) and the interaction of two factors (p=0.0066 and 0.0004) for both cropping seasons. The observed interaction indicates that the two factors interacted with each other on peanut pod yield under the agro-ecological conditions of Isiro town.

As for the multiple comparison of means, the least significant difference test for the first season LSD (5%.1% and 0.1%) = 142.15; 204.42 and 300.66 for date; 70; 95.2 and 127.1 for density; 45.2; 63.6 and 90.1 for interaction and for the second season LSD = 69.6; 100.1; 147.2 for date; 48.8; 66.3; 88.6 for density and 6.81; 9.62; 13.29 for interaction of two factors; showed similarities, significant differences, highly significant differences and very highly significant differences.

4. Discussion

In this study, which was carried out over two growing seasons, early planting at high densities resulted in low disease incidence (21.1 and 21.58%), while late planting at low densities resulted in very high attack rates (94.9 and 97.7%). This situation was the result of Gohier's (1946) observation [6] that late sowing coupled with low densities during the season resulted in high attack rates on the peanut rosette. However, it has also been proved by the national plant protection service in Niamey, which believes that early, dense sowing and the use of resistant varieties are easy ways of controlling groundnut rosette [20].

In fact, the rosette incidence values (21.1% and 97.7%) recorded during our study are within the range of 10 to 100% found by Subrahmanya *et al* (1992) [21] studying groundnut diseases in Niger and Burkina Faso. Moreover, in the experimental units where sowing was carried out early (March 15th and 30th; August 1st and 15th, 2023), the disease appeared late, in the fourth week, whereas in the plots where seeds were sown late (April 15th and 30th; August 30th and September 15th, 2023), the disease appeared in onset early in the first two weeks.

Bay the way, in the experimental conditions of our study, the disease reached its peak on the 84th day, for all combinations (sowing date and density). This situation was contrary to that of Alahou *et al* (2021) [2], who observed the appearance of disease on the 45th day of sowing, with the peak reached one month later (75th day). With regard to rosette appearance, the National plant protection service in Niamey believes that an early onset of disease before thirty days can destroy the crop [20]. As for severity, the absence of symptoms (score 1) was observed for the most part on plots that had been sown early (March 15th and 30th; August 1st and 15th, 2023), on the other hand, symptoms were highly visible (score 4 and 5) in plots where peanuts were sown late (April 15th and 30th; August 30th and September 15th). This situation can be explained in the same way as rosette incidence. Alahou *et al* (2021) [2] in his study in central Ivory Cost recorded virus severity values ranging from 1, 8 ±0, 21 to 2, 75±0, 21, within the range of 1 to 5 observed in our two trials. In terms of pod yield, the averages obtained in our trials (444, 35 and 300,6kg/ha) were within the range of 287, 33 to 784,5kg/ha found by Biteghe (1999)[3] under senegalese conditions. They are also lower and within the range of 324 to 1200kg/ha found by Cattan (1996)[4] and Shilling (2001) in plots without fertilizer in their studies of Groundnut yield components under Ouagadougou and French conditions. These differences between the results found by our predecessors and ours can be explained by the agro-ecological conditions of each trial (environment, method and variety).

5. Conclusion

The aim of this research was to study the influence of sowing dates and densities on the incidence and severity of Groundnut rosette, by assessing its impact on pod yield in the Isiro agroecological area. The split plot system with two factors, namely sowing date and density was adopted for both seasons. The treatments defined according to the date factor and three levels of the sowing density factor made a total of 12.

The results show that in comparison with early sowing (sowing on March 15 and 30 for the first season and sowing on August 01 and 15, 2023 for the second season) coupled with high densities (250.000 and 111.111plants/ha); late sowing (on April 15 and 30 for the first season and on August 30 including September 15, 2023 for second season) coupled with low planting densities (62500plants/ha) ensure:

- A very high incidence of rosette disease: 94, 9% for the first and 97, 7% for the second season, compared with early sowing coupled with high densities (21, 1 and 15, 1%)
- Early onset of disease in both seasons (second week) with stronger symptoms (scores 4 and 5) compared with early planting (Late onset of disease at fourth week) with weaker symptoms (score1).
- Low peanut pod yields: 113, 7 and 70 kg/ha compared with high density early sowing (775 and 531, 2 kg/kg).

Analysis of variance (ANOVA) for all parameters studies revealed significant differences with a positive interaction between factors. These results therefore confirmed the hypothesis that early sowing (in relation to the return of rains) coupled with a high sowing density in each cropping season, reduces the incidence of rosette and improves Groundnut production in the Isiro agroecological zone.

6. Acknowledgements

We thank the Agronomic faculty sciences of Uélé University for its moral and intellectual support. We are grateful to the plant production researchers at the Faculty Institute of Agronomic Sciences of Yangambi, IFA-Yangambi for their various contributions.

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