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Effect of Fertilization on the Severity of Attack by the Defoliator Caterpillar (Noorda blitealis Walker, 1859) and on the Yield of Moringa (Moringa oleifera Lam, 1785)

Bibata Ali Outani[1,2], Haougui Adamou[1*], Basso Adamou[1] and Ali Mahamane[2]
[1]Institut National de Recherche Agronomique du Niger (INRAN)
[2]Université de Diffa (Niger)

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Abstract

Purpose: Moringa, which is increasingly grown pure in semi-intensive and intensive systems, requires adequate fertilization to produce well. In some cases, this operation can inhibit the development of its bioaggressors. The aim of this study was to determine the effect of different types of fertilization on the defoliator caterpillar (*Noorda blitealis*) and moringa production.

Methodology: The trial was conducted on the Kalapaté experimental station belonging to the Institut ational de la recherche agronomique du Niger over two seasons. The experimental design was a split-plot with 4 replications in which the main plots were represented by fertilizer types (NPK, cattle, poultry and compost). The elementary plots were made up of fertilizer doses (0, 0, 5, 1 and 1.5 kg/ha for organic fertilizers, and 0, 3, 6 and 9 g/package for NPK). The severity of the caterpillar attack and moringa yield were recorded.

Findings: The results showed that NPK acted faster than other fertilizers in reducing the severity of attack by *N. blitealis*. The reduction rate was 28.40% in the first season compared with cattle manure, which is the most attacked. In the second season, compost had a similar effect to NPK. Both reduced this parameter by over 45% each compare to cattle and poultry manure. Their action consequently increased moringa yield compared with cattle manure and poultry droppings. Also, a negative linear relationship was noted between manure dose and severity of attack, while the dose-yield relationship was of the second-degree polynomial type.

Unique Contribution to Theory, Practice and Policy: Compost can therefore be used to minimize attacks by *Noorda blitealis* and can enable sustainable production without any risk of toxicity from synthetic pesticides. In view of these results, moringa growers must compost cattle and poultry manure, and all other organic sources of fertilization, before any application.

Keywords: *Attack Severity, Fertilization, Moringa Oleifera, Noorda Blitealis, Niger, Yield*

INTRODUCTION

Good moringa production requires sufficiently fertile soil or, failing that, adequate fertilization. In Niger, this is achieved by applying mineral fertilizers (mainly NPK 15-15-15 compound fertilizer or urea) and organic fertilizers (mainly cattle manure, compost or poultry droppings). Planting density depends on the grower's objectives. Intensive leaf production, with very high densities of around 15 × 15 centimeters or 20 × 10 centimeters (Palada and Chang, 2003), is rarely used, with growers preferring semi-intensive production, where spacings of 1m x 0.5m are frequently used, resulting in an aerated plantation with fewer diseases.

Moringa can also be grown extensively. It can be combined with other crops (notably vegetables) or planted as a living hedge. In these cases, it is generally planted at spacings of 1m x1m (Walser, 2015) or even 4m x 2m (Saint-Sauveur, 2010). In terms of fertilization, the recommended doses for semi-intensive and intensive systems are 5-6 kg/m2 of organic fertilizer at soil preparation and 1-2 kg/m2 after each cut (SOFRECO, 2022). This gives 50 to 60 tons per hectare of organic matter, with 10 to 20 tons after each cut. For 5 to 6 cuttings in 4 months, 100 to 160 tons of organic matter per hectare would be needed, which is a very large quantity and beyond the reach of most growers. Boulama et al (2023) recommend 100 g organic fertilizer/package (i.e. 4 tons/ha for a density of 40,000 bunches per ha), plus 2 g NPK 15-15-15 per bunch at planting (i.e. 80 kg/ha for a density of 40,000 bunches per ha), followed by 120 kg/ha of the same mineral fertilizer as maintenance fertilizer. This dose was also recommended by Sarwar et al, (2018) who showed that at this level of fertilization, with NPK compound, moringa produced taller, wider plants, with more leaves, more branches already at the 8th week of growth. It also has a higher protein content. For semi-intensive production of around 40,000 bunches per ha, Bibata et al. (2023) recommend the application of 20 tons of organic fertilizer per hectare.

Organic and mineral fertilizers are important for moringa growth, as this plant is very rich in protein and other micronutrients. They therefore provide the essential elements required for optimal crop development (Masarirambi, et al., 2010). When crops are planted year after year in the same field, soil minerals are depleted, particularly nitrogen, phosphorus and potassium. Fertilizers therefore help to provide the elements important for moringa's rapid growth and enhance its ability to produce healthy plants (Jones 1999). Moringa needs potassium for growth and resistance to drought and disease (Parker 1998). Indeed, several studies have shown that good soil fertility management can directly reduce plant susceptibility to pests and diseases (Phelan et al., 1995; Yu-Tzu et al., 2009; Miguel et al., 2012). Soil amendment with organic matter not only improves mineral content, but also promotes the development of predators involved in regulating pest populations (Rowen et al., 2019); plants develop well and acquire a certain resistance to bio aggressors (Culliney and Pimentel, 1986; Bayissa et al., 2023; Sinha et al., 2018).

The ability of a crop to resist or tolerate insect pests and diseases is linked to the optimal physical, chemical and, above all, biological properties of the soil (Miguel and Nicholls (2003). Our surveys in the Maradi and Tillabéri basins of Niger have shown that fertilization is given per plant. This may seem sensible to take account of the different densities practiced by growers, but it does not preclude reasoning on a per-unit-area basis, in order to have orders of magnitude to better calculate fertilization needs and costs. The same survey showed that the most important moringa pest is the defoliating caterpillar, *Noorda blitealis*). It has been known in the country for a long time but was only identified in 2011 by Ratnadass et al., (2011). This insect pest can cause yield losses of 100% during a season: it devours all the new leaves that form. It is more severe in the rainy season than in the rainy season and does not spare any of the two most planted varieties (Halilou, 2022). Given the wide diversity of fertilization practices observed among growers and the negative effect of certain fertilizers on pests, the aim of this study is to propose a fertilizer dose better adapted to growers' constraints (optimal dose), likely to protect moringa plants from attack by the caterpillar, *Noorda blitealis*.

Material and Methods

The trial was set up at the research station of the Kalapaté national agricultural research institute. The design was a split-plot with 4 replications, in which the main factor was the type of manure and the secondary factor was the manure dose. The large plots were thus composed of three types of organic manures (cattle manure, poultry droppings, compost) compared with a compound fertilizer NPK (15-15-15); the secondary plots (sub-plots) received the manure doses; the different treatments selected are described in Table 1.

Table 1: Selected Treatments

Treatments	Organic manure (cattle, poultry and compost): Doses (kg/m^{2})	Mineral fertilizer
T0	0kg	0g
T1	0,5kg	3g
T3	1kg	6g
T4	1,5kg	9g

The fertilizers were applied every 20 days immediately after each harvest. During the 9 months of the trial, the sub-plots, numbering 16 per dose of fertilizer applied, received 0kg (0T/ha), 64kg (5T/ha), 128kg (10T/ha) and 192kg (15T/ha) for T0, T1, T2 and T3 respectively. In terms of mineral fertilizer (NPK), a total of 16 elementary plots were supplied with NPK at different doses: 0T, 1.536T, 3.072T and 4.608T for treatments T0, T1, T2 and T3 respectively.

Measured Parameters

a. Agronomic Parameters: Leaf Weight

Harvesting was carried out on the 14 plants of the 2 central lines (14 plants in total) of each elementary plot.

b. Entomological Parameters

Leaf damage caused by natural infestations of moringa caterpillars was assessed on the basis of larval damage to moringa leaves. This assessment was carried out by sampling all plants in the two central rows of each plot during each harvest.

The severity of infestation was assessed by visual observation, using the Bédane et al. (2013) severity scale, which runs from class 0 to class 4 (0= no damage; 1= 1-25%; 2=26-50%; 3=51-75% and 4=76-100% defoliation). Next, the scale was modified using the midpoint method of Chala et al (2007), which creates a 5th class to calculate average severity where 1=13%, 2= 38%; 3= 63%, 4= 88% and 5=100% defoliation.

Data were first entered into Excel software before being transferred to STATISTICS VERSION10.0 software to perform the analysis of variance (ANOVA) followed by the LSD test of separation of means at the 5% threshold. Dose-response curves and coefficients of determination were plotted in Excel.

RESULTS

Average Severity over 2 Seasons

The overall average severity of attack by *N. blitealis* over the 9 months was 34.93%. It ranged from 30.42% on compost to 40.99% on cattle manure. Statistical analysis showed a significant difference between treatments. Two homogeneous groups emerged: group 1, comprising cattle and poultry manure, and group 2, comprising NPK and compost (table 2).

Table 2: Effectiveness of Treatments on the Average Severity of *Noorda blitealis* Attacks over Seasons

Types of fertilizer	Average overall severity for both seasons (%)
Cattle	40,99a
Poultry	39,82a
NPK	28,47b
Compost	30,42b
Grand mean	34,93
Standard deviation	6,39

General Trend in Severity of Noorda blitealis Attacks over Two Seasons

The evolution of severity in the trial showed two peaks: one in September (around 80% on organic fertilizers) and another in February (over 90% on NPK, cattle manure and poultry droppings). The month of November was the least severe, with attacks below 2.42%. In the first season (mid-October 2023), results for NPK manure were significantly different from the others (July-September). Then in the second season, NPK and organic compost manures showed a significant difference from December 2023 to February 2024, compared with cattle and poultry manures. The latter two reached up to 90% severity, compared with 55% for the former (figure 1).

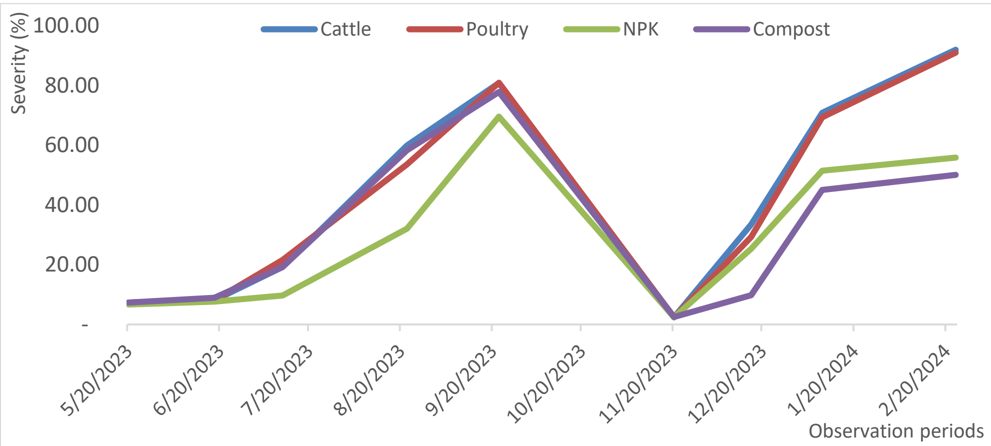

Figure 1: Evolution of Severity on Site during the Seasons

Effect of Dose on Average Moringa Yield over the Two Seasons

Figure 2 shows that the effect of fertilizer dose on severity is a linear function, as observed in seasons I and II. Whatever the type of fertilizer used, the severity of N. blitealis attack decreases as the dose increases. This relationship is of the type y = ax+b.

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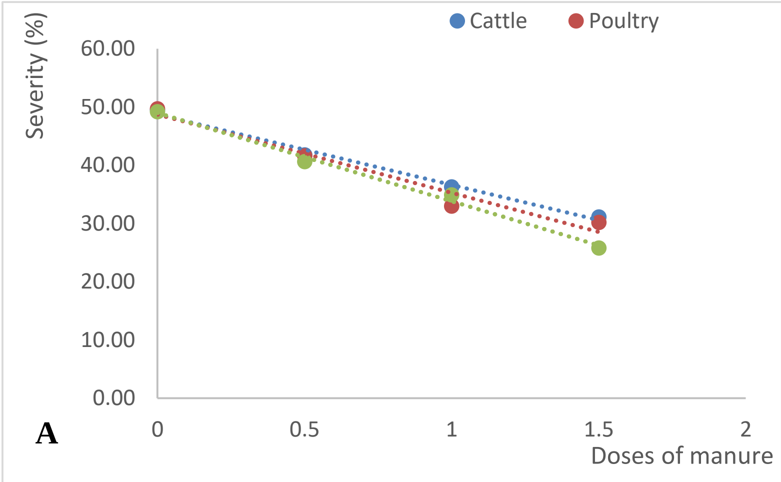
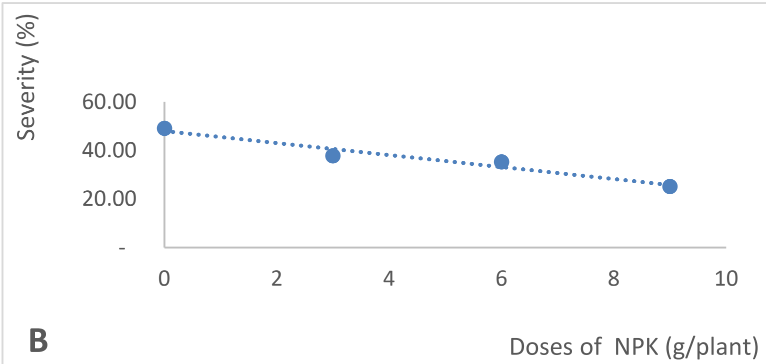
	Cattle manurey = -12,114x + 48,728 R^2 = 0,991 Poultry manure: y = -13,45x + 48,7 R^2 = 0,9623 Compost: y = -15,168x + 48,996 R^2 = 0,9931
	NPK: y = -2,4743x + 47,971 R^2 = 0,9535

Figure 2: Relationship between Manure Dose and Severity of Noorda blitealis Attacks

Effect of Fertilizers on Average Yield over Two Seasons

Average Moringa Yield as a Function of Fertilizer Type over Two Seasons

Table 3 shows that the average yield over the 9 months of observations was 79.02 g/plant (all fertilizers and all doses combined). It varied from 73.74 g/plant on plots with cattle manure to 84.79 g/plant on plots with NPK. Statistical analysis showed two groups of fertilizers: group 1, made up of NPK and compost, had significantly higher yields (σ = 5.94; α= 00.05) than group 2, made up of cattle manure and poultry droppings.

Table 3: Average Yield of the Trial as a Function of Treatment over Two Seasons

Types of manure	Yield (g/plant)
Cattle	73,74b
Poultry	74,06b
NPK	84,79a
Compost	83,50a
Standard deviation	5,94

Evolution of Average Yield as a Function of Treatment over the Two Seasons

Yield trends over the two trial seasons showed two production peaks, one in June 2023 and another in November 2023. The lowest yields were recorded in September 2023 (40 g/plant for all treatments) and February 2024 (less than 20 g/plant on cattle manure and poultry droppings (Figure 3).

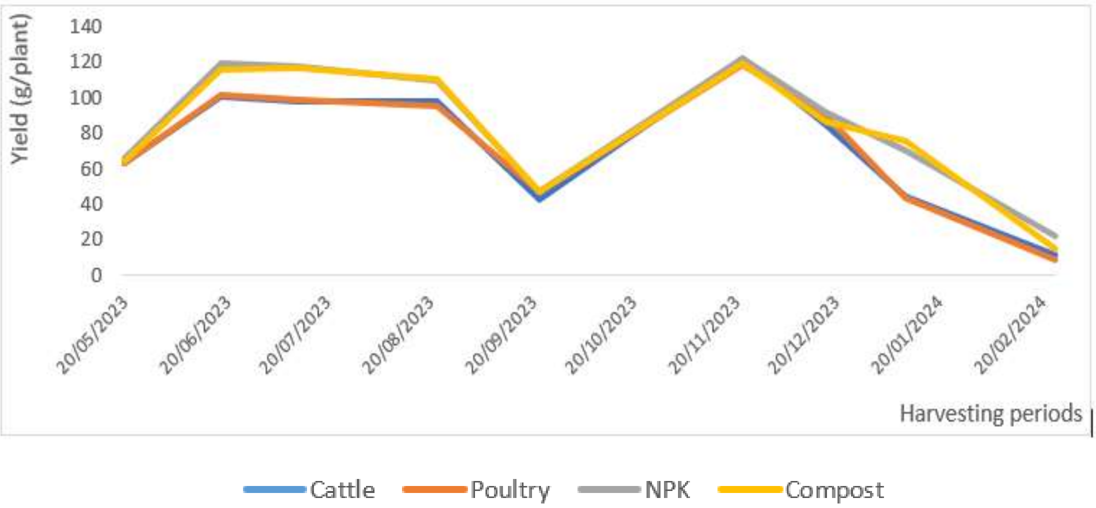
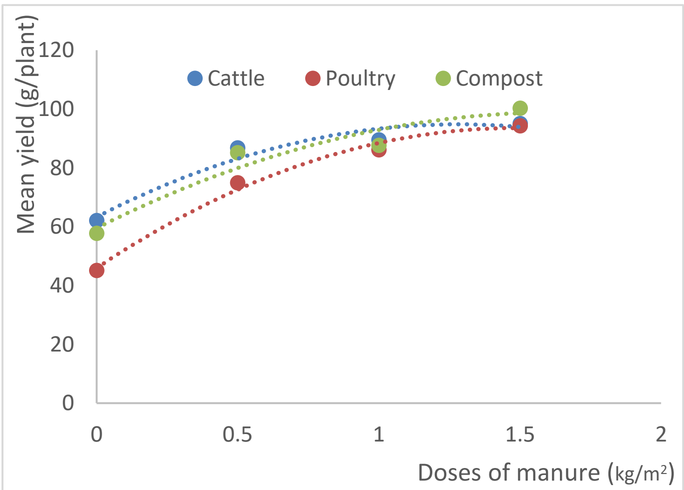


Figure 3: Moringa Yield as a Function of Treatment over the Two Seasons

Relationship between Manure Dose and Moringa Yield over Two Seasons

The average effect of fertilizer doses over the two seasons is shown in Figure 4. The curves are polynomial with a negative slope, admitting an optimum at the point of abscissa (x=(-b)/2a). Optimum doses (kg/m^2) were 1.49 for poultry manure, 1.63 for compost and 1.28 for cattle manure. NPK was 7.93 g/pack (Figure 4).



Cattle: $y = -19{,}21x^2 + 49{,}185x + 63{,}322$
$R^2 = 0{,}9519$

Poultry: $y = -21{,}55x^2 + 64{,}043x + 45{,}956$
$R^2 = 0{,}9913$

Compost: $y = -14{,}75x^2 + 48{,}163x + 59{,}536$
$R^2 = 0{,}936$

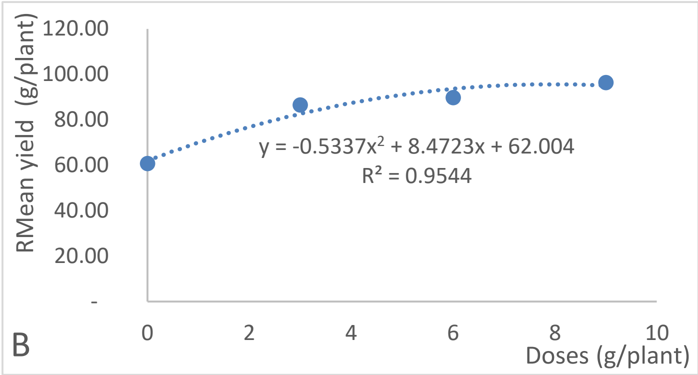
	NPK: $y = -0{,}5337x^2 + 8{,}4723x + 62{,}004$ $R^2 = 0{,}9544$

Figure 4: Relationship between the Various Treatments and Moringa Yield over the Two Seasons

Discussions

The effect of fertilizer type (NPK, cattle manure, poultry droppings and compost) and manure dose on the severity of caterpillar (*Noorda blitealis*) attacks and on moringa yield was studied on-station over two seasons (rainy and cold dry).

In the rainy season, the severity was significantly lower for the mineral fertilizer NKP, which is the farmers' practice, than for the other organic fertilizer treatments. However, if we study the evolution of this parameter during this period, we can see that this significant difference is due to the effects observed in July and August. The lower severity of insect attack under mineral fertilization, and particularly nitrogen fertilization, compared with organic fertilization, has been reported by Kempf (2020) for several insect pests. This is certainly due to the fact that the elements contained in synthetic fertilizers dissolve more rapidly in the soil, providing crops with sufficient nutrients in a short space of time (Masarirambi et al., 2010). For example, the assimilation of mineral nitrogen leads to the production of amino acids, which are rapidly converted into certain proteins that are difficult for certain insects to digest. Occasionally, certain plants, under adequate mineral nutrition, produce enzymes that prevent the insect from digesting the proteins (Walker, 2022).

In the cold dry season, the severity of attack by *Noorda blitealis* was rather lower on compost treatments than on other biofertilizers and on farmers' practice (NPK), whereas an increase in attack severity of 32.75% with NPK, 46.96% with poultry dung and 48.64% with cattle manure was observed. The other two manures (cattle manure and poultry droppings) are fresh and therefore not decomposed. They are therefore not in a form that can be immediately assimilated, although they may still contain elements that are soluble and can be assimilated by the plant, which will use the mineral elements present in the soil. As a result, these two fertilizers cannot have a short-term impact on production or on protecting moringa from pests. The action of compost is due to the fact that, at this time, it has begun to release the mineral elements that contribute to moringa growth, and possibly to its protection. This is due to the fact that it was partially decomposed at the time of application (nitrogen=0.6%; phosphorus=0.52%; potassium=40%).

The action of organic amendments with well-decomposed manures has, in many cases, enabled plants to resist insect pests and diseases. For example, Eigenbrode and Pimentel (1988) reported significantly lower flea beetle densities on plants grown with (well-decomposed) compost than on those grown with fresh manure. This finding was also made by Ponnuswami

(2006), who recommends the use of well-decomposed farmyard manure in fields. According to this author, partially decomposed manure offers favorable conditions for the survival of newly hatched insect pest larvae.

For moringa, Anjaneya et al (1992) demonstrated that organic soil amendment with neem seed powder reduced attacks by fruit flies (*Gitona distigmata*) if applied to plants at the 50% flowering stage. The same applies to the work of Ragumoorthi et al, (1998). This could be due to the composition of the plant grown on a soil amended with compost. Indeed, according to Sarwar et al. (2020), moringa plants grown in such conditions produce additional pigments, phenolic compounds and flavonoids that boost their resistance to pests.

Not to mention that organic soil amendment improves soil structure and the composition of useful mineral elements, which are gradually released into the soil (Huber and Schaub, 2011; Kwey, 2019; Patel et al., 2020). Compost soil amendments promote plant growth by increasing the activity of micro-organisms, and thus biological fertility (Bayissa et al., 2023). They also improve the agronomic fertility of these soils by reducing the C/N ratio, which would make nitrogen more available to plants (Springob and Kirchmann, 2003; Ostrowska and Porębska, 2015). Under such conditions, plants develop well and acquire a certain resistance to bio aggressors (Culliney and Pimentel, 1986; Bayissa et al., 2023; Sinha et al., 2018). According to Miguel and Nicholls (2003), a cultivated plant's ability to resist or tolerate insect pests and diseases is linked to the optimal physical, chemical and, above all, biological properties of the soil.

But organic matter inputs don't always reduce the level of plant infestation by pests. For example, Nandju et al, (2018) showed that the addition of cow manure not only increases the level of insect pest populations on maize, but also attracts a diversity of pest species to the crop. The same is true of the work of Zehnder (2009), who reported that excess nitrogen on crops can actually increase pest problems. According to the same author, increased levels of soluble nitrogen in plants can reduce their resistance to aphids and mites. Studies by Sinha et al (2018) on the aphid, *Lipaphis erysimise*, have shown that this pest only develops large populations on crops receiving high levels of nitrogen. This is because cycle length is reduced with high fecundity (Fallahpour et al., 2015; Tamburini, 2018).

The study also showed that, whatever the season and type of fertilizer, severity decreased as the fertilizer dose increased. In other words, higher doses of fertilizer reduce moringa attack by defoliator caterpillars. So, the poorer the soil, the more sensitive the plants are to *N. blitealis attack*. Sturz and Christie (2003) reported that crops grown on soils with good fertility generally show lower abundance of several insect pests. On the other hand, nutrient imbalances can reduce resistance to pests (Altieri and Nicholls 2003).

Over the two seasons of manuring and nine months of observation, a yield increase of 83.91% was recorded for poultry manure, 83.92% for compost and NPK, and 83.80% for cattle manure. The manure dose-yield relationship is classically observed in such studies; it is a relationship that admits an optimal dose beyond which application is no longer beneficial and even negatively affects productivity in the case of urea (Zamukulu et al., 2018; Kouyate, 2023; Useni, 2024).

Observation of severity and yield over the 9 months shows that periods of peak severity correspond to the lowest yields. This is in line with the negative relationship between the two parameters described by Bédane et al. (2013) on the moringa/Noorda pair, and by Chala et al., (2007) on other crops such as sorghum and leaf diseases.

Conclusion

The study provides a comparative description of the reaction of the moringa pest *Noorda blitealis* to certain sources of organic fertilization and their rate of use. It shows that compost, which is a well-decomposed organic fertilizer, can be used to minimize the impact of the defoliator caterpillar on moringa production. It can therefore be included in agro-ecological protection programs against moringa's main enemy, in order to minimizing the use of synthetic chemical pesticides. In fact, the use of these pesticides poses risks to human health and the environment, especially in a context of ignorance and lack of mastery of application techniques for these products. So, the other organic fertilizers such as cow dung and poultry droppings should be composted before use in moringa production. In the other hands, the use of such a product in the control of this major moringa pest can be widely popularized among growers to minimize the quantity of pesticides to be imported into the country and, consequently, foreign exchange losses.

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