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Adaptation of a double hopper seeder for the improvement of cowpea productivity (*Vigna unguiculata)* in Niger: Case of the Maradi and Zinder regions

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ABSTRACT: This study aims to evaluate the effect of using the adapted Gangaria seeder combined with localized organomineral fertilization on labor productivity, yield and profitability of cowpea (Vigna unguiculata) cultivation in Niger. A randomized block trial with four treatments crossing sowing method (manual or mechanized) and fertilization (with or without microdose) was conducted over two (2) agricultural seasons (2023 and 2024) in the Mardi and Zinder region. The results show that mechanized sowing halved the working time per hectare and contributed to a significant improvement in grain yields up to 959 kgha $^{-1}$ and dried haulm (1052 kgha $^{-1)}$ at the level of the mechanized treatment combined with localized fertilizer inputs (T3). Mechanization alone resulted in an increase in grain yield of 180 kg/ha, a 26.8% improvement compared to manual sowing. The average yield of the two treatments obtained with the application of microdoses of compost was 274 kg/ha higher than the yield in the two treatments without microdoses, which corresponds to an increase of 43.0%. Compared to manual sowing, the economic analysis shows that mechanized sowing without fertilizer application (T2) generates the highest net margin, due to the high cost of purchased compost. Local production of compost thus appears as an alternative to optimize the benefits of the technology. The use of the adapted Gangaria seeder constitutes a promising strategy to sustainably increase agricultural productivity and improve the agricultural incomes of cowpea producers in Niger.

KEYWORDS: Gangaria seeder, Cowpea, Animal traction, Localized fertilization, Economic profitability.

1 INTRODUCTION

Cowpea is considered an important plant to address the challenges posed in Africa by climate change, in order to cover and secure the food and nutritional needs of populations [1]. It is also a potential source of productivity to contribute to improving producers' incomes [2].

In Niger, cowpea plays an important role in human and livestock nutrition. It is the most important cultivated legume. Cowpea is cultivated on an area of 5,573,430 ha, with a production of 2,763,022 tonnes and a yield of 496 kg/ha in rural areas [3]. Niger ranks second among the main cowpea producing countries in West Africa [4].

Population growth [5], increasing urbanization and more pronounced economic and food aspirations make it essential to increase agricultural production to guarantee food security and self-sufficiency. This is why it is important to consider the influence of animal traction in agricultural production [6].

Cowpea production is expected to increase significantly in the coming decades as more short-season, pest-resistant varieties become available and cowpea cultivation progresses further as a niche crop in cereal cropping systems [7].

Pest pressure, end-of-cycle drought, poor soils, the use of rudimentary agricultural equipment and the lack of improved varieties are the main causes of the decline in cowpea yield [8]. For farmers, the transition from manual cultivation to animal traction profoundly changes the functioning of the production system. It allows a significant increase in the cultivated area per farm thanks to gains in labor productivity [9].

The development of microdosing of fertilizers has also made it necessary to develop discs suitable for the simultaneous sowing of seeds and fertilizer. One of the advantages of mechanized sowing, compared to manual sowing, is that it makes it more difficult for rodents and birds to locate the location of sown seeds [10]. Microdosing of fertilizers and mechanization are low-cost ways to improve agricultural yields and reduce the need for labor [11]. Many farmers use labor-intensive production techniques because they do not have the resources to invest in machinery that can facilitate cultivation [7].

Due to the inability of the legume to fix nitrogen at the beginning of its cycle, a minimum of nitrogen fertilizer is necessary in poor soils to improve yields [12]. Integrated management of mineral and organic fertilizers, combined with the potential for atmospheric nitrogen fixation, would be appropriate for better soil fertilization and obtaining better crop yields [13]. Given the limited effects of organic and mineral fertilizers taken separately, it is better to combine them in order to sustainably increase agricultural production [14].

In Niger, animal traction represents an alternative to motorized mechanization, which is still inaccessible to the majority of small producers. However, animal traction equipment specifically designed for legume crops, such as cowpea, remains rare or poorly adapted. The Gangaria seed drill, initially developed for cereals, has undergone technical adaptation to meet the specific needs of cowpea cultivation. The modified version includes a double hopper: one for seeds, the other for localized application of a compost-chemical fertilizer mixture (NPK 15-15-15), allowing for precision fertilization using the microdose technique.

Purchasing fertilizers is a financial burden, but yield will increase significantly with the application of appropriate fertilizer [15]. Agriculture in West Africa is particularly vulnerable to climate change due to its heavy reliance on rain-fed agriculture and increased climate variability [16].

The economic relevance of applying 2g of DAP per pocket in the context of microdosing is now being questioned. Indeed, recent research suggests that lower doses could be sufficient to ensure good yields [10]. In addition, the mechanization of the application of these small quantities of fertilizer is now possible thanks to the development of seed drills with separate hoppers for seeds and fertilizers.

In terms of good practices for cowpea cultivation, research institutions recommend composting, respecting the spacing between pockets, the use of small mechanization, respecting the sowing period, sowing in rows and seed treatment [17]. However, very little work has focused on improving cowpea productivity through mechanization combined with fertilization.

The objective of this study is to evaluate the combined effect of mechanized sowing and localized fertilizer application on the agronomic performance of cowpea. More specifically, it involves comparing four (4) sowing treatments combining the sowing method (manual or mechanized) and the application of fertilizers (with or without microdose). The study aims to determine the impact of the treatments on yields, workload and economic profitability.

2 MATERIALS AND METHODS

2.1 MATERIAL

The trial mobilized a set of equipment to meet the technical requirements of cowpea cultivation. The seed variety used is IT90, chosen for its good adaptability to the soil and climate conditions of the Maradi and Zinder regions. The main sowing tool is the adapted Gangaria seeder. It has been specially modified to adapt to the specific needs of this legume, particularly in terms of spacing between pockets, sowing depth, and simultaneous distribution of inputs. The seeder is hitched to a pair of oxen (Figure 1). It was used for mechanized treatments, also requiring a driver and a guide to ensure regular sowing. The field equipment included a GPS for precise delimitation of plots, a stopwatch to measure the duration of cultivation operations, as well as stakes and string for marking experimental plots according to the defined dimensions. A precision electronic scale was used to weigh seeds, crops, and inputs. Finally, for manual treatments, a large traditional hoe was used to open seed pockets, allowing for comparison between manual and mechanized practices.

2.2 METHODS

2.2.1 PRESENTATION OF THE GANGARIA SEEDER

The Gangaria seed drill is an innovative and newly developed tool that allows for the simultaneous sowing and application of seed and organomineral soil fertilization (Figure 1). It has two independent hoppers for seeds and compost (Figure 2b), each with a perforated disc adapted to the type of input (Figure 2a). The rotation of the wheels drives distribution, while elements such as the openers, skimmers and the press wheel ensure efficient sowing. It is lightweight (approximately 20 kg) and designed for animal traction.

The adaptation of the seeder to cowpea cultivation consisted of adjusting the distribution system for larger seeds, adjusting the sowing depth (3–5 cm), and the spacing between pockets (25 cm). The seeder now allows the simultaneous application of compost and mineral fertilizer thanks to its separate hoppers. The seeder was developed by INRAN and manufactured by the metal construction workshops of Niger.

Fig. 1. The Gangaria Seed Drill: Integrated Tool for Simultaneous Sowing and Organomineral Fertilization

2.2.2 STUDY AREA

The trial was conducted for two years (2023 and 2024) in the Regional Agronomic Research Centers (CERRA) of Maradi and Zinder. The Maradi region is located between latitude 13°30’00”North and longitude 7°06’06”East and that of Zinder located between latitude 13°48’25 “North and longitude 8°59’17” East. These two regions (Figure 3) constitute the agricultural center par excellence of the country. They contribute 47% to the national production of cowpea [3]. These two regions of Maradi and Zinder are located in the center-south of Niger and have predominantly sandy soils. Annual rainfall in these regions varies from 400 to 500 mm [18].

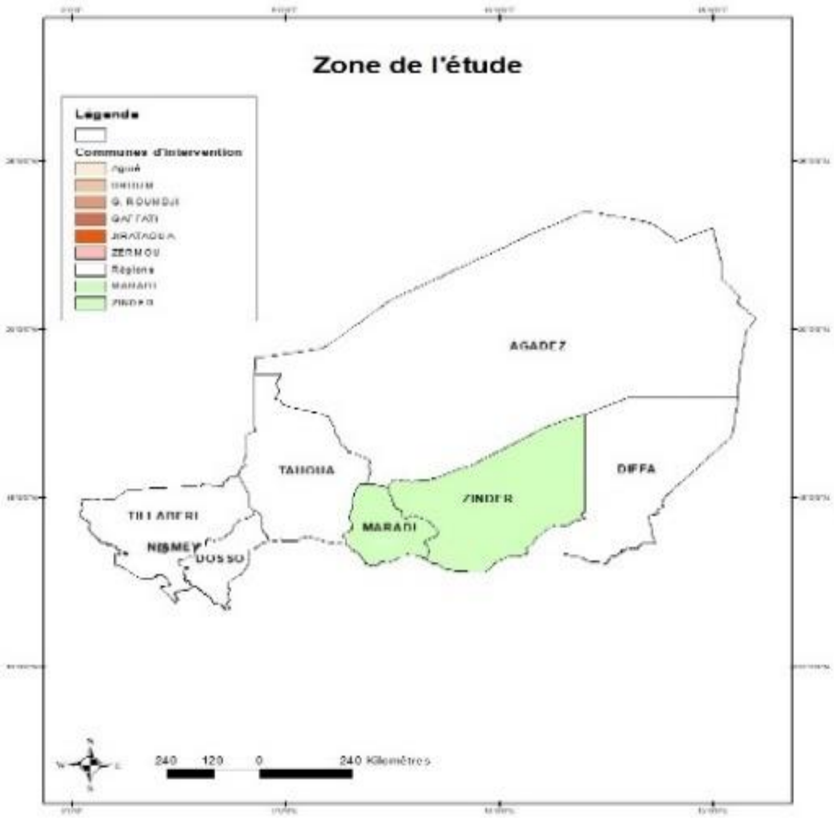

Fig. 2. Map of the study area

2.2.3 EXPERIMENTAL DEVICE

An experimental design was set up to evaluate the combined effect of mechanization and fertilization on cowpea cultivation. Four treatments (T0, T1, T2, T3) were defined according to a factorial structure crossing two sowing methods (manual and mechanized) and two fertilization levels (with or without inputs). The experiment was conducted according to a randomized complete block design with four replications.

2.2.4 DESCRIPTION OF TREATMENTS

- **Treatment T0 – Manual sowing without fertilization:**

This treatment corresponds to the traditional practice, without any fertilizer application. Two people carried out the sowing: one opened the pockets using a large hoe, the other placed the seeds before closing the holes.

- **Treatment T1 – Manual sowing with organomineral fertilization:**

Three people were involved in this treatment. The first opened the holes, the second introduced a mixture of 25 g of compost and 0.6 g of NPK (15-15-15) into each pocket, and the third placed the seeds before closing the pockets.

- **Treatment T2 – Mechanized sowing without fertilization:**

Sowing was carried out using an adapted Gangaria seed drill, hitched to a pair of oxen. One person drove the team while another guided the seed drill. Only the seed hopper was used, without the addition of fertilizers.

- **Treatment T3 – Mechanized sowing with organomineral fertilization:**

This treatment combines mechanization and the addition of inputs. The Gangaria seeder was simultaneously supplied with seeds and fertilizers (25 g of compost and 0.6 g of NPK per pocket). The equipment was always harnessed to a pair of oxen and operated by two people (driving and guiding). In each treatment, cowpea was sown with a spacing of 60 cm x 25 cm. Each elementary plot includes 6 rows and each row includes 120 plants. An elementary plot is composed of 720 cowpea plants. An elementary plot has an area of 108 m^2 (30 m x 3.6 m).

2.2.5 DATA COLLECTION AND ANALYSIS

The performance evaluation of the different treatments was based on a methodological approach that combines work efficiency measurements, agronomic parameters and an economic analysis. This integrated approach made it possible to better understand the technical and economic effects of the different sowing methods applied to cowpea cultivation.

- Cowpea yield (kg/ha)
- The required working time (hours)
- Work output (h/d/ha)
- Agricultural yield (Kg/ha)

The Agricultural Work Yield is expressed as follows:

The labor output in agriculture corresponds to the working time required to carry out an agricultural operation on a given area (ha). It is expressed in:

- hours per hectare (h/ha), where
- man-day per hectare (hd/ha), considering a standard 8-hour day.

Yield measures the technical efficiency of agricultural work [19]. It is expressed by the following formulas:

- Hourly output = T / S
- Man- day output = T / (8 × S)

With:

- T: total working time (hours), - S: area worked (hectares).

Work yield in animal traction

According to the work of [20] and [21], the efficiency in animal traction is expressed by the following formula in animal traction:

R = T / (S × C)

Work output in manual cultivation (hour/ha)

Work output is a key indicator for assessing labor efficiency in agricultural production systems, particularly in the Sahel region. It is expressed in man-days per hectare, according to the following relationship: *Yield = (N × T) / S,* where N is the number of workers, T is the duration of work (in days), and S is the area worked (in hectares). This ratio makes it possible to estimate the human labor load required to cover a unit of area [22].

The yield of tropical grain legumes:

Agricultural yield represents the amount of biomass produced per unit area. In the case of cowpea, three products are valued: seeds, tops, and pods [23]. Yield is expressed in dry weight [24]. Before harvesting, a sample of 7 plants by 1 m^2 was taken from each useful plot (PU) to analyze the yield components. The PU corresponds to 4 rows, excluding borders, over an area of 70.8 $m^{2,}$ for a total of 472 plants harvested. After air drying to constant weight, the seed yield (kg/ha) is calculated by multiplying the sum of the dry weights (PU + sample) by the conversion factor (10,000 m^2 / PU area). The haulm yield follows the same method [25].

2.2.6 Economic Evaluation

According **to** the work of [26] farm economics is based on the systematic analysis of inputs, yields and costs. In order to better understand and evaluate the economic performance of agricultural production systems. Farm incomes were estimated based on yields and average selling prices of grains, haulms and pods observed on local markets. Gross margin was calculated as the difference between total revenues and operating expenses, while net margin included all costs, including depreciation. The economic evaluation was conducted based on technical and financial data collected from 235 cowpea producers located in the Maradi and Zinder regions. These data included input costs (seeds, fertilizers, compost, pesticides), labor-related expenses (land cleaning, sowing, weeding, harvesting) and transport costs. In addition, fixed costs were integrated through the depreciation of agricultural equipment used (seeder and cultivator), calculated on the basis of their useful life.

2.2.7 Economic Analysis

- **Evaluation of charges**

There are two types of costs in this study: fixed costs and variable costs. Variable costs include expenses directly related to production, such as seeds, fertilizers, plant protection products, labor, and transportation. Fixed costs are related to the depreciation of equipment, namely the seeder and cultivator. The average price of equipment on the market is 150,000 and 110,000 FCFA respectively for the seeder and cultivator. The depreciation allowance is 15,000 and 11,000 respectively for the seeder and cultivator (Table 5). The depreciation allowance was calculated by dividing the respective prices of the equipment by the average lifespan of the equipment (10 years for the seeder and cultivator). Regarding the evaluation of the quantities of inputs used, for mechanized sowing, the density is 66,667 pockets/ha. With the addition of 0.6g/pocket of NPK triple 15 mixed with 25g of compost, 1667kg of compost and 40kg of NPK triple 15 per hectare will be required. The seed requirement is 20 and 25kg/ha respectively for mechanized and manual sowing.

- **Cost of inputs, labor and transportation**

The price of seeds is set at 1000 CFA francs kg $^{-1,}$ pesticides/insecticides at 25000 CFA francs ha $^{-1,}$ NPK triple 15 fertilizer at 360 CFA francs kg $^{-1,}$ organic manure (compost) at 80 CFA francs per kg $^{-1.}$ Labor is 1500 CFA francs man-day. The average price of transporting a 100kg bag of cowpea to a weekly market is 300 CFA francs.

- **Cost of labor outside of harvest**

Non-harvest labor refers to the sum of labor costs for cultivation operations that begin from field clearing to the final weeding. For mechanized cultivation with microdosing of organomineral fertilizer, non-harvest labor amounts to 2,000 CFA francs compared to 30,000 CFA francs ha $^{-1}$ for manual cultivation without fertilizer and 42,000 CFA francs ha $^{-1}$ (Table 5).

- **The cost of harvesting labor** represents the sum of the labor costs of the operations that begin from harvesting to packaging, it is constant and amounts to 15,000 FCFA ha $^{-1}$ for all cultivation methods (Table 5).

3 Results

3.1 Effect Of Using The Gangaria Seeder On Work Efficiency

Mechanized sowing (T2 and T3) shows the best work yields, with averages of 3.62 h/ha for T2 and 3.5 h/ha for T3, calculated on the Maradi and Zinder sites. In comparison, manual sowing without fertilizer (T0) has an average of 6.25 h/ha, and manual sowing with microdosing of fertilizer (T1) reaches 8.12 h/ha. (Table 1). Analysis of variance with statistic 8.1 software shows that there is a highly significant difference between mechanized and manual sowing. There is no significant difference between mechanized sowing with fertilizer application and mechanized sowing without fertilizer application, which shows that the microdose does not increase the task. On the other hand, there is a highly significant difference between manual treatment with the addition of fertilizers and manual treatment without the addition of fertilizers (Table 1).

Table 1. Work yield depending on sowing method and site

Work Yield (H/ha)			
Treatment	Maradi site	Zinder site	Average
T0	8.01± 0.66 a	4.5±0.44 b	6.25±2.04 b
T1	8.75±1.08 a	7.5±0.69 a	8.12±0.98 a
T2	4.25±0.43 b	3±0.18 c	3.62±0.74 c
T3	3.75±0.39 b	3, ±0.46 c	3.5±0.62 c
P	0.01	0.01	0.01
resume	12.12	11.7	23.53

H/ha-Hour/hectare

Mechanized sowing with animal traction saves labor. Comparing manual sowing with mechanized sowing with animal traction, it appears that manual sowing with fertilizer application requires an average labor of 3.16 man/day/ha compared to 2 man/day/ha for mechanized sowing with fertilizer application with a yield of 0.49 day/ha (Table 2). There is no significant difference between the labor required for manual sowing without fertilizer application and that mobilized for mechanized sowing (Table 2).

Table 2. Work output depending on the sowing method and the labor used

Yield	h/d/ha	h/d/ha	d/ha	Workforce	d/ha	Workforce
Treatment	T0	T1	T2	T2	T3	T3
Average	2.08	3.16	0.51	2	0.49	2
Standard deviation	0.27	0.28	0.09	0	0.08	0

h/d/ha - man-day/hectare, d/ha - day/hectare

3.2 Effect Of Mechanization Combined With Fertilization On Grain Yield

On average over 2023-2024, treatment T3 (manual sowing with microdosing) gave the highest grain yield (959 ± 38.01 kg/ha), followed by T1 (838 ± 26.64 kg/ha), T2 (743 ± 32.18 kg/ha) and T0 (505 ± 15.54 kg/ha), confirming the positive effect of microdosing on production. The average yield of the two treatments obtained with the application of microdoses of compost was 274 kg/ha higher than the yield in the two treatments without microdosing, which corresponds to an increase of 43.0%. Mechanization alone resulted in an increase in grain yield of 180 kg/ha, an improvement of 26.8% compared to manual sowing (Table 3). Analysis of variance with Statistics8.1 software shows that treatment (T3) is highly significant and different from other treatments. On the other hand, treatment (T1) is significantly different from treatment (T2), but the latter is significantly different from T0. Indeed, the mechanization of sowing with the Gangaria seeder combined with mechanized weeding and organomineral manure contributed to the improvement of cowpea grain yield by 88.5 and 14.6% respectively compared to T0 and T1 (Table 3).

Statistical analysis shows highly significant differences between treatments ($p < 0.001$), between sites ($p < 0.001$), and between years ($P < 0.012$), reflecting the cumulative effect of climate, sowing method, and inputs on agronomic performance.

Table 3. Cowpea grain yield as a function of treatment and site

Site	Year	Grain yield (kg/ha)			
		T0	T1	T2	T3
Zinder	2023	496±13.76 d	814±12.91b	714±7.07 c	935±23.22 a
	2024	495±9.57d	844±17.97b	716±12.5d	924±25.62 a
Maradi	2023	516±11.08 d	825±12.91 b	785±7.07 c	981±23.22 a
	2024	511±16.52 d	868±26.30 b	770±18.25 c	995±31.09 a
Average	2023	506±15.75d	819±13.21b	749±39.40 c	958±30.81a
	2024	503±16.24 d	856±24.41b	743±32.17 c	959±46.32a
Average	2023-2024	505±15.54 d	838±26.64b	743±32.18c	959±38.01a
Source					P
Site					0.001
Year					0.012
Treatment					0.001
Site *Year					0.888
Site * Treatment					0.001
Year * Treatment					0.008
Site * Year * Treatment					0.256
resume					3.67

3.3 Effect Of Mechanization Combined With Fertilization On The Yield Of Dried Haulm

The average yields of dried haulm from 2023-2024, calculated on the Maradi and Zinder sites, show that T3 is the best performing (1,052 ± 40.86 kg/ha), followed by T1 (925 Kgha $^{-1)}$, T2 (897) and T0 (838), highlighting the positive effect of microdosing. On average, microdosing (T3) increases the yield of dried haulm by 25.5% compared to the treatment without fertilizer (T0), based on the combined data of 2023 and 2024 for the Maradi and Zinder sites. Mechanization allowed an increase in haulm yield of 93 kg/ha, corresponding to an improvement of 10.5% compared to manual sowing. Analysis of variance with Statistics 8.1 software shows that treatment T3 is highly significant and is different from the other treatments. On the other hand, treatment T1 is significantly superior to treatment T2 but treatment T2 is not significantly different from T0 (Table 4). Indeed, these results show that mechanization combined with organomineral fertilization contributes to the increase in haulm yield of 24.81 and 11.34% respectively compared to treatments T0 and T1. Statistical analysis also shows highly significant differences between treatments ($p < 0.001$), between sites, reflecting the cumulative effect of pedology, sowing method and inputs on agronomic performance. On the other hand, there is no significant effect between years ($p < 0.143$).

Table 4. Yield of dried haulm over two (2) years at the different sites

Site	Year	Dried haulm yield (kg/ha)			
		T0	T1	T2	T3
Zinder	2023	810±22.17 c	908±12.90 b	815±12.90 c	1011±22.86 a
	2024	820±18.25c	916±11.08 b	839±17.50 c	1035±12.90 a
Maradi	2023	878±22.17c	935±12.90b	965±12.90	1073±22.86a
	2024	842±17.07 c	940±18.25 b	970±18.25b	1090±48.30 a
Average	2023	844±39.35 c	921±17.47b	890±80.84bc	1043±37.60 a
	2024	831±20.31 c	928±18.88 b	904±72.08.34 b	1062±43.99 a
Average	2023-2024	838±30.93,52 c	925±17.93b	897±74.36 b	1052±40.86a
Source					P
Site					0.001
Year					0.143
Treatment					0.001
Site *Year					0.058
Site * Treatment					0.001
Year * Treatment					0.104
Site * Year * Treatment					0.432
resume					5.09

3.4 ECONOMIC EVALUATION

The cost of non-harvest labor varies from 2000 (T3) to 42000 FCFA ha $^{-1}$ (T1). It is higher for manual sowing with fertilization in the form of microdose. This result shows that the use of the adapted Gangaria seeder combined with mechanized weeding has a positive effect on labor savings in cowpea cultivation. It allows for a saving of 40000 FCFA ha $^{-1}$ (Table 5). The seed requirement is 20000 FCFA ha $^{-1}$ with the use of the Gangaria seeder compared to 25000 FCFA ha $^{-1}$ for manual sowing. Indeed, the Gangaria seeder allows for a saving of 5000 FCFA ha $^{-1}$ (Table 5) on seed costs. Compost is the organic manure used in the form of microdose with the Gangaria seeder and in manual sowing with fertilizer. On the other hand, if farmers produce it locally, they would save 133,360 CFA francs per ha on the cost of growing cowpea (Table 5). The selling price was obtained during the survey conducted in 2023 among 235 cowpea producers spread between the Maradi and Zinder regions. On this basis, the average selling price of a 100 kg bag of hulled cowpea varies from 32,000 to 44,000 CFA francs during the year. The selling price of a 25 kg bag of dried tops varies from 750 to 1,250 CFA francs during the year. The average selling price of a 45 kg bag of hulls is 6,500 CFA francs. The revenues from the sale of grains, dried haulms and hulls were estimated by multiplying respectively the average grain yields (Table 3) and the average dried haulm yields obtained during the trial (Table 4) by the different corresponding prices. The estimated revenues according to treatments are 308900, 513040, 454940, 587220 FCFA ha $^{-1}$ respectively for T0, T1, T2, and T3. It appears that the revenues (587220 FCFA ha $^{-1)}$ estimated on the production from mechanized sowing with fertilization (T3) are higher than the other treatments. The smallest amount of revenue is recorded at the control level T0 (308900 FCFA). The net margin is equal to the difference between the revenues and the estimated costs of the types of crops. The costs are composed of variable costs and fixed costs. From the analysis of the results, it emerges that treatments T0, T1, T2, T3 recorded the respective net margins of 187700, 203760, 331365, and 277485 FCFA ha $^{-1}$ (Table 5). The net margin obtained is 331365 FCFA ha $^{-1}$ with mechanized cultivation without the addition of organomineral fertilization against 187700 and 203 760 FCFA ha $^{-1}$ respectively for treatments To and T1 (Table 5). The net margin obtained with T2 is also higher than that obtained with T3. The difference in margin between T2 and T3 is 53880 FCFA ha $^{-1.}$ It can be reduced if the producer reduces or cancels the cost of compost. This is only possible when the farm begins to produce it with the droppings of draft animals (Table 5). The purchase of compost is not profitable, which is why the net margin of T2 is higher than that of T3. Cultivating cowpea with the adapted Gangaria seeder contributes to improving the profitability of cowpea cultivation by gaining a net margin of 331365 FCA ha $^{-1}$ this net margin should have been 464725 FCA ha $^{-1}$ if the compost had been produced by the farm. The net margin of treatment T2 is higher than that of treatment T3, which shows that the combined effect of mechanization and localized fertilization had no effect on the net margin.

Table 5. Economic analysis of cowpea cultivation

Treatment	T0	T1	T2	T3
Grain sale	191900	318440	282340	364420
Fane sale	101000	167600	148600	191800
Cosse Sale	16000	27000	24000	31000
Recipes	308900	513040	454940	587220
		Production cost		
Seeds	25000	25000	20000	20000
Pesticides/Insecticide	25000	25000	25000	25000
Chemical fertilizer	0	14400	0	14400
Organic manure (compost)	0	133360	0	133360
Non-harvest labor	30000	42000	2000	2000
Harvest labor	16000	27000	24000	55000
PICS bag	5000	9000	8000	10000
Simple bag	12625	20950	18575	23975
Transportation	7575	12570	0	0
Seeder amortization	0	0	15000	15000
Weeder amortization	0	0	11000	11000
Total	121200	309280	123575	309735
Net margin	187700	203760	331365	277485

4 DISCUSSION

Work efficiency and labor saving

The significant reduction in labor loads in mechanized sowing (3.5 h/ha) compared to manual sowing (6.25 h/ha without fertilization and 8.12 h/ha with fertilization) shows the efficiency of the modified Gangaria seeder. These results corroborate the observations of [19], which emphasize that small mechanization allows improving labor productivity, thus reducing labor requirements.

Improved grain yield

The treatment that combines mechanized sowing and fertilization (T3) generated an average yield of 959 kg ha $^{-1,}$ an increase of 88.5% compared to the manual treatment without fertilizer (T0). These results confirm the work of [10], which indicates that mechanized sowing associated with microdose of fertilizer contributes to improving agricultural yield. Compared to manual sowing, mechanized sowing is characterized by a higher density, increased regularity and a sowing depth that limits the access of predators, which explains the observed yield differences.

Yield in dried haulm

Mechanization combined with organomineral fertilization also contributes to the increase in haulm yield of 24.81% compared to T0 treatments. These results are consistent with the work of [23] which had already highlighted the multiple valorization of cowpea (grains, haulm, pods) to strengthen the resilience of small rural producers.

Economic analysis and profitability

Mechanization reduced non-harvest labor costs (2000 FCFA ha $^{-1}$ compared to 42000 FCFA ha $^{-1}$ for fertilized manual sowing). However, the highest net margin was recorded for mechanized sowing without fertilization (T2), due to the high cost of compost in T3. This observation confirms the analyses of [26] which emphasize the need to control variable costs to optimize the profitability of farms. If the compost were produced locally, the net margin of T3 would be considerably improved to reach 464725 FCFA ha $^{-1.}$

Combined effect of mechanization and fertilization

Although grain yield is maximized by the T3 treatment, the combined economic effect of mechanization and fertilization remains limited in the short term due to the cost of purchasing compost. This economic paradox demonstrates the need to integrate local compost production to fully benefit from the use of the modified Gangaria seeder.

5 Conclusion

This study demonstrated that adapting the Gangaria seeder, combined with localized application of compost and mineral fertilizer, significantly improves the productivity and economic profitability of cowpea cultivation. Mechanized sowing has halved labor time per hectare and increased grain and haulm yield. Although the cost of compost can reduce net margins, local production of compost would maximize profits. The higher yields observed with mechanized sowing are mainly due to higher seeding density, more regular seed distribution, and optimal seeding depth. These combined factors help limit predator access to seeds, thereby reducing emergence losses and promoting better crop establishment. The dissemination of the adapted Gangaria seeder, supported by training programs and access to agricultural equipment, represents a strategy to strengthen food security and income for cowpea producers in Niger.

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References

[1] Z. Abdoulkader, A. Laouali, A. Amadou, et M. Ali, « Analyse De La Rentabilité Economique Des Systèmes De Production Du Niébé (Vigna Unguiculata L. Walp), Dans La Région De Zinder », vol. 17, p. 15-23, 2024, doi: https://doi.org/10.9790%2F2380-1711011523.

[2] Haladou, I Oumarou, S. B., T. A, et Y. B;, « Evaluation Des Rendements En Graines Et Fanes Des Varietes Ameliorees Et Locales De Niebe [vigna Unguiculata (l.) Walp.] En Champ Ecole Et En Champ De Multiplication De Semences a Karma (niger) », vol. 29, p. 19-17, 2017.

[3] M.A. E, « Rapport campagne agricole Niger 2024», Document Technique Niger, 51p 2025.

[4] S. B. Bachirouu, « Hétérogénéité Spatiale Et Fonctionnelle De Surface Du Sol Et Son Influence Sur La Production Du Niébé Dans Les Exploitations Familiales Au Niger Thèse Dirigée Par M. Jean-Marie Karimou Ambouta, Universite Abdou Moumouni De Niamey Et Par M. Gilles Fronteau, Universite De Reims Champagne-Ardenne», UAM, Niamey, 2019.342 p.

[5] N. ABDOURAHAMANE, « Effets De La Mécanisation Des Opérations Culturales Sur La Productivité Du Mil (pennisetum Glaucum L.) Au Niger », DOCTORAT, UNIVERSITE DAN DICKO DANKOULODO DE MARADI, Maradi/Niger, 2021.159 p.

[6] Warouma Arifa1, Chaibou Mahamadou2, Saley Adamou Laouali2, « Animal Traction and Agricultural Productivity In Niger »: vol. 52, nº 01, p. 11, 2021.ISSN00845841.

[7] S. I. Nterany et B. David, « Oléagineux et Niébé», Document technique, (2015) 30p.

[8] A. Maimouna, I. Baoua, M. M. Rabe, A. A. Saidou, et L. Amadou, « Étude diagnostique des principales contraintes de la culture du niébé (Vigna unguiculata L. Walp) dans les régions de Maradi et Zinder au Niger», 2020.vol 6, ISSN 1813-548X.

[9] L. Philipe, H. Michel, et V. Eric, *La traction animale*. 2010. 243P ISBN 978-2-7592-0887-6.

[10] J. B. Aune, A. Coulibaly, et K. Woumou, « Intensification of dryland farming in Mali through mechanization of sowing, fertiliser application and weeding», *Arch. Agron. Soil Sci.,* vol. 65, nº 3, p. 400-410, févr. 2019, doi: 10.1080/03650340.2018.1505042.

[11] N. Abdourahamane, A. K. Saidou, et J. B. Aune, « Development and Use of a Planter for Simultaneous Application of Seed, Fertilizer and Compost in Pearl Millet Production in Niger, Effects on Labor Use, Yield and Economic Return», *Agronomy,* vol. 10, nº 12, p. 1886, nov. 2020, doi: 10.3390/agronomy10121886.

[12] B. V. Bado, « Rôle Des Légumineuses Sur La Fertilité Des Sols Ferrugineux Tropicaux Des Zones Guinéenne Et Soudanienne Du Burkina Faso», Thèse de Doctorat, 197 p. 2002. http://theses.ulaval.ca/archimede/fichiers/20487/20487.html.

[13] S. Wilfried, Effets de la fertilisation organominerale sur le rendement du niébé (Vigna unguiculata l. Walp.) Et les parametres chimiques du sol en situation réelle de culture a l'ouest du Burkina Faso « Diplôme D'ingénieur Du Développement Rural Option: Agronomie » 2016.72 P.

[14] H. Zeinabou, Contribution du niébé et des fumures organiques et minérales à la nutrition azotée et aux rendements du mil dans les systèmes de cultures en zone sahélo-soudanienne au Niger « Thèse, Université' Nazi Boni, 2017.154p.

[15] H. Ishikawa, I. Drabo, S. Muranaka, et O. Boukar, « Guide pratique sur la culture du niébé pour le Burkina Faso», Document Technique, IITA, 2013.32 P. ISBN: 978-978-8444-15-2.

[16] B. Sultan et M. Gaetani, « Agriculture in West Africa in the Twenty-First Century: Climate Change and Impacts Scenarios, and Potential for Adaptation», vol. 7, nº 1262, 2016, doi: https://doi.org/10.3389/fpls.2016.01262.

[17] M. Diallo, V. M. T.A., H. E?, et de B. W., « _rapport De La Collecte Des Données Primaires Pour L'évaluation Du Secteur Des Semences Issd/Sahelniebe», 2021.

[18] O. Bakoye *et al.,* « Production et Stockage d'Arachide », 2019, doi: https://doi.org/10.5539/jas.v11n4p25.

[19] F. Baudron *et al.,* « Re-examining appropriate mechanization in Eastern and Southern Africa: two-wheel tractors, conservation agriculture, and private sector involvement », *Food Secur.,* vol. 7, nº 4, p. 889-904, Août 2015, doi: 10.1007/s12571-015-0476-3.

[20] « The economics of animal traction in Africa. World Animal Review», vol. 78, nº 1, p. 3-10, 1994.

[21] Starkey, P. (1997). The Introduction of Animal Traction in Farming Systems: Guidelines for Decision-making. FAO Animal Production and Health Paper 125. FAO, Rome. Document technique.

[22] Houmy, K., Clarke, L. J., Ashburner, J. E., & Kienzle, J. (2013). Développement de la mécanisation agricole: Un manuel pour les planificateurs et les décideurs. Organisation des Nations Unies pour l'alimentation et l'agriculture (FAO), Rome.

[23] M. J. Mortimore et B. Singh, « Cowpea in traditional cropping systems ». 1995.

[24] J. D. Ehlers et A. E. Hall, « Cowpea (Vigna unguiculata L. Walp.). Field Crops Research», vol. 53, p. 187-204., 1997, doi: https://doi.org/10.1016/S0378-4290 (97) 00031-2.

[25] CILSS, « Elaboration rendement du niébé ». Protocole, 22p. 2021.

[26] J. L. Dillon et J. B. Hardaker, « Farm management research for small farmer development. FAO. » 1993.Document technique.