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RESEARCH ARTICLE

EFFECT OF A JATROPHA CURCAS-BASED AGROFORESTRY SYSTEM ON PERFORMANCE OF ASSOCIATED CROPS IN SEMI-ARID ZONE, SENEGAL

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Abstract

Agroforestry systems based on *Jatropha curcas* are recommended as a potential solution for ensuring food insecurity, providing biofuel and buffering energy deficit that compromises socio economic development of Sahelian countries. In order to evaluate the influence of such systems on crop performance, a study was carried out over 3 years (2013-2015) in Ngouye village in the semi-arid zone (650-800 mm) in Senegal. The experimental design was randomized complete blocks with 3 replications and 4 treatments including two agroforestry systems with *Jatropha curcas* spacing of 4 m x 3 m (J4) and 6 m x 3 m (J6), millet monoculture (MM) groundnut monoculture (GM) and *Jatropha curcas* monoculture (JM). Measurements concerned morphological variables and crop yields. The results showed that *Jatropha curcas* intercropped with food crops showed a significant depressive effect on the morphological parameters of *Jatropha curcas* only during the early stages of growth (1-4 months). The presence of 1- to 2-year-old *Jatropha curcas* plants showed no significant effect on millet (first year of cultivation) and groundnut (second year of cultivation), respectively. However, 3-year-old plants showed a significant effect on the growth and yield of millet. The number of leaves and the number of tillers were significantly reduced in J4 (10 and 36% respectively) relative to MM and J6; leading reduction of 34% of grain yield. In conclusion, this study showed that J6 was the best agroforestry system compare to MM according to yield. However, as water is a critical resource in the study area, it is important to assess the impact of the agroforestry systems studied on soil water dynamics.

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Introduction:-

Jatropha curcas (*Jatropha curcas*), a species in the Euphorbiaceae family, is widely distributed in tropical and subtropical regions. Its potential for biofuel production is well-recognized (Heller, 1996). West African countries have promoted its large-scale cultivation to reduce dependence on fossil fuels, diversify agricultural production, and stimulate the rural economy (Diedhiou et al., 2012a). Over the past twenty years, there has been a decline in the

production of major crops. This is the case for millet and peanuts in Senegal, crops that play a significant role in the country's food supply and economy (Noba et al., 2014). The poor performance of these crops is linked to extreme climate variation, droughts, soil depletion due to the misuse of chemical fertilizers, and pest infestations (Djiba et al., 2025 ; Traore et al., 2021). These issues have prompted farmers to diversify their crops, including cultivating *Jatropha curcas*. Under these conditions, arable land usually reserved for food production could be reoriented toward biofuel cultivation. Many specialists and rural development actors therefore predict that, in the medium term, there will be competition for space between food crops and *Jatropha curcas* cultivation (Abugre et al., 2015 ; Diedhiou et al., 2017). To address this, agroforestry systems combining *Jatropha curcas* and annual crops are recommended. These systems improve soil fertility, maintain stable agricultural production, and mitigate conflicts between population growth and limited availability of arable land (Subbulakshmi et al., 2021). However, the success of the system depends on the complementarity of the associated crops (Subbulakshmi et al., 2019) and the density of the trees (Noda-Leyva et al., 2024). Unfortunately, there is little reliable scientific knowledge on the performance of such agroforestry systems in the Senegalese Peanut Basin. This study aims to assess growth, yield, and interaction effects of *Jatropha curcas* spacing on millet and groundnut performance.

Materials and methods:-

Biophysical characteristics of the site:

Location and climate:

The study was carried out in the village of Ngouye (13° 59' 44.07'' N and 15° 35' 52.15'' W), located in the municipality of Ndiognick, department of MBirkelane and the region of Kaffrine. The climate of the area is Sudano-Sahelian, characterized by annual rainfall varying between 400 mm and 900 mm and two seasons (a dry season lasting 7 to 8 months and a rainy season lasting 4 months). The average monthly minimum and maximum temperatures are 16.2°C (January) and 42.1°C (May) respectively. The average annual temperature is 29.6°C (Sarr, 2013a).

Soil and vegetation:

The soil (Lixisol) (FAO, 2006), known locally as Dior is sandy in texture (95% sand) and had carbon and total nitrogen contents of 0.43% and 0.035% respectively, and mean pH of 6.6 (Dièye, 2016).

The vegetation is savanna, with a woody layer dominated by *Cordyla pinnata* (Lepr. ex A. Rich.) Milne-Redh., *Piliostigma reticulatum* (DC.) Hochst. and *Combretum micranthum* G. Don. Herbaceous vegetation in the interspace between tree stands consists of annuals dominated by *Digitaria ciliaris* (Retz.) Koeler, *Pennisetum pedicellatum* Trin., *Eragrostis tremula* Steud. and *Alysicarpus ovalifolius* Schumach. and Thonn. (Sarr, 2013b). Farmers' fields are occupied by agroforestry parklands, with two main species (*Cordyla pinnata*, and Perr. and *Sterculia setigera* Del.).

Plant material:

***Jatropha curcas*:**

The plants used for the trial were grown in a nursery in polyethylene bags measuring 12 cm in diameter and 25 cm in length, filled with compost produced from cattle manure. The seeds used belong to a local accession of *Jatropha curcas* collected in the commune of Ndiognick. These plants were transplanted at 4 months old.

Millet (*Pennisetum glaucum* L.):

Souna 3 variety was used. It is a short-cycle variety (90 days), drought-tolerant, with high tillering capacity and non-photoperiodic (Sy et al., 2015). The growing cycle is subdivided into vegetative, reproductive and maturation phases (Kadri et al., 2019). The optimal yield of this variety is estimated at 2.4-3.5 t/ha (ISRA, 2012).

Groundnut (*Arachis hypogaea* L.):

The 73-33 variety was used. It is a Virginia type with a growing cycle of 105 days and a potential yield of 2 to 2.5 t/ha. The weight of 100 seeds is 48-52 g and the percentage of seeds at shelling is 73% (Gautreau et al., 1980). The seeds used for both varieties (73-33 and Souna 3) were obtained from the seed production department of the Senegalese Institute for Agricultural Research (ISRA).

Experimental design:

The experiment was arranged in randomized complete block design and replicated thrice. Four treatments were studied :

- *Jatropha curcas* monoculture (JM) with 3 m spacing between trees in the row and 3 m spacing between tree rows, giving a density of 1,111 trees/hectare;
- *Jatropha curcas* intercropped with food crops, with 3 m spacing between trees in the row and 4 m spacing between tree rows, giving a density of 833 trees/hectare (J4) ;
- *Jatropha curcas* intercropped with food crops, with 3 m spacing between trees in the row and 6 m spacing between tree rows, giving a density of 555 trees/hectare (J6) ;
- Millet monoculture (MM) or Groundnut monoculture (GM).

The elementary plot was 144 m² (12 m long by 12 m wide). The spaces between blocks are 3 m wide. Within a block, the spacing between elementary plots is 3 m.

Crop management:

Following the dominant farmer practices in the region, all plots had a crop rotation of groundnut and millet over the experimental period from 2013 to 2015. Thus, crops were sown for millet in 2013 and 2015, and for groundnuts in 2014.

Millet:

During both years, millet was sown after sufficient rainfall was registered as follows:

- for J4, the spacing between tree rows and adjacent millet rows is 0.5 m, i.e., four millet rows per band and 12 rows per elementary plot (three bands per elementary plot).
- for J6, the spacing between tree rows and adjacent millet rows is 0.5 m, i.e., 6 millet rows per band and 12 rows per elementary plot (2 bands per elementary plot).
- for MM, the spacing between millet holes is 1 m, while the millet rows are 1 m apart, i.e., 12 rows per elementary plot.

NPK (15-10-10) mineral fertilizer was applied at sowing (150 kg/ha). Urea was applied at 12 and 45 days after sowing (50 kg/ha each application). After germination, the plants were thinned to three plants per hole. Weeding was carried out as needed throughout the growing cycle.

Groundnut:

Groundnut was sown horse-drawn sowing after sufficient rainfall was registered and as follows:

- for J4, the spacing between tree rows and adjacent peanut rows is 0.5 m, and the spacing between peanut rows is also 0.5 m; thus, there are 5 peanut rows per strip and 15 rows per elementary plot (3 strips per elementary plot) ;
- for J6, the spacing between tree rows and adjacent peanut rows is 0.5 m, and the spacing between peanut rows is also 0.5 m; thus, there are 9 peanut rows per strip and 18 rows per elementary plot (2 strips per elementary plot) ;
- for GM, the spacing between peanut rows is 0.5 m, or 23 rows per elementary plot.

NPK (6-20-10) mineral fertilizer was applied at sowing (150 kg/ha). Weeding was carried out as needed throughout the growing cycle.

Measurements:

Morphological variables of crops:

***Jatropha curcas*:**

The variables measured were height, taken from the base of the plant to the apex of the main stem using a graduated ruler ; the north-south and east-west diameters of the canopy using a tape measure. These measurements were taken on 15 trees per plot (i.e., 45 trees per treatment and 135 trees for the entire trial). The trees were chosen from among the most central ones, when the total number of trees in the plot allowed, in order to avoid edge effects.

Millet:

The variables recorded at 7-day intervals are the number of leaves per main stem and the number of tillers per plant. The number of leaves was determined by counting the main stem, which was measured for height. The number of tillers is monitored in the 15 plants previously selected in each elementary plot. This involved counting the tillers from the start of tillering until a constant number of tillers was reached.

Yield parameters of crops:**Jatropha curcas:**

The harvest was carried out on the 15 trees selected for dendrometric measurements and consisted of collecting all ripe fruit (yellow or brown in color), separating them by tree, and drying them separately. This harvest was carried out between July and October at 15-day intervals. The number of fruits produced per tree and the number of seeds produced per tree were determined by counting. The weight of the seeds per tree was measured using a precision scale.

Millet:

Yield squares were delineated in all the elementary plots. They are rectangular and measure 8 m long by 2 m wide (16 m²). At maturity, the plants contained in each yield square were cut and the spikes harvested, then counted and dried.

The yield components determined are as follows :

- the number of spikes per plant ;
- the length of the spikes, which was measured with a tape measure for all spikes harvested in each yield square ;
- the grain yield, which was determined after weighing with a precision scale, of the grain harvested per yield square (kg/ha) ;
- the weight of 1,000 grains, which was determined for each elementary plot on the basis of three samples of 1,000 grains.

Groundnut:

The measurements were taken in rectangular yield squares measuring 2.5 m wide by 10 m long (25 m²). The yield components determined were : total number of pods/m², pod yield and grain yield (g/m²).

Data Analysis:-

The data were subjected to various tests to verify that the conditions for performing analyzes of variance were met. The Shapiro-Wilks test was performed to verify the normality of the distributions of the variables studied, and the Breusch-Pagan test was performed to verify homoscedasticity (Akewugberu et al., 2023). Then, analyzes of variance were performed using Statistix (version 12.x) software to investigate the effects of the treatments studied on the variables measured on the plants. The Tukey's test at a 5% significance level was used to compare the treatment means due to its ability to adjust multiple comparisons and control the error rate effectively.

Results:-**Effect of treatments on growth and yield parameters of Jatropha curcas:****Height:**

Regardless of the measurement date, there was no significant differences between treatments regarding height. At the last measurement date, 28 months after transplanting (MAT), the average height of Jatropha curcas varied between 136.4 cm for the JP treatment and 140.6 cm for the J6 treatment (Table 1).

Table 1. Effect of treatments on height of Jatropha curcas.

Treatments	Height (cm)			
	July 21, 2013 (1 MAT)	October 28, 2013 (4 MAT)	October 30, 2014 (16 MAT)	October 14, 2015 (28 MAT)
J6	39,1 ^a	106,4 ^a	122,2 ^a	140,6 ^a
J4	38,7 ^a	103,7 ^a	116,5 ^a	137,5 ^a
JP	40,7 ^a	108,5 ^a	120,9 ^a	136,4 ^a

MAT: months after transplantation ; J6 : Jatropha curcas intercropped with food crops with 6 m spacing between tree rows ; J4: Jatropha curcas intercropped with food crops with 4 m spacing between tree rows ; JP: Jatropha curcas monoculture with 3 m spacing between tree rows; Values within a column with the same letter are not statistically different at P <0.05.

Canopy diameter:

There are significant differences between treatments regarding canopy diameter at 1 MAT and 4 MAT (Table 2). Treatment J4 has the most significantly low values compared to the other treatments, whose average values are not statistically different on these dates. Thus, at 1 MAT, the canopy diameter is 34.1 cm for J4 compared to 37.7 cm for JP (maximum value). At 4 MAT, J4 has an average value of 118.2 cm, which is statistically lower than the highest value (143.8 cm) observed for JP.

Table 2. Effect of treatments on canopy diameter of *Jatropha curcas*.

Treatments	Canopy diameter (cm)			
	July 21, 2013 (1 MAT)	October 28, 2013 (4 MAT)	October 30, 2014 (16 MAT)	October 14, 2015 (28 MAT)
J6	36,4 ^{ab}	133,3 ^{ab}	158,4 ^a	207,2 ^a
J4	34,1 ^b	118,2 ^b	193,7 ^a	201,2 ^a
JP	37,7 ^a	143,8 ^a	165,5 ^a	210,6 ^a

J6 : *Jatropha curcas* intercropped with food crops with 6 m spacing between tree rows ; **J4:** *Jatropha curcas* intercropped with food crops with 4 m spacing between tree rows ; **JP:** *Jatropha curcas* monoculture with 3 m spacing between tree rows; Values within a column with the same letter are not statistically different at $P < 0.05$. At 16 and 28 MAT, no significant differences were noted between treatments regarding canopy diameter, suggesting a significant influence of the *Jatropha curcas* intercropped with food crops on this parameter during the early stages of growth.

Yield parameters:

Analysis of variance showed no significant differences between treatments for yield parameters (number of fruits per tree, number of seeds per tree, and seed weight per foot) (Table 3).

Table 3. Effect of treatments on yield parameters of *Jatropha curcas* in 2015.

Treatments	Yield parameters		
	Number of fruits per tree	Number of seeds per tree	Seeds weight per tree (g)
J6	27,8 ^a	79,3 ^a	41,3 ^a
J4	41,3 ^a	104,4 ^a	59,2 ^a
JP	28,5 ^a	74,2 ^a	41,5 ^a

J6 : *Jatropha curcas* intercropped with food crops with 6 m spacing between tree rows ; **J4:** *Jatropha curcas* intercropped with food crops with 4 m spacing between tree rows ; **JP:** *Jatropha curcas* monoculture with 3 m spacing between tree rows; Values within a column with the same letter are not statistically different at $P < 0.05$.

Effect of treatments on growth and yield parameters of millet:**Numer of leaves:**

Treatments significantly influenced number of leaves of millet at 35 DAS and 57 DAS (Table 4). For both dates, treatment J4 had the lowest statistical values, with 7.5 and 9.9 cm, respectively. The other two treatments showed statistically homogeneous values, with 8.0 leaves for J6 and 8.3 leaves for MM at the 35 DAS on the one hand, and 10.4 leaves for J6 and 10.8 leaves for MM at the 50 DAS on the other.

Table 4. Effect of treatments on number of leaves over the growing season in 2015.

Treatments	Number of leaves								
	20 DAS	28 DAS	35 DAS	43 DAS	50 DAS	57 DAS	64 DAS	71 DAS	78 DAS
J6	3,7 ^a	5,2 ^a	8,0 ^{ab}	9,3 ^a	10,4 ^a	10,4 ^a	9,4 ^a	8,6 ^a	7,2 ^a
J4	3,5 ^a	4,6 ^a	7,5 ^b	8,8 ^a	9,6 ^b	9,9 ^a	8,9 ^a	8,1 ^a	7,0 ^a
MM	3,7 ^a	5,4 ^a	8,3 ^a	9,6 ^a	10,8 ^a	10,6 ^a	9,3 ^a	8,5 ^a	7,5 ^a

DAS: days after sowing ; **J6 :** *Jatropha curcas* intercropped with food crops with 6 m spacing between tree rows ; **J4:** *Jatropha curcas* intercropped with food crops with 4 m spacing between tree rows ; **MM:** millet monoculture ; Values within a column with the same letter are not statistically different at $P < 0.05$. For all other dates, treatments

didn't show significant effect on number of leaves. It should also be noted that the number of leaves reached an asymptote at the 50 DAS. Beyond this date, the number of leaves decreased slightly in line with the leaf senescence phase that sets in towards the end of the millet development cycle.

Number of tillers:

Except for the first two observation dates (20 and 28 DAS), treatments showed a significant effect on number of tillers (Table 5). J4 had the lowest statistical values for the number of tillers, regardless of the date considered between the 35 and 64 DAS. The other two treatments had significantly higher but statistically similar values.

Table 5. Effect of treatments on number of tillers over the growing season in 2015.

Treatments	Number of tillers						
	20 DAS	28 DAS	35 DAS	43 DAS	50 DAS	57 DAS	64 DAS
J6	1,9 ^a	6,6 ^a	11,3 ^a	14,7 ^a	15,2 ^a	15,1 ^a	14,5 ^a
J4	2,0 ^a	4,8 ^a	8,3 ^a	10,0 ^b	10,6 ^b	10,7 ^b	10,1 ^b
MM	1,9 ^a	7,3 ^a	12,2 ^a	16,7 ^a	16,7 ^a	16,7 ^a	15,2 ^a

J6 : *Jatropha curcas* intercropped with food crops with 6 m spacing between tree rows ; **J4**: *Jatropha curcas* intercropped with food crops with 4 m spacing between tree rows ; **MM**: millet monoculture ; Values within a column with the same letter are not statistically different at $P < 0.05$. During this period, the number of tillers varied between 2.0 (20 DAS) and 10.7 (57 DAS) for J4, while it ranged from 1.95 (20 DAS) to 16.7 (50 DAS and 64 DAS) for MM. Consequently, J4 reduced the number of tillers by 34% compared to other treatments. It should also be noted that the number of tillers peaked between the 43 and 50 DAS.

Yield parameters:-

In 2013, there was no significant differences between treatments in millet yield (Table 6). In 2015, treatments didn't show significant effect on spike length and 1,000-seed weight. However, there was significant differences between treatments in number of spikes and grain yield (kg ha^{-1}). *Jatropha curcas* intercropped with millet decreased these yield parameters compared to the other treatments (J6 and MM). This reduction reached 34% in the case of grain yield (Table 6).

Table 6. Effect of treatments on millet yield parameters in 2013 and 2015.

Treatments	Spike length (cm)		Number of spikes		1,000 seed-weight (g)		Grain yield (kg/ha)	
	2013	2015	2013	2015	2013	2015	2013	2015
J6	40,6 ^a	46,2 ^a	-	5,2 ^a	7,1 ^a	7,5 ^a	376,9 ^a	1634,6 ^a
J4	40,3 ^a	45,9 ^a	-	4,4 ^b	7,3 ^a	8,7 ^a	151,3 ^a	1188,0 ^b
MM	38,5 ^a	46,8 ^a	-	5,7 ^a	7,2 ^a	5,5 ^a	180,6 ^a	1791,4 ^a

J6 : *Jatropha curcas* intercropped with food crops with 6 m spacing between tree rows ; **J4**: *Jatropha curcas* intercropped with food crops with 4 m spacing between tree rows ; **MM**: millet monoculture ; Values within a column with the same letter are not statistically different at $P < 0.05$.

Effect of treatments on yield parameters of groundnut:

There was no significant effect of treatments on groundnut yield parameters over phenology stages. (Table 7).

Table 7. Groundnut yield parameters according to treatments in 2014.

Treatments	Number of pods per m^2	Pod yield (g/m^2)	Grain yield (g/m^2)
J4	121.6 ^a	43.0 ^a	18.6 ^a
J6	150.3 ^a	51.0 ^a	19.6 ^a
GM	160.6 ^a	62.0 ^a	21.0 ^a

J6 : *Jatropha curcas* intercropped with food crops with 6 m spacing between tree rows ; **J4**: *Jatropha curcas* intercropped with food crops with 4 m spacing between tree rows ; **GM**: groundnut monoculture ; Values within a column with the same letter are not statistically different at $P < 0.05$.

Discussion:-

The results of this study showed that *Jatropha curcas* intercropped with food crops, had a negative effect on the height and canopy diameter of *Jatropha curcas* plants during the early stages of growth (1-4 MAT). During this period (2013 growing season), *Jatropha curcas* was intercropped with millet. The height and density of millet cover must have reduced the access to light for the *Jatropha curcas* plants, with negative consequences on their vegetative growth. In 2014 (16 MAT) and 2015 (28 MAT), *Jatropha curcas* plants had grown to a size that allowed them to compete with crops for light. Their maximum average height was 122.2 cm and 140.6 cm, respectively. These observations are similar to those obtained by Subbulakshmi et al. (2019) in Tamil Nadu (India).

The results also showed that in the semi-arid tropical conditions of Senegal, young *Jatropha curcas* plants (1-4 MAT or 16 MAT) had no significant effect on millet and groundnut, respectively. However, a 28-month-old *Jatropha curcas* plantation had a significant influence on the morphological (number of leaves, number of tillers) and yield (number of spikes, and grain yield) parameters of millet. Thus, no significant differences were noted between millet monoculture and the J6 treatment (6 m x 3 m spacing) for any of these parameters. However, the J4 treatment (4 m x 3 m spacing) showed significantly lower values for these parameters. Thus, a 10% reduction in leaf number at 35 and 50 days after sowing, a 36% reduction in tiller number at heading/ear emergence, and a 34% reduction in grain yield were observed. This result could be explained by the fact that, the lower production of leaves and tillers in J4 reduced the crop leaf index and its ability to intercept and convert light energy into chemical energy through photochemistry, which led to a reduction in the photosynthetic capacity of millet and lower grain production.

However, this behavior of millet in J4 is likely the result of competition between crops for light. Indeed, competition for mineral nutrition is certainly limited since the crops received mineral fertilizer. Furthermore, previous studies have demonstrated the ability of *Jatropha curcas* to improve the chemical fertility of soils (Dieye et al. 2016 ; Aminu et al., 2025). In India, the findings of Subbulakshmi et al. (2019) support this argument. They showed that *Jatropha curcas* planting distances had a significant effect on light availability in agroforestry systems. Maximum light was intercepted at wider spacing of *Jatropha curcas* (4 m x 3 m). These observations are consistent with those of Diedhiou et al. (2017), who reports that competition for light in a *Jatropha curcas*/groundnut association with 3 m x 3 m spacing caused an 84% reduction in groundnut yield compared to groundnut monoculture and treatment with 6 m x 6 m spacing. In addition, they showed a complementarity in the use of soil water between *Jatropha curcas* and groundnut. *Jatropha curcas* appears to preferably draw water from deep horizons, while groundnut was exploiting water of surface horizons (0-110 cm). Also, our results are consistent with those of Abugre et al. (2015), who showed that close spacing of *Jatropha curcas* (2 m x 1 m) associated with maize caused a significant reduction in maize yield, unlike larger spacing of 4 m x 1 m, which improved it. They also corroborate those of Bazongo et al. (2015) on the *Jatropha curcas*/sorghum association with spacing of 5 m x 2 m, as well as those of Touckia (2016) on the *Jatropha curcas*/maize and *Jatropha curcas*/groundnut associations with spacing of 3 m x 3 m and 4 m x 2 m. Finally, our results are consistent with those of more recent studies conducted in India. They revealed that the yield of crops grown in association with *Jatropha curcas* is significantly higher in agroforestry systems with the largest spacings such as 4 m x 3 m (Subbulakshmi et al., 2019 ; Subbulakshmi et al., 2021) and 50 % of the area with *Jatropha curcas* and 50 % planted with food crops (Noda-Leyva et al., 2024).

Thus, optimizing *Jatropha curcas*/food crop associations requires the development of a planting geometry that reduces competition between the associated crops, taking into account the morphological and functional characteristics of the species as well as the soil and climate conditions of the sites (Bazongo et al., 2015 ; Diedhiou et al., 2017 ; Subbulakshmi et al., 2019 ; Subbulakshmi et al., 2021 ; Noda-Leyva et al., 2024). In this study, the 6 m x 3 m (J6) planting geometry proved to be the best. The association of *Jatropha curcas* with crops based on this planting geometry can reinforce the promotion of sustainable cropping systems in the Southern Peanut Basin of Senegal. It offers yields comparable to those of crops monocultures, and it makes better use of environmental resources than these. In addition, recent studies suggest that the association of *Jatropha curcas* with cereals could be considered to combat land degradation and contribute to improving food security in the Sudanese regions. The species contributes to improving the organic status and chemical and biological quality of soils (Dièye et al., 2016 ; Bazongo et al., 2021).

Conclusion:-

The study revealed that intercropping had no significant influence on crop growth and productivity parameters during the first two years of the trial. However, it did have a significant influence on millet in the third year. The J4 treatment (*Jatropha curcas* spacing of 6 m x 3 m) experienced a significant reduction in leaf number during stem elongation and heading (10%) and tiller number (36%), resulting in a 34% decrease in grain yield.

The spacing of 6 m between rows of trees and 3 m between trees in a row (6 m x 3 m) appears optimal for establishing agroforestry systems combining *Jatropha curcas* and common annual crops (millet and peanuts) in the Senegalese Peanut Basin. Its adoption by smallholder farmers would help maintain soil fertility, diversify and increase agricultural production, and thus improve their living conditions.

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