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Effects of Agro forestry and Micro doses of Fertilizers on Spodoptera frugiperda control in the East of DR CONGO.

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ABSTRACT

The objective of this work was to determine the cultural practice that can be used to control the Spodoptera frugiperda. The results show that: Treatment with NPK-Manure (34.4%) and Control (25.5%) had more attacked maize plants and a significantly higher incidence (P = 0.001) for both cropping seasons A and B than agro forestry system treatments (4.1%). In addition, the mean numbers of Spodoptera frugiperda caught in the NPK-Manure (14) and control (7) treatments during the two growing seasons were significantly higher (P = 0.001) than the others treatments in agro forestry system (3). Contrary for maize varieties, there were no significant differences between the three varieties in the number of attacked plants (P = 0.877), incidence (P = 0.956) and number of collected spodoptera (P = 0.803) per varieties for both seasons. With respect to the seasons, there were more attacked plants with a higher incidence in season B than A. The labor cost for Spodoptera capture was higher for the NPK-Manure (26.3 USA$) and the control (23.4 US $) treatments in comparison with agro forestry practice with the low cost (4.7- 7.8 US). The application of agro forestry has an advantage for farmers to control Spodoptera frugiperda in the study environment.

KEYWORDS: Associations, grass, labor cost, leguminous shrubs, and maize varieties.

1 INTRODUCTION

Cereal-legume associations could contribute to the development of agriculture that combines productivity and high environmental value. They appear, in conventional farming, an efficient way to produce as much (yield, protein content) as the average of the pure cultures with much less nitrogen inputs and thus induced energy consumption (Naudin et al., 2010; Bedoussac et al. 2010, Pelzer et al 2012). However, association is a way of bringing the simultaneous culture of two or more species into the same space and for a significant duration of their cycle (Willey, 1979).

Pelzer et al. (2012) show that cereals are more competitive than legumes because of their deeper root systems and faster growth. In the case of companion cereal-legume combinations, the leguminous plant is a cover crop that can remain in place until the harvest of the cereal, and this until the establishment of the next crop, and which ensures only agro functions - ecological throughout the cycle of the cereal and in the longer term: reduction of weed infestations, regulation of bio-aggressors, trapping of excess nitrate, contribution to soil organic nitrogen stock, maintenance / improvement of soil structure, increase of biodiversity on the agricultural parcel. Thus, these authors (Naudin et al., 2010, Corre-Hellou et al., 2006 and Hilt runner et al., 2007) show that the functioning and performance of cereal-legume associations depend strongly on the nitrogen availability of the plant. middle. Nitrogen fertilization (dose and date) can be considered as an important lever to guide the associated cover towards different proportional objectives of each species in the final mixture. However, the other elements of the technical itinerary could be adjusted such as density or variety choice but have so far been little explored.

Many technical questions remain on the design of technical itineraries for these cereal-legume seed and forage combinations and companion legume cereal combinations aimed at satisfying different outlets with high levels of production and quality of harvested products and minimizing inputs as well as on the reasoning of the place of these associations in the succession of cultures. In addition to those listed above, another unknown scientist is the application of this technique to the regulation of bio-aggressors.

The cultivation of maize is currently subject in all African countries to the attack of Spodoptera frugiperda and the latter is resistant to all forms of insecticides. Given the importance of maize in the African continent, the mobilization of the population to find solutions to this new invasion would be an asset to produce better. Thus, associations could be of interest for controlling certain pests, but the conclusions could not be generalized because of the mechanisms specific to each pest; hence the work of the effects of farming practices integrating agro forestry and micro doses of fertilizers in the fight against Spodoptera frugiperda maize INERA-Mulungu, Kabare North.

Indeed, the application of these cultural practices integrating agro forestry and micro doses of fertilizers would have an impact in the fight against the armyworm, Spodoptera frugiperda.

The overall objective of this work is to determine which cultural practices integrating agro forestry and micro doses of fertilizers can control the armyworm, Spodoptera frugiperda and increase the cost of labor for the collection of Spodoptera frugiperda by man. day during the two growing seasons A and B.

The choice of this topic is explained by the concern to bring information necessary for the fight against the armyworm, Spodoptera frugiperda in Kabare in general and INERA-Mulungu in particular. The interest of this work for the population lies in the fact that its recommendations will allow it to improve the production of maize and therefore the living conditions of the population. No studies have been done in the region yet maize is of nutritional and economic importance in the region.

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2 MATERIAL AND METHODS

2.1 STUDY ENVIRONMENT

2.1.1 Location

The test was conducted in the grouping of Miti Kabare territory on the site or area of INERA-Mulungu. The latter is created in 1933 and located in the province of South Kivu, territory of Kabare 25 km from Bukavu and 5 km from Kavumu. The annual precipitation is 1730 m and the average temperature is 15 ° -19 °. The total area is 1,122 hectares and the exploitable area is 187 hectares. The research programs are: food crops, perennial crops, forestry and livestock. INERA-Mulungu is located between 28 ° 43 'east longitude and 2 ° 18' south latitude, at 1700-2430 m altitude, while the experimental field is located between 28 ° 46'540 " longitude East and 2 ° 19'907 " South latitude, at 1825 m altitude, Figure (1.), below presents the map of the study environment.

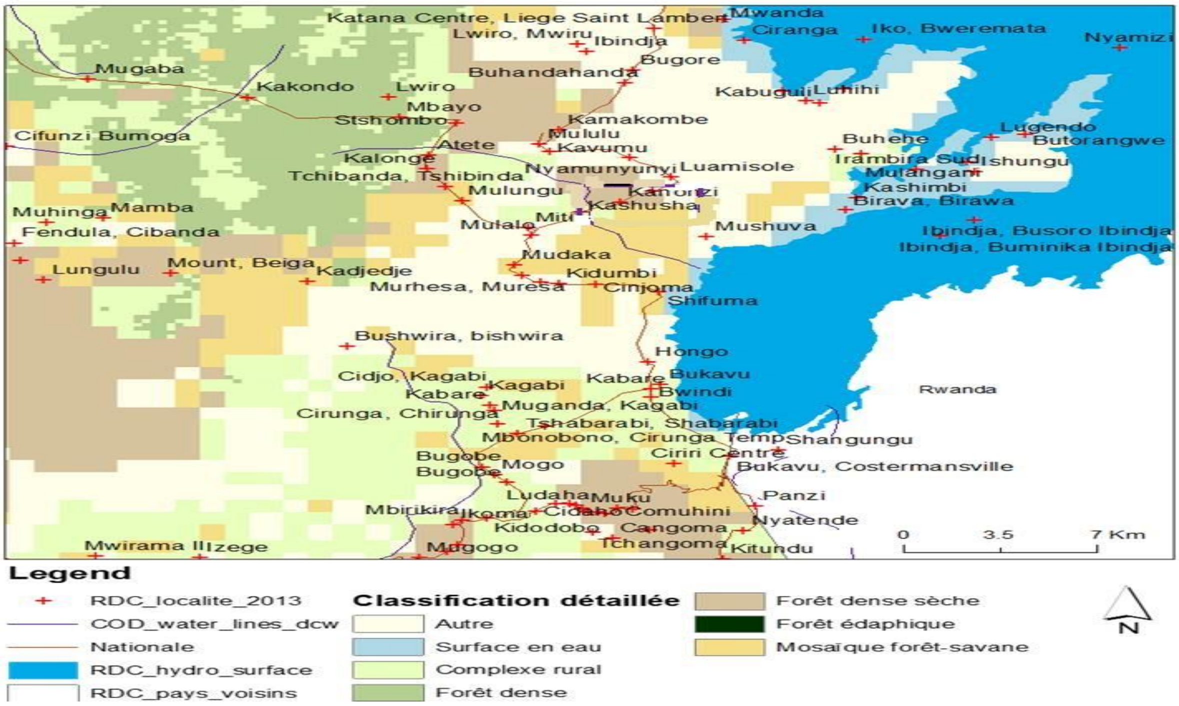

Figure 1. Location Map (ATLAS, 20137)

The study concerns a grouping, namely: Mite which is part of 14 groupings that counts the collectivity-chieftaincy of Kabare, which bears the same name of the territory and is located about 30 km from Bukavu; the chief place of the province of South Kivu.

The territory of Kabare is located between 28 ° 45 'and 28 ° 55' east longitude and 2 ° 30 'and 2 ° 50' south latitude; it is composed of the two communities (chiefdoms) which are notably the community of Nindja and that of Kabare. The latter is subdivided into fourteen groups:

Bushumba, Bugorhe, Irhambi-Katana, Bugobe, Bushwira, Cirunga, Ishungu, Lugendo, Luhihi, Kagabi, Miti, Mudaka, Mudusa and Mumosho.

2.1.2 Climate and vegetation

The Miti group benefits from a humid tropical climate, including a long rainy season of 9 months (from September to May) and a short dry season of 3 months (from June to August). The average annual air temperature is 19.5 ° C, the relative humidity varies between 68 and 75% (LWIRO 2017) and the annual rainfall is 1500 mm. The vegetation consists of a cultivated savannah, which has replaced the original Albizia grandibacteata forest (Bagalwa and Baluku 1997, Furaha et al., 2013, Bisusa et al.

2.1.3 Activities of the population

Agriculture is the main activity of 92.6% of households, although the soil is more and more exhausted. In addition, the high population density has transformed the landscape into a checkerboard of very small plots (Pypers et al, 2010). Moreover, in the near absence of improved varieties, plant protection products and chemical fertilizers, the only way out is to bring organic matter to the soil and gradually correct their acidity (pH) with applications of travertine or lime, two difficult, slow and expensive operations (Didier de Failly, 2000 cited by Furaha et al., 2013, Ntamwira et al., 2017). Thanks to the presence of a partly partly undamaged road (paved from Bukavu to Kavumu), which links the localities to the provincial capital (Bukavu), commerce is the second activity that attracts households and thus promotes a high concentration of the population along this route.

2.1.4 Climatic condition of the period of the test

The period of the test benefited from a precipitation distributed as follows in table (1), below

Table 1. Climatic data of Mulungu during the year 2017.

Month	January	February	Mars	Avril	Mai	June	July	August	September	October	November	December
T°C	23,3	23,5	23,4	23,4	23,4	22,8	22,7	23,5	24,0	23,6	23,2	23,3
P.mm	185	154	189	187	133	52	40	59	100	163	201	208

(**Source**: INERA, 2017)

2.1.5 Edaphic condition of the experimental field.

According to the classification of INERA-MULUNGU, the soil is developed on the basic rock to heavy clayey Olivine with as A horizon, pronounced.

2.2 MATERIAL

2.2.1 Equipment

Corn (Zea Mays L.) is the biological material of work. The seeds are from INERA-Mulungu and are SAM VITA A, SAM VITAB and GV664. The characteristics of these varieties are illustrated in Table 2.

Table 2. Characteristics of SAM VITA A, SAM VITAB and GEN varieties (GV 664)

variety	Yield (Kg / ha)	Production cycle (months)
GV 664	1719	4
SAM VITA A	2328	4
SAM VITA B	1419	4

(**Source**: (Ntamwira et al., 2018, in press)

2.2.2 Tools and appliances

The tools and apparatus used are: the hoe was used for plowing, the machete was used to find the stakes, the peel for digging the alleys, the slat for measuring the leaf area and the height of the plants, the labels for distinguishing the treatments, the rake for the harrowing of the flower beds, the stakes for delimiting the plots, the twine for sowing in line, the bag for the transport of organic matter, the precision electronic balance and the mechanical scale for measuring the weights.

2.3 METHODS

2.3.1 Experimental device

This test was conducted in A and B crop seasons, ranging from March-July 2017 (Season B) to September-January 2018 (Season A). The experimental device is the Split plot having as main factor the combination of grass shrub species and secondary factor the varieties of maize. The land was subdivided into blocks which are subdivided into 8 main plots (treatments) each subdivided into 3 secondary plots corresponding to the 3 varieties of corn, ie a total of 96 plots for the four replicates. T1: Leucaena + Calliandra + Pennicetum + NPK-manure; T2: Leucaena + Albizia + Pennicetum + NPK -Smith; T3: Albizia + Leucaena + Setaria + Pennicetum + NPK-manure; T4: Leucaena + Calliandra + Setaria + Pennicetum + NPK-manure, T5: Leucaena alone + Setaria + Pennicetum + NPK-manure, T6: Calliandra +

Leucaena + Pennicetum + Tithonia + NPK-manure, T0: With mineral fertilizer (NPK) and manure of farm and T00: Without fertilization or fallow (witnesses). Each treatment or main parcel had a size of 10 x 10 m or 100 m2 distant of 3 m while the secondary plot per variety of corn measured 3, 3 m2. After plowing, manure (20 t MS) and NPK fertilizer microdoses (50 kg / ha) were applied except for the T00 control treatment. Thus, a mixture of 200 kg of well-decomposed cow dung solubilized with ½ pound soil and 500 g of NPK was dissolved in the water rubbed between two hands in a bucket until the granules disappeared. Grasses and shrubs were planted in association at 1 m intervals. Spacing on the line was 25 cm for grasses and 50 cm for shrubs.

2.3.2 Phytosanitary round

Phytosanitary rounding or phytosanitary prospecting (Dupriez and Simbizi, 1998) was carried out in these associations studied by the diagonal and corn observation methods. It consisted in identifying the Spodoptera frugiperda using the photographs (key of identification) proposed by Goergen et al. (2016) and to collect and / or capture the insect pest by hand (Dagnelie, 1992) along the diagonal. Insect collection began on March 12, 2017 for crop season B and on September 2, 2018 for crop season A; 2 times a month and every 2 weeks per treatment.

2.3.3 Methods of data processing

The analysis by the software Genstat discovery 11th version. The analysis consisted of the two-way analysis of variance (ANOVA II) was used and the comparison of means was made by the method of smallest significant difference (LSD) at p value 0.005.

3 RESULTS AND DISCUSSION

3.1 INTERPRETATION OF RESULTS

3.1.1 Results for maize plants attacked according to crop seasons A and B

3.1.1.1 Corn plants attacked by treatment during both cropping seasons A and B

Table 3 illustrates the data of maize plants attacked during the two growing seasons A and B.

Table 3. Number of attacked and total maize plants in both crop season A and season B by variety and treatmen

		Plants attacked			Incidence		
Culture system	treatment s	Season B	Season A	Average	Season B	Saison A	Average
NPK-	T0*	24.3a	3.8a	14.0a	63.3a	5.5a	34.4a

manure							
Witness	T00	15.8b	3.2a	9.5b	47.1a	4.0a	25.5ab
	T1	1.2d	0.6b	0.9c	12.4bc	0.8b	6.6 c
	T2	1.5d	0.1b	0.3c	2.6c	0.1	1.4 c
	T3	3.5c	1.0b	2.3c	23.0b	1.4b	12.2 bc
Agroforestry-NPK-manure	T4	0.4d	0.0b	0.2c	1.9c	0.0b	1.0 c
	T5	0.5d	0.2b	0.3c	3.0c	1.2b	1.6 c
	T6	0.5d	0.0b	0.3c	4.5c	0b	2.2 c
	Average	1.3	0.3	0.7	7.9	0.6	4.1
	Post mortem	6.0	1.1	3.5	19.7	1.6	10.6
	LSD	1.5	1.5	1.5	18.1	2.6	15.13
	FPr	0.001	0.001	0.001	0.001	0.001	0.001

* T0: With mineral fertilizer (NPK) and farm manure and T00: Without fertilization or fallow (controls);

T1: Leucaena + Calliandra + Pennicetum + NPK-manure; T2: Leucaena + Albizia + Pennicetum + NPK -Smith; T3: Albizia + Leucaena + Setaria + Pennicetum + NPK-manure; T4: Leucaena + Calliandra + Setaria + Pennicetum + NPK-Manure, T5: Leucaena + Setaria + Pennicetum + NPK-Manure and T6: Calliandra + Leucaena + Pennicetum + Tithonia + NPK-Manure.

#: The numbers followed by the same letter in the same column are not significantly different according to the LSD test (the smallest significant difference) $p < 0.05$.

The difference in mean values between different treatment levels is greater than might be expected by chance after taking into account the effects of differences in Varieties. There is a statistically significant difference ($P = < 0.001$). To isolate which group (s) differ from the others, use a multiple comparison procedure.

Thus, compare the 2 to 2 means by the method of the small significant difference (Fisher LSD Method). The incidence varies from 0.3 to 4.9% for treatments with agroforestry system, it was significantly elevated 5 and 24% during seasons A and B.

3.1.1.2 Corn plants attacked by treatment variety during the two growing seasons A and B

Table 4. Averages of attacked maize plants and incidence during both crop seasons A and B by variety.

	Plants attacked			Incidence		
variety	Season B	Season A	Average	Season B	Season A	Average
GV664	5.0a	1.0a	3a#	17.8	1.9a	9.8a
Sam Vita A	5.1a	0.7a	2.8a	19.8	0.9a	10.4a
Sam Vita B	4.1a	1.2a	2.6a	21.5	1.7a	11.6a
Post mortem	4.7	0.95	2.8	19.7	1.5	10.6
LSD	4.8	4.8	4.8	26.1	2.5	12.4
FPr	0.877	0.877	0.877	0.956	0.675	0.956

#: The numbers followed by the same letter in the same column are not significantly different according to the LSD test (the smallest significant difference) $p < 0.05$.

Table 4 shows that there is no significant difference between the 3 varieties in incidence and plants attacked by the caterpillar. The difference in the mean values between the different levels of varieties is not large enough to exclude the possibility that the difference is due to the random sampling variability after taking into account the effects of differences in treatments. The power of the test carried out with alpha is 0.0877 for the average attacked plants and 0.703 for the average incidence of two seasons

3.1.2 Results for Spodoptera frugiperda caught during cropping seasons A and B

3.1.2.1 Number of Spodoptera frugiperda caught by treatments during both cropping seasons A and B

The number of Spodoptera frugiperda caught during the two growing seasons A and B is presented in Table 5 below.

Table 5. Mean number of Spodoptera frugiperda caught by treatments during both cropping seasons A and B.

Culture systems	treatments	Season B	Season A	Average
NPK-manure	T0*	24.6a	3.7a	14.2a

Witness	T00	12.7b	1.9a	7.3b
Agro forestry + NPK-Manure	T1	1.0c	0.2a	0.6c
	T2	0.3c	0.2a	0.3c
	T3	0.1c	0.5a	0.3c
	T4	0.2c	0.0a	0.1c
	T5	0.01c	0.4a	0.2c
	T6	0.2c	0.2a	0.2c
	Average	0.3	0.3	0.9
	Post mortem	4.9	0.9	2.6
	LSD	4.8	4.8	4.8
	FPr	0.001	0.001	0.001

* see table 3.

#: The numbers followed by the same letter in the same column are not significantly different according to the LSD test (the smallest significant difference) p <0.05.

This table shows that T0 treatment has more Spodoptera frugiperda captured during Crop Season A than other treatments.

The difference in average values between different treatment levels is greater than might be expected by chance after taking into account the effects of differences in varieties. There is a statistically significant difference (P = <0.001). The power of the test performed with alpha is 0.0500 for the treatment is 1.000. To isolate which group (s) differ from the others.

3.1.2.2 Number of Spodoptera frugiperda caught by variety during the two growing seasons A and B

Table 6. Number of captured Spodoptera frugiperda caught by variety during both cropping seasons A and B.

variety	Season B	Season A	Average
GV664	3.41a	0.8a	2.1a
Sam Vita A	4.55a	0.45a	2.5a

Sam Vita B	3.05a	0.89a	1.97a
Average	3.67	0.71	2.19
LSD	1.67	1.67	1.67
FPr	0.803	0.803	0.803

#: The numbers followed by the same letter in the same column are not significantly different according to the LSD test (the smallest significant difference) p <0.05.

The difference in the mean values between the different levels of varieties is not large enough to exclude the possibility that the difference is due to the random sampling variability after taking into account the effects of differences in treatments. The power of the test performed with alpha is 0.05. There is no statistically significant difference (P = 0.803).

3.1.4 Evaluation of the workforce for the collection of Spodoptera frugiperda during the two cropping seasons A and B for 1 ha.

Table 7 shows the number of people who collected Spodoptera frrigiperda by killing them within 50 cm of plant height

Table 7. Number of caterpillar, male days for caterpillar picking per treatment per 1 ha.

treatments	Number of caterpillars	Man's day (MO)	$(USA)
With mineral fertilizer (NPK) and manure	11300		26.3
Without fertilization or fallow (witnesses);	5830	25	23.4
Leucaena + Calliandra + Pennicetum + NPK-fumier	470	5	4.7
Leucaena + Albizia + Pennicetum + NPK –Fumier ;	200	6,3	5.9
Albizia + Leucaena + Setaria + Pennicetum + NPK-fumier;	220	6,3	5.9
Leucaena + Calliandra + Setaria + Pennicetum +NPK-fumier;	60	6,3	5.9
Leucaena + Setaria + Pennicetum + NPK-fumier	170	8,3	7.8
Calliandra + Leucaena + Pennicetum +Tithonia + NPK-fumier	130	7,5	7.0

The results in this table show that many Spodoptera collected per hectare were higher for the T0 (11300) and Too (5830) treatments, which increased the labor force (28 and 25 man days (5-8) and the cost (26.3 and 23.4 US $) in comparison with agro forestry practice with a number of spodoptera (60-470), man days and low cost (4.7- 7.8 US $.

3.2 DISCUSSION

3.2.1 Discussion of maize plants attacked by pests following crop seasons A and B

The cropping systems of the combination of NPK-Manure and natural fallow have more maize plants attacked during both cropping seasons (A and B) than the agro forestry cropping system. What joins (Escalante-Ten. And Maïga 2018) which show the attack of several parasites especially insects like the larva of the corn borer (Ostrinia nubilalis), the black cutworm (Agrotis ipsilon), the worm of the spike maize (Helicoverpa zea), rootworm (Diabrotica virgifera), maize flea beetle (Chaetocnema pulicaria), maize aphid (Rhopalosiphum maidis), larvae and adults of the corn leafhopper (Zyginidia scutellaris) and Fall armyworm (Spodoptera frugiperda) on corn affecting maize yields. The functioning and performance of cereal-legume associations is strongly dependent on the nitrogen availability of the medium (Naudin et al., 2010, Hiltbrunner et al., 2007). Nitrogen fertilization can be considered as an important lever to control diseases and pests (Yousfi, 2016).

3.2.2 Discussion of Spodoptera frugiperda caught during Crop A and B seasons

Maize plants in the NPK-Manure combination cropping system were more prevalent in Season A (5.5%) as in Crop Season B (63.3%) compared to the other two cropping systems (Natural Fallow and agro forestry of 1-12.2%). However, comparing natural fallow with agro forestry, natural fallow was more common in crop season A (4%) as in crop season B (and 47.1%) compared to agro forestry against 0.6% in season A and 7.9% in cultivation season B. This is in line with the biological control by conservation proposed by www.agropolis.fr (June, 2018) which has recently developed with the introduction of systems management in crop protection. This consists in improving the target in its capacity to react against its aggressor (by manipulation of the soil, microclimate or mutualism) or to encourage, or protect the populations of auxiliaries already present in the agro system (by refuge zones such as grass strips or border hedges).

3.2.3. Discussion on the incidence of Spodoptera frugiperda caught during both cropping seasons A and B

The growing system of the NPK-Manure combination has a large number of caterpillars (14) compared to the other two cropping systems (natural fallow and agro forestry). However, comparing natural fallow with agro forestry; it is also large (7) compared to agro forestry (0.3). The number a varies from 0.1 to 0.6% by treatments less than 50% during crop seasons A and B. This result is consistent with those of (Akanvou et al., 2006 20) which showed that the incidence of insect pests are generally low, but it can become important. The agro forestry cropping system has a minimal impact ranging from 0 to 2.933%. These results are in line with recent developments and have integrated concepts of evolution, ecology of antagonistic plant-pest interactions within the concept of biological control by www.agropolis.fr (June, 2018). In the concept of sustainable agriculture, the management of pest populations by non-chemical methods is the final phase of the long process of studies and analyzes of invasive and emerging species and their interactions with other species and the environment that is they invade [www.agropolis.fr (June, 2018).

3.2.4. Discussion on the assessment of the labor force for the collection of Spodoptera frugiperda during the two growing seasons A and B for 1 ha

Analysis of the cost of labor for spodoptera collection shows that it can be controlled by collection, especially in the agro forestry system in which there is little caterpillar. In addition, the cost of collection is low in agro forestry treatments and higher in treatments with NPK-Manure and T00 control.

4. CONCLUSION

The different grass-tree combinations (Agro forestry practice) reduced the number of caterpillar-attacked maize plants, the number of caterpillars per plot and the incidence of attacked plants compared to the control plots and those fertilized with NPK-Manure.

The study showed that agro forestry practice under the conditions of this trial has a great effect on the control of the armyworm Spodoptera frugiperda and that this practice reduces the cost of caterpillar harvesting compared to traditional practices (without or with fertilsation) used by farmers. In addition, the agro forestry practice has other advantages such; restoration of soil fertility and forage production for livestock as well as carbon sequestration.

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